Final Technical Report

(Feb, 2018 to Nov, 2021)

of the Project

Establishment of functional foods R&D centre and dissemination of the developed technology for the livelihood, nutritional security and entrepreneurship of the farm women of Himachal Pradesh

Submitted to

National Mission on Himalayan Studies
GBPNIHESD, Ministry of Environment, Forest and Climate Change, GoI, Almora, Uttarakhand

By

Dr NS Thakur
(Principal Investigator)

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NMHS-Himalayan Institutional Project Grant

NMHS-FINAL TECHNICAL REPORT (FTR)

Demand-Driven Action Research and Demonstrations

NMHS Reference No.:	NMHS/2017-18	Date of Submission:	d	D	m	m	y	y	y	y

PROJECT TITLE

ESTABLISHMENT OF FUNCTIONAL FOODS R&D CENTRE AND DISSEMINATION OF THE DEVELOPED TECHNOLOGY FOR THE LIVELIHOOD, NUTRITIONAL SECURITY AND ENTREPRENEURSHIP OF THE FARM WOMEN OF HIMACHAL PRADESH

Project Duration: *26.02.2018 to* 30.11.2021

***Submitted to*:**
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NMHS-Final Technical Report (FTR) *template*

Demand-Driven Action Research Project

DSL: Date of Sanction Letter
Project Completion

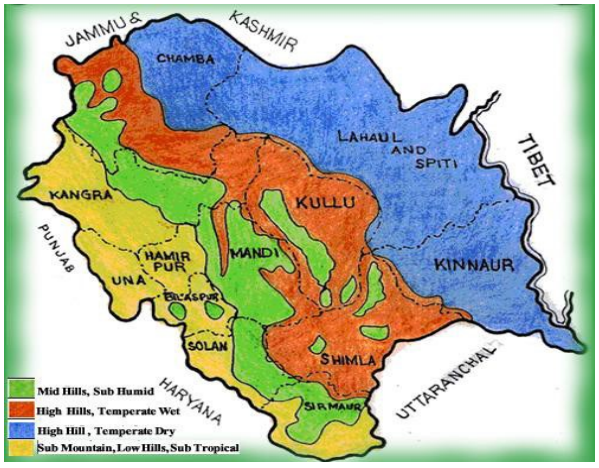
2	6	0	2	**2**	**0**	**1**	**8**
d	d	m	m	y	y	y	y

DPC: Date of

3	0	1	1	**2**	**0**	**2**	**2**
d	d	m	m	y	y	y	y

Part A: Project Summary Report

1. Project Description

i.	Project Reference	NMHS/2017-18/SG30/11							
ii.	Type of Project	Small Grant		**Medium**		✓	Large Grant		
iii.	Project Title	Establishment of functional foods R&D Centre and dissemination of the developed technology for the livelihood, nutritional security and entrepreneurship of the farm women of Himachal Pradesh							
iv.	State under which Project is Sanctioned	HP, J&K and Uttrakhand							
v.	Project Sites (IHR States covered) (Maps to be attached)	Solan, Chamba, Shimla, Kinnaur and Lahaul and Spiti Districts of Himachal Pradesh 							
vi.	Scale of Project Operation	Local		Regional	✓	Pan-Himalayan			
vii.	Total Budget/ Outlay of the Project	1.48 Cr							
viii.	Lead Agency	Department of Food Science and Technology Dr YS Parmar University of Horticulture and Forestry, Solan, Himachal Pradesh - 173 230							

	Principal Investigator (PI)	Dr. K.D. Sharma Former Professor and Head, Department of Food Science and Technology Dr YS Parmar University of Horticulture and Forestry, Solan, Himachal Pradesh - 173 230 +Phone No.9418752628 Email:kdsharma40@yahoo.com
	Co-Principal Investigator (Co-PI)	1. Dr (Ms) Anju Dhiman, Dean, College of Horticulture Dr YS Parmar University of Horticulture and Forestry, Solan, Himachal Pradesh - 173 230 Phone No.94181-23300 Email:dhimananju@yahoo.com 2. Dr NS Thakur, Professor Department of Food Science and Technology, Dr YS Parmar University of Horticulture and Forestry, Solan, Himachal Pradesh - 173 230 Phone No.9418057933 Email:nsthakurpht@gmail.com 3. Mrs Surekha Attri, Scientist (Rtd)) Department of Food Science and Technology, Dr YS Parmar University of Horticulture and Forestry, Solan, Himachal Pradesh - 173 230 Phone No.01792-252450 Email:attrisurekha@yahoo.com 4. Dr NS Kaith, Principal Scientist and Head, Krishi Vigyan Kendra, Rohru, District Shimla, Himachal Pradesh – 171 207 Phone No. 9459802063 Email:narenderkaith63@gmail.com 5. Dr Renu Kapoor, Scientist, Krishi Vigyan Kendra, Chamba, Himachal Pradesh – 176 314 Phone No.982541041 Email:rnkapoor56@gmail.com 6. Dr Arun Kumar, Scientist, Krishi Vigyan Kendra, Sharbo, Rekong Peo, District Kinnaur – 172 107 Phone No.7018580075 Email:arunkumar.negi@gmail.com 7. Dr Savita Kumari, Scientist, Krishi Vigyan Kendra, Tabo (Spiti), District Lauhal and Spiti, Himachal Pradesh – 172 113 Phone No.9459113065 Email: kvktabo@yspuniversity.ac.in

ix.	Project Implementing Partners	**Project Partner**	**Affiliations**	**Role & Responsibilities**
		Partner 1	KVK, Chamba at Saru, HP	Familiarization of developed technology for further dissemination to the farm women through organization of trainings.
		Partner 2	KVK, Rohru, Shimla, HP	Familiarization of developed technology for further dissemination to the farm women through organization of trainings.
		Partner 3	KVK, Sharbo, Rekong Peo, HP	Familiarization of developed technology for further dissemination to the farm women through organization of trainings.
		Partner 4	KVK, Tabo, Lahaul and Spiti, HP	Familiarization of developed technology for further dissemination to the farm women through

	Key Persons / Point of Contacts with Contact Details, Ph. No, E-mail	1. Dr. K.D. Sharma Former Professor & Head-cum-PI, Department of Food Science and Technology, Dr YS Parmar University of Horticulture and Forestry, Solan, Himachal Pradesh - 173 230 Phone No.9418752628 Email:kdsharma40@yahoo.com 2. Dr (Ms) Anju Dhiman, Former Dean, College of Horticulture Dr YS Parmar University of Horticulture and Forestry, Solan, Himachal Pradesh - 173 230 Phone No.94181-23300 Email:dhimananju@yahoo.com 3. Dr NS Thakur, Professor-cum-OSD to Hin'ble VC Dr YS Parmar University of Horticulture and Forestry, Solan, Himachal Pradesh - 173 230 Phone No.9418057933 Email:nsthakurpht@gmail.com 4. Mrs Surekha Attri, Scientist (RTd.) Department of Food Science and Technology, Dr YS Parmar University of Horticulture and Forestry, Solan, Himachal Pradesh - 173 230 Phone No.01792-252450 Email:attrisurekha@yahoo.com 5. Dr NS Kaith, Principal Scientist and Head, Krishi Vigyan Kendra, Rohru, District Shimla, Himachal Pradesh – 171 207 Phone No. 9459802063 Email:narenderkaith63@gmail.com 6. Dr Renu Kapoor, Scientist, Krishi Vigyan Kendra, Chamba, Himachal Pradesh – 176 314 Phone No.982541041 Email:rnkapoor56@gmail.com 7. Dr Arun Kumar, Scientist, Krishi Vigyan Kendra, Sharbo, Rekong Peo, District Kinnaur – 172107 Phone No.7018580075 Email:arunkumar.negi@gmail.com 8. Dr Savita Kumari, Scientist, Krishi Vigyan Kendra, Tabo (Spiti), District Lauhal & Spiti, Himachal Pradesh– 172113 Phone No.9459113065 Email: kvktabo@yspuniversity.ac.in

2. Project Outcomes

2.1. Abstract (not more than 500 words) [it should include background of the study, aim, objectives, methodology, approach, results, conclusion and recommendations).

Background:

The R&D programme was initiated at the main campus for the incorporation of locally available crops for the development of functional foods. On the basis of baseline survey at KVK districts, trainings were planned for the farm women regarding value addition by food preservation and processing and skill development, for converting their agricultural produce to shelf-stable functional food products.

Objectives/ Aim: The main objective of the project is to develop low cost, simple and easily adoptable technology along with value-addition of inferior quality and unmarketable surplus agri-horti produce to ensure remunerative price and nutritional security to the farming families.

Methodology: The trainings regarding the preparation of functional foods (R&D experiments executed in the Department of FST, Solan) from locally available raw materials were conducted for farm families in selected Panchayat/ Blocks of four KVK districts after completion of baseline survey.

Approach: The trainings and demonstrations were organised for a group of 10 - 30 farm women at KVKs and off-KVKs. The training schedule lagged behind due to the restrictions imposed due to COVID-19.

Results: Seven research experiments on the development of functional food products based on fruits, vegetables, flowers, spices, medicinal and aromatic plant, cereals, pulses and oilseeds were completed during 2020 - 2021. In total, 50 Nos. training and demonstration camps ranging from 1 – 3 days were organized at different locations selected under different KVKs of Chamba, Shimla, Lahaul and Spiti and Kinnaur districts of Himachal Pradesh.

Conclusion: The functional foods project has led to optimistic approach of the farm women about home scale preservation resulting in reduction of perishables glut and postharvest losses besides, availability of nutritive and good quality food products at reasonable price.

Recommendations: Farmer's need to be encouraged to grow food crops of functional importance on commercial scale. Regional Centres on functional food with long term projects of 15-20 years duration should be established to make consistent efforts for the enhancement of nutritional and economic status of the farmers of Himalayan region states.

2.2. Objective-wise Major Achievements

S. No.	Objectives	Major achievements (in bullets points)
1.	Model functional foods processing center with reasonable investment for prospective entrepreneurship and skill development.	• Low cost, simple and easily adoptable technology resulting in the remunerative price to the farm women (04 models in tribal belt): The baseline survey regarding the status of functional foods for nutrition and livelihood has been done and analysed **The following technologies have been developed:** • Technology for the extraction of dietary fibre from bamboo and its utilization for nutritional supplementation • Development of beverages from wild jamun (*Syzygium cumini* L.) • Preparation and preservation of persimmon (*Diospyros kaki* L.) pulp and its utilization in dairy products • Ready-to-serve beverages from persimmon (*Diospyros kaki* L.) • Development and storage of granular powder from wild pomegranate (*Punica granatum* L.) • Extraction and utilization of phenolic antioxidants from wild pomegranate (*Punica granatum* L.) fruits • Utilization of apple pomace for the preparation of functional rolls • Soybean enriched apple pomace flour roll • Pseudocereals-based carrot pomace flour enriched bakery products • Dehydration of persimmon (*Diospyros kaki* L.) for product development • Development of muffins from ripe pumpkin (*Cucurbita moschata*) • Development of anardana from unmarketable fruits of commercial pomegranate • Carrot juice concentrate production and utilization • Extraction of isoflavone and development of functional food products from soybean (Glycine max L. Merri

2	Training and demonstration center(s) for various stakeholders	The R&D programs have been developed on the basis of the region specific and locally available raw materials viz., fruits, vegetables, cereals, oilseeds, pulses, wild flowers, wild fruits etc. **In 2019-20** • Organized 60 trainings of 3 days duration at each Krishi Vigyan Kendra (KVKs) and off-KVKs in selected districts of the Himachal Pradesh and adjoining areas of J&K and Uttarakhand: 14 number trainings each of 2 days duration were successfully organized **In 2020-21** • Organized 30 trainings of 3 days duration; 01 No. (2 days) and 06 Nos. (1 day)} have been successfully organized at Krishi Vigyan Kendra (KVKs) and off-KVKs in selected districts of the Himachal Pradesh and adjoining areas of J&K and Uttarakhand: **In 2021-22** • Organized 50 trainings of 3 days duration at each Krishi Vigyan Kendra (KVKs) and off-KVKs in selected districts of the Himachal Pradesh and adjoining areas of J&K and Uttarakhand. Besides this, 02 exposure visits were also conducted for the farmers of Lahul & Spiti to Solan and Palampur
3	Enhancement in living standard and economic status of the farmers through nutritional security and livelihood	• Total 20-30 BPL women were benefited from each training camp: • About 3356 farm women from the districts of Chamba, Kinnaur, Shimla and Lahaul & Spiti have been benefitted from training camps
4	Benefit to large scale food manufacturers in urban settings from the availability of quality semi-finished ingredients at a reasonable price	• Generated trained manpower in the field on food processing to cater the need of food processing industry. • The local trained manpower could establish linkage with urban establishments for supply of semi-finished products at a reasonable price
5	Other Publications and Knowledge Products generated	• 06 Nos. training booklets/ pamphlets of the developed technology on the functional food products containing pages ranging from 4 - 24 in each were published • 12 original research papers published in refereed journals • 02 Nos. patent filed on the technology developed

2.3. Outputs in terms of Quantifiable Deliverables*

S. No.	Quantifiable Deliverables*	Monitoring Indicators*	Quantified Output/ Outcome achieved	Deviations made, if any, & Reason thereof:
1.	Model functional foods processing centre with reasonable investment for prospective entrepreneurship and skill development.	No. of New Database/ Datasets generated on the identified dynamics (No.): i) The baseline survey regarding the status of functional foods for nutrition and livelihood has been done and analysed during initial phase of the project.	• Technology for the extraction of dietary fibre from bamboo and its utilization for nutritional supplementation • Development of beverages from wild jamun (Syzygium cumini L.) • Preparation and preservation of persimmon (Diospyros kaki L.) pulp and its utilization in dairy products • Ready-to-serve beverages from persimmon (Diospyros kaki L.) • Development and storage of granular powder from wild pomegranate (Punica granatum L.) • Extraction and utilization of phenolic antioxidants from wild pomegranate (Punica granatum L.) fruits • Utilization of apple pomace for the preparation of functional rolls • Soybean enriched apple pomace flour roll	-

			• Pseudocereals-based carrot pomace flour enriched bakery products • Dehydration of persimmon (Diospyros kaki L.) for product development • Development of muffins from ripe pumpkin (Cucurbita moschata) • Development of anardana from unmarketable fruits of commercial pomegranate • Carrot juice concentrate production and utilization • Extraction of isoflavone and development of functional food products from soybean (Glycine max L. Merri	
2.	Training and demonstration center (s) for various stakeholders.	Periodic submission on region-specific best practices/ demonstrative models (No.): The R&D programs have been developed on the basis of the region specific and locally available raw materials *viz*., fruits, vegetables, cereals, oilseeds, pulses, wild flowers, wild fruits etc.	• The R&D programs have been developed on the basis of the region specific and locally available raw materials viz., fruits, vegetables, cereals, oilseeds, pulses, wild flowers, wild fruits etc. • Organized 140 trainings of 3 days duration and two days duration at each Krishi Vigyan Kendra (KVKs) and off-KVKs in	

			selected districts of the Himachal Pradesh and adjoining areas of J&K and Uttarakhand	
3.	Enhancement in living standard and economic status of the farmers through nutritional security and livelihood	No. of Capacity Building Programs/ Trainings conducted/ organized Different trainings and demonstrations have been organized at 4 KVK of Shimla, Chamba, Kinnaur and Lahaul & Spiti district	• Total 20-30 BPL women were benefited from each training camp: • About 3252 farm women from the districts of Chamba, Kinnaur, Shimla and Lahaul & Spiti have been benefitted from training camps	
4.	Benefit to large scale food manufacturers in urban settings from the availability of quality semi-finished functional ingredients at a reasonable price.	No. of Stakeholders benefitted (No. of Rural Youth, No. of Women, and Total No. of Beneficiaries) with update on Income generation (Rs./ person); 3356 Nos. Female= 3252 Male= 104	• The local trained manpower could establish linkage with urban establishments for supply of semi-finished products at a reasonable price. • 06 Nos. training booklets/ pamphlets of the developed technology were published • 12 papers published in refereed journals • 02 Nos. patent filed on the technology developed	

(*) As stated in the Sanction Letter issued by the NMHS-PMU.

2.4. Strategic Steps with respect to Outcomes (in bullets)

S. No.	Particulars	Number/ Brief Details	Remarks/ Attachment
	New Methodology developed	1. Studies on extraction of dietary fibre from bamboo grown in Himachal Pradesh and its utilization for nutritional supplementation 2. Development of beverages from wild jamun (*Syzygium cumini* L.) 3. Studies on preparation and preservation of persimmon (Diospyros kaki L.) pulp and its utilization in dairy products 4. Ready-to-serve (RTS) beverages from persimmon (Diospyros kaki L.) 5. Development and storage of granular powder from wild pomegranate (Punica granatum L.) 6. Technology for the development of Soybean enriched apple pomace flour roll. 7. Pseudocereals-based carrot pomace flour enriched bakery products was investigated. 8. Dehydration of persimmon (Diospyros kaki L.) for product development 9. The technology for the development of muffins from ripe pumpkin (*Cucurbita moschata*) was developed. 10. Development of formulations for low glycemic index foods using fruits, vegetables and pseudo- cereals 11. Development of anardana from unmarketable fruits of commercial pomegranate 12. Carrot juice concentrate production and utilization 13. Extraction of isoflavone and development of functional food products from soybean (Glycine max L. Merrill)	Annexure 1-13 attached
2.	New Models/ Process/ Strategy developed	i) New Strategy for the extraction and utilization of phenolic antioxidants from wild pomegranate (*Punica granatum* L.) fruits ii) New strategy for the utilization of apple pomace for the preparation of functional rolls	Annexure 14-15 attached
3.	New Species identified	--NA--	

S. No.	Particulars	Number/ Brief Details	Remarks/ Attachment
4.	New Database established	Household based primary data collection and analysis	
5.	New Patent, if any	Two	
	I. Filed (Indian/ International)	1) No.202011038548 filed on 07/09/2020 (Nutritious oat-fortified fruit rolls with pulp and skin & its method thereof) by KD Sharma and Vinay Chandel 2) No.202111011583 filed on 18/03/2021 (Healthful rolls of apple pomace bio-waste & method thereof) by KD Sharma and Vivek Mehta	Annexure 16 attached
	II. Granted (Indian/ International)	-NA--	
	II. Technology Transfer(if any)	--NA--	
6.	Others (if any)	-NA--	

2. Technological Intervention

S. No.	Type of Intervention	Brief Narration on the interventions	Unit Details (No. of villagers benefited / Area Developed)
1.	Development and deployment of indigenous technology	In all about 15 farmers friendly technologies/ process or product have been developed for the benefit of farmers of the state. For familiarization of developed technology different trainings were organized at KVKs	Farmer's were encouraged to grow food crops of functional importance on commercial scale. About 3356 farm women were trained/ benefited
2.	Diffusion of High-end Technology in the region	• The importance of functional foods was highlighted through organization of training camps • Farmers' friendly technologies developed were popularized and farmers were encouraged to adopt these technologies for entrepreneurship • Farmers' of the respective	6 practical manuals of developed technologies (Annexure- 17 attached)

		regions were encouraged for ***VOCAL FOR LOCAL*** • 6 manuals published during previous year in Hindi (Preparation of Functional Food Products) are being distributed free of cost to the trainees during the camps	
3.	Induction of New Technology in the region	The NGOs working in the specific areas have shown keen interest in starting food processing as an enterprise in the local region	
4.	Publication of Technological / Process Manuals	1. Bhatt K, Thakur NS, Hamid, Thakur A and Sharma C. 2020. Optimization of juice and total Soluble solids concentration for the preparation of wild jamun syrup: Effect of packaging materials and temperature conditions on nutritional quality during storage. *Current Journal of Applied Science and Technology,* 39(5): 116-124. 2. Bhatt K, Thakur NS, Thakur A, Hamid and Sharma C. 2020. Standardization of recipe for the preparation of wild jamun squash: effect of packaging materials and temperature conditions on nutritional quality during storage. *International Research Journal of Pure and Applied Chemistry,* 21(12): 34-44 3. Gautam A, Dhiman AK, Attri S and Kathuria D. 2020. Nutritional and functional characteristics of ripe persimmon fruit. *Journal of Pharmacognosy and Phytochemistry,* 9(4): 3364-3367 4. Gautam A. Dhiman AK, Attri S and Kathuria D. 2020. Formulation and storage studies of herbal based RTS beverages from persimmon fruit. *Annals of Phytomedicine,* 9(2): 155-163	• 6 manuals • 12 research publications • 2 patents (Annexure- 17)

		5. Gautam A. Dhiman AK, Attri S and Kathuria D. 2020. Optimization of pulping method for extraction of pulp from ripe persimmon and its stability during storage. *Journal of Applied and Natural Science*, 12(4): 618-627 6. Sharma B and Sharma KD. 2020. Nutritional quality assessment of oilseed powder enriched biscuits. *Food and Nutrition Journal,* 5(2): 223-228 7. Sharma S and Sharma KD. 2020. Development of carrot juice concentrate enriched functional cookies. *International Journal of Current Microbiology and Applied Sciences,* 9(12): 3129-3135 8. Sharma S and Sharma KD. 2020. Nutritional characteristics of different types of carrot. *International Journal of Chemical Studies,* 8(6): 2275-2278 9. Kumar P, Thakur NS, Sharma KD, Hamid and A Thakur. 2020. Effect of type and permeability behaviour of packaging material on the quality characteristics of dried carrot roundels during storage. *Current Journal of Applied Science and Technology*, 39(7): 83-92 10. Soni P, Sharma KD, Sharma S, Mehta V and Attri S. 2020. Development of apple pomace enriched oat floor biscuits and their quality evaluation during storage. *International Journal of Current Microbiology and Applied Science*, 9(8): 2642-2652 11. Thakur NS, Aarti, Gautam S, Chandel A, Rana N, Thakur A and Hamid. 2020. Comparative assessment of Rhododendron (*Rhododendron arboreum* Sm.) flowers extract	

		beverages through biochemical analysis and its quality evaluation during storage. *Annals of Phytomedicine,* 9(2): 222-230 12. Thakur NS, Aarti, Hamid, Thakur A and Gautam S. 2020. Utilization of edible rhododendron (*Rhododendron arboreum* Sm.) flowers for development of spiced beverage (appetizer) and its shelf-life evaluation during storage. *International Research Journal of Pure and Applied Chemistry,* 21(7): 52-62 **Patents** 1. No.202011038548 filed on 07/09/2020 (Nutritious oat-fortified fruit rolls with pulp and skin & its method thereof) by KD Sharma and Vinay Chandel 13. No.202111011583 filed on 18/03/2021 (Healthful rolls of apple pomace bio-waste & method thereof) by KD Sharma and Vivek Mehta	

4. New Data Generated over the Baseline Data

S. No.	New Data Details	Status of Existing Baseline	Additionality and Utilisation New data
	Livelihood baseline survey	2018-19; The local farmers, especially farm women were not aware of the functional foods, their importance and processed foods	The baseline survey was done and on the basis of survey trainings were conducted

5. Demonstrative Skill Development and Capacity Building/ Manpower Trained

S. No.	Type of Activities	Details with number	Activity Intended for	Participants/Trained			
				SC	ST	Woman	Total
1.	Workshops	-	-	-	-		--
2.	On Field Trainings	• Conducted about 150 on field three days training programme on preparation of functional foods for the livelihood, nutritional security and entrepreneurship of the farm women of District Kinnaur, Chamba, Shimla and Lahul & Spiti of HP	• Community knowledge building and awareness • Practical process was demonstrated to the participants and the participants were encouraged to do at their own level to learn more	**1482**	**1770**	**3252**	**3356**
3.	Skill Development	-	• The basic knowledge upgrade to basic skill level • Dissemination of knowledge and skill development initiatives for income generation				
4.	Academic Supports						
	Others (if any)						

6. Linkages with Regional & National Priorities (SDGs, INDC, etc)/ Collaborations

S. No.	Linkages /collaborations	Details	No. of Publications/ Events Held	Beneficiaries
1.	Sustainable Development Goal (SDG)	• Reduction on postharvest losses of fruits and vegetables, thereby enhancing the farmer's income • Growing of local fruit bearing fruits and vegetables as a source of functional foods		Farmers, entrepreneurs, young youth of the areas and NMHS stakeholders
2.	Climate Change/INDC targets	• In this era of climate change, postharvest management id of great concerns		NMHS stakeholders
3.	International Commitments	-	-	-
4.	Bilateral engagements	-	-	-
5.	National Policies	• National Food Processing Policy, PMFME, Pradhan Mantri Kisan Sampada Yojana (PMKSY), · Mega Food Parks and Swachha Bharat Mission	-	-
6.	Others collaborations	• Besides, KVKs, collaborations were made with collaborations with local administration and NGOs and line departments (Horticulture, Forestry, Rural Development, Animal husbandry etc) of the respective districts during the project.	-	-

7. Project Stakeholders/ Beneficiaries and Impacts

S. No.	Stakeholders	Support Activities	Impacts
1.	Gram Panchayats	• Gram panchayat representatives extended their support in arranging the farmers, especially farm women for their participation in training programmes. They also helped in making arrangements for the successful organization of camps	• Awareness and knowledge Building • This will improve the livelihood, nutritional security of the women farmers of Kinnaur and will also motivate them to start entrepreneurship for upliftment of the economic status of the agricultural women of Himachal Pradesh. This will also help them to process locally available fruits and vegetables and reduce the high post-harvest losses.
2.	Govt Departments (Agriculture/ Forest)	• The state departments of Horticulture and Forestry and line departments extended their support in nominating the progressive farmers and entrepreneurs for the training camps	• The NGOs, were got identified who were interested to start the their enterprise in Food Processing
3.	Villagers	• Cooperated in organization of camps and visits	Support activities; Linkage between university/ KVKs were established
4.	SC Community	• Cooperated in organization of camps	Strengthening local livelihoods and income generation
5.	ST Community	• Cooperated in organization of camps	Strengthening local livelihoods and income generation
6.	Women Group	• The farm women were highly satisfied and happy with the training camps	• Most of the farm women requested for such more trainings and skill development practical training at main campus
7.	Others (if any)	Line Departments	• Development of strategies that are implementable at the local level • Highlights the concerns and barriers faced by locals in processing and marketing

9. Financial Summary (Cumulative)

S. No.	Financial Position/ Budget Head	Funds Sanctioned (Rs.)	Expenditure	% of Total cost
I	Salaries/ Manpower cost	5899680.00	4476819	76.0
II	Travel	800000.00	476133	60.0
III	Expendables & consumables	250000.00	249111	99.6
IV	Contingencies	250000.00	249526	99.8
V	Activities & other project cost	3300000.00	3085735	93.5
VI	Institutional Charges	500000.00	500000	100
VII	Equipments	3886000.00	3885792	99.9
	Total	14885680.00	12923116	86.8
	Interest accrued	144913		
	Grand Total (Refund)	2107477		

* Please attach the consolidated and audited Utilization Certificate (UC) and Year wise Statement of Expenditure (SE) separately, *ref*. **Annexure I.**

9. Major Equipment/ Peripherals Procured under the Project** (if any)

S. No.	Name of Equipments	Cost (INR)	Utilisation of the Equipment after project
1	Weighing Balance Biogen BGS-LB (small) (5 No.)	29,000	100%
2	Spectrophotometer (1 No.)	2,27,510	100%
3	Prestige Wet Grinder (5 No.)	47,500	100%
4	Double distillation unit All-Glass 2.5 L with Vacuum pump (1 No.)	2,48,500	100%
5	Vacuum Packaging Machine (1 No.)	98,495	100%
6	Fruit Grating Machine (4 No.)	1,26,000	100%
7	Pulper (4 No.)	1,32,160	100%
8	Hydraulic juice press (4 No.)	4,34,560	100%
9	Hand Refractrometer (5 No.)	36,960	100%
10	Mechanical Dehydrator (4 No.)	2,59,840	100%
11	HPLC Tray drive assembly (01 No.)	1,25,462	100%
12	Ultrapure water purification system (01 No.)	4,20,000	100%
13	Baking Oven (5 No.)	2,74,350	100%
14	Crown corking machine (4 No.)	48,380	100%
15	Vortex Mixer (1 No.)	12,000	100%
16	Stainless Steel Table 8X4X4	1,88,800	100%

Details should be provided in details **(*ref* **Annexure III &IV).**

10. Quantification of Overall Project Progress

S. No.	Parameters	Total (Numeric)	Remarks/ Attachments/ Soft copies of documents
1.	IHR States Covered	3	
2.	Project Site/ Field Stations Developed	*5*	The districts of Chamba, Shimla, Kinnaur, Lahaul and Spiti of Himachal Pradesh besides, the Department of Food Science and Technology at Nauni, Solan, Himachal Pradesh
3.	New Methods/ Modeling Developed	15	*Annexure 1 to 15- attached*
4.	No. of Trainings arranged	140	*Annexure 18-20 attached*
5.	No of beneficiaries attended trainings	3356	
6.	Scientific Manpower Developed (Phd/M.Sc./JRF/SRF/ RA):	10 M.Sc and Ph.D	
7.	SC stakeholders benefited		
8.	ST stakeholders benefited		
9.	Women Empowered	*3252*	
10.	No of Workshops Arranged along with level of participation	-	*The importance of functional foods was highlighted during the talk delivered by PI in 2 webinars/ trainings (One conducted by the department of FST at Solan and 2nd conducted by Navsari Agriculture University, Gujarat)*
11.	On field Demonstration Models initiated	*04*	*KVK Headquarter at Chamba, Rohru, Sharbo and Tabo*
12.	Livelihood Options promoted		*Value addition of local produce*
13.	Technical/ Training Manuals prepared	*6*	
14.	Processing Units established	*5*	
15.	No of Species Collected	-	
16.	New Species identified	-	
17.	New Database generated (Types):	-	
	Others (if any)	-	

11. Knowledge Products and Publications:

Sr. No.	Publication/ Knowledge Products	*Number*		*Total Impact Factor*	*Remarks/* Enclosures
		National	International		
1.	Journal Research Articles/ Special Issue:		12	-	List attached
2.	Book Chapter(s)/ Books:		-		
3.	Technical Reports/ Patents publishes	02			List attached
4.	Training Manual (Skill Development/ Capacity Building)				
5.	Papers presented in Conferences/Seminars	02			
6.	Policy Drafts/Papers				
7.	Others:				

* Please append the list of KPs/ publications (with impact factor and further details) with due Acknowledgement to NMHS.

12. Recommendation on Utility of Project Findings, Replicability and Exit Strategy

Particulars	Recommendations
Utility of the Project Findings	The farming community in the state is not much aware of the processing and value addition techniques. Therefore, technical guidance and skill development on functional food development from agri-horti produce into processed products will lead to create awareness among them, which can play a significant role in providing ample opportunities for business as self-help groups, improving their nutritional status and solving the unemployment problem to some extent. Besides, the proposed study is expected to provide a new avenue in the field of food processing industry. The nutritious functional foods having properties to combat deadly life-style diseases can be made available to the masses in the form of variety of processed products which will ultimately lead in improving the dietary standards. The farm women would be encouraged towards the better protection of wild fruits and the fruit plants growing in the barren land which will preserve the biodiversity. Moreover, developing various products of Indian palatability from various sources of natural antioxidants will ultimately prove remunerative to the growers and new product range to the industry.
Replicability of Project	In the beginning the most backward area in the 4 selected districts were selected for the dissemination of technology. The project got great impact in the selected districts and the success could be replicated in other districts with the funding from the state government besides, transmitting the developed technology to the line departments of the state government for incorporation into their developmental programmes.
Exit Strategy	It is expected that the developed technologies could be taken up by the interested entrepreneurs however, the emphasis would be to train the farm women to take up and implement the technology to develop nutritious products for self consumption besides, earning money through commercially selling the new products to the consumers in open market. Better returns of the quality products can give a way to the self-sustainability not only to farm women of the area but a society as a whole. Also unemployed girls could be encouraged to adopt this technology as a profession which in long run could look for specialized markets for these products for export purpose. We are hopeful that our results will be of use to them for better livelihood options.

(**PROJECT PROPONENT/ COORDINATOR**)

(Signed and Stamped)

(**HEAD OF THE INSTITUTION**)

(Signed and Stamped)

Place: ……..
Date: …../……/……

PART B: PROJECT DETAILED REPORT

1 EXECUTIVE SUMMARY

Increased interest in functional foods has arisen from numerous epidemiological studies which suggest that certain phytochemicals can prevent diseases. Functional foods are the foods or the food components that provide health benefits beyond basic nutrition. Hippocrates proclaimed over 2500 years ago, *"Let food be the medicine and medicine be the food"*. Functional food may improve health in general, reduce impact of illness, delay onset of disease, treat disease in progress or even cure disease e.g. calcium fortified juices for maintaining bone health, omega-3 fat substituted food products for protecting against certain forms of cancer and cardiovascular diseases. Even broccoli, blueberry, cranberry, soybean, green tea, oatmeal and flax seeds might be considered as functional foods as they contain dietary components that may reduce the risk of certain chronic diseases. Functional foods availability in Indian markets is virtually negligible whereas the demand for such foods has considerably increased among the affluent section of the society. The department of Food Science & Technology has a mandate to develop and transfer food processing technologies to the food industry, self-help groups and farmers besides, imparting institutional trainings to the extension agencies and education to under-graduate and post-graduate students. The main emphasis of the project is on creation of an infrastructure for research and training on functional foods processing to the farmers/ self-help groups for inculcating entrepreneurship particularly in the women of the remote locations of Himachal Pradesh (one processing unit each in Kinnaur, Chamba, Solan and Shimla district) of Himachal Pradesh. Excellent quality of agri-horti produce are extensively grown in tribal and other remote locations of the state however, due to the lack of local markets and transportation difficulties, huge quantity of the production either goes waste or small quantities preserved by drying in open sun by the growers are unhygienic, discoloured and poor in taste. Besides, marketable surplus and culled fruits not suitable for drying due to low sugar and high acid content and get spoiled and hence, growers do not get good returns for their produce.

Therefore, it is very important to equip the youth/ self-help groups/ growers with the technical know-how to convert their agri-horti produce into processed products either into complete functional food product or semi-finished product and further encourage them to sell their products to large scale factories in urban locations manufacturing food products. The successful implementation of this project will lead to establishment of more factories in private/ co-operative sector in remote locations in Himachal Pradesh and the adjoining areas of the state of J&K and Uttarakhand in due course of time, which ultimately will raise the income of the farmers, generate employment for the rural youth and prevent the post-harvest spoilage which is 15-40% depending upon the type of agri-horti-commodity.

2 INTRODUCTION

2.1 Background of the Project (max. 500 words)

The department of Food Science & Technology of Dr YS Parmar University of Horticulture & Forestry, Solan has a mandate to develop and transfer processing technologies to the food industry, self-help groups and farmers besides, imparting institutional trainings to the extension agencies and education to under-graduate and post-graduate students. The main emphasis of the project would be on creation of an infrastructure for research and training on functional foods processing to the farmers/ self-help groups for inculcating entrepreneurship particularly in the women of the remote locations of Himachal Pradesh. Excellent quality of agri-horti produce is extensively grown in tribal and other remote locations of the state however, due to the lack of local markets and

transportation difficulties, huge quantity of the production either goes waste or small quantities preserved by drying in open sun by the growers are unhygienic, discoloured and poor in taste. Besides, marketable surplus and culled fruits not suitable for drying due to low sugar and high acid content get spoiled and hence, growers do not get good returns for their produce. Increased interest infunctional foods have arisen from numerous epidemiological studies which suggest that certain phytochemical can prevent diseases. Functional foods are the foods or the food components that provide health benefits beyond basic nutrition. Hippocrates proclaimed over 2500 years ago, *"Let food be the medicine and medicine be the food"*. Functional food may improve health in general, reduce impact of illness, delay onset of disease, treat disease in progress or even cure disease e.g. calcium fortified juices for maintaining bone health, omega-3 fat substituted food products for protecting against certain forms of cancer and cardiovascular diseases. Even broccoli, blueberry, cranberry, soybean, green tea, oatmeal and flax seeds might be considered as functional foods as they contain dietary components that may reduce the risk of certain chronic diseases. Functional foods availability in Indian markets is virtually negligible whereas the demand for such foods has considerably increased among the affluent section of the society.

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2.2 Overview of the Major Issues to be Addressed:

The small land holdings in the state do not fulfill the basic needs of the farmers and therefore, alternate sources for generation of income are required to be explored to raise their socio-economic status. In hilly regions, the women are the backbone of farming however, they are not much aware about the processing and value addition of agri-horti produce for nutritional security and livelihood. Skill development on converting their produce to shelf-stable functional food products can play a significant role in providing ample opportunities for business as self-help groups, improving their nutritional status and solving the unemployment problem. The technological feasibility of the envisaged project adoption by the women as future entrepreneurs is assumed to be very high since the domestic and global demand for functional food products is increasing due to change in the life-style of the people. The nutritious functional food products could be made available to the masses in the form of variety of processed products. Further, the farm women would be encouraged towards the cultivation of indigenous agri-horti crops having high natural antioxidants which ultimately will prove remunerative to them. No systematic approach has been envisaged on this aspect by the scientific community hence, the scientific investigations are required to develop, document and disseminate the appropriate functional foods technology to the farm women of Himachal Pradesh.

2.3 Baseline Data and Project Scope (max. 1000 words):

Himachal is one of those states in India which was rapidly transformed from the most backward part of the country to one of the most advanced states. At present, Himachal ranks fourth in respect of per capita income among the states of the Indian Union. Agriculture contributes nearly about 45% to the net state domestic product. It is the main source of

income as well as employment in Himachal. About 93% of the state population depends directly upon agriculture. Although, Himachal is comparatively a better-off state, yet about 25 per cent of its population lives below the poverty line and the livelihood dependence on forest goods and services is high amongst poor people in many areas. The farmers of Himachal Pradesh are not aware of the importance of functional foods. Baseline survey was conducted to know the present status of production and use of food processing and preservation practices in fruit, vegetable and minor forest produce by the farmers. Processing and value addition of agri-horti produce into functional food products will improve the living standard and economic status of the farmers. There would be ample opportunities for employment generation for farm women and encouragement of the rural youth for setting-up processing unit at home and cottage scale. Diverting of agri-horti produce at remote locations of the state for value addition would automatically regulate the marketing of fresh produce for table purpose thus better price for the farmers by preventing glut in the markets.

2.4 Project Objectives and Target Deliverables (as per the NMHS Sanction Order)

1. Model functional foods processing center with reasonable investment for prospective entrepreneurship and skill development.
2. Training and demonstration center(s) for future vocational students from schools, industrial training institutes, NGO's, youth clubs, unemployed youths and self-help groups interested in manufacturing of functional foods.
3. Enhancement in living standard and economic status of the farmers through nutritional security and livelihood.
4. Benefit to large scale food manufacturers in urban settings from the availability of quality semi-finished functional ingredients at a reasonable price.

3 METHODOLOGIES, STARTEGY AND APPROACH

3.1 Methodologies used for the study

Methodology: Team of Scientists (PI and Co-PI) in the department of Food Science & Technology at Solan will work out the detailed date wise/ month wise trainings/ activities schedule in consultation with the SRFs and the Incharges of the 4 KVKs. Procurement of all machineries/ equipment will be done immediately after the implementation of the project. The research work on the development of functional foods has already been started by the postgraduate students which will further be strengthened in a big way. Most R&D work will be concentrated to the department of the Food Science & Technology, Solan. However, the dissemination of technology will be carried out in the remote districts of hills and tribal belt of Himachal Pradesh and the adjoining states of J&K and Uttarakhand bordering these districts. The SRFs under the guidance of PI and Co-PIs located at four districts KVKs will also be involved initially at headquarter of the university in R&D work and later they will have modification in the standard products at their centres in view of the local needs. The developed technology will be disseminated through the organization of training camps in the batches of 20 women and the women interested in entrepreneurship will be provided with detailed project report, protocols and technical guidance for implementing the project. Achieving the given targets by generation of new information on the development of functional foods and organizing trainings for the dissemination of the developed technology to the farm women and youth in the selected districts.

I. **Key beneficiaries**: Farm women, unemployed youth, secondary and tertiary students, researchers, entrepreneurs, health workers and food industry.

II. **Expected results**: The farming community in the state is not much aware of the processing and value addition techniques. Therefore, technical guidance and skill development on functional food development from agri-horti produce into processed products will lead to create awareness among them, which can play a significant role in providing ample opportunities for business as self-help groups, improving their nutritional status and solving the unemployment problem to some extent. Besides, the proposed study is expected to provide a new avenue in the field of food processing industry. The nutritious functional foods having properties to combat deadly life-style diseases can be made available to the masses in the form of variety of processed products which will ultimately lead in improving the dietary standards. The farm women would be encouraged towards the better protection of wild fruits and the fruit plants growing in the barren land which will preserve the biodiversity. Moreover, developing various products of Indian palatability from various sources of natural antioxidants will ultimately prove remunerative to the growers and new product range to the industry.

III. Expected outcome of the project

- Development of low cost, simple and easily adoptable technology resulting in the remunerative price to the farm women.
- Value addition for inferior quality and unmarketable surplus agri-horti produce.
- Improvement in living standard and economic status of the farmers.
- Employment generation for rural youth by encouraging them for setting-up processing units at home and cottage scale.
- Prevention of glut and spoilage in the markets thus better price for the farmers'
- Better care of wild fruits growing in barren lands and forests which ultimately will result in protection of environment.
- Availability of nutritive and good quality food products to the consumers at reasonable price.

3.2 Preparatory Actions and Agencies Involved

The Officer Incharges of the line departments of the state government in a project implementation district for example the department of Agriculture, Horticulture, Forest, Rural Development, Education, industry etc would be contacted by visiting them personally. Meetings in KVKs would be convened to acquaint them with the goals and objectives of the proposed project and the benefit to the farmers would be explained. The main agencies involved for implementation of the project are as under:

1. Krishi Vigyan Kendra, Chamba, District Chamba, Himachal Pradesh:
2. Krishi Vigyan Kendra, Tabo, District Lahaul&Spiti, Himachal Pradesh:
3. Krishi Vigyan Kendra, RekongPeo, District Kinnaur, Himachal Pradesh:
4. Krishi Vigyan Kendra, Rohru, District Shimla, Himachal Pradesh:

3.3 Details of Scientific data collected and Equipments Used

The following research activities (sub-projects) were carried out during the 2nd year of the project implementation (2019-2020)

a) Studies on extraction of dietary fibre from bamboo grown in Himachal Pradesh and its utilization for nutritional supplementation
b) Development of beverages from wild jamun (Syzygium cumini L.)
c) Studies on preparation and preservation of persimmon (Diospyros kaki L.) pulp and its utilization in dairy products
d) Ready-to-serve beverages from persimmon (Diospyros kaki L.)

e) Development and storage of granular powder from wild pomegranate (Punica granatum L.)
f) Extraction and utilization of phenolic antioxidants from wild pomegranate (Punica granatum L.) fruits
g) Utilization of apple pomace for the preparation of functional rolls

The following research activities (sub-projects) were carried out during the year 2020-2021

i. Soybean enriched apple pomace flour roll
ii. Pseudocereals-based carrot pomace flour enriched bakery products
iii. Dehydration of persimmon (*Diospyros kaki* L.) for product development
iv. Development of muffins from ripe pumpkin (*Cucurbita moschata*)
v. Development of anardana from unmarketable fruits of commercial pomegranate
vi. Carrot juice concentrate production and utilization
vii. Extraction of isoflavone and development of functional food products from soybean (*Glycine max* L. Merrill)

Whereas, the following research activities (sub-projects) were carried out during the year 2021-2022

i) Extraction and utilization of phenolic antioxidants from wild aonla
ii) Low cost complementary food formulations to combat malnutrition in infants & children
iii) Low glycemic index functional food products
iv) Processing of Spiti apple into juice and utilization of pomace in pseudocereals cake

3.4 Primary Data Collected

The research experiments were conducted in the university mostly on plant foods. The data pertaining to nutritional profiling, medicinal value, safety and sensory quality was recorded following standard methods. The products were also evaluated during storages for their self life studies. The research was documented and communicated to the farm women by the way of organizing trainings and distribution of developed technology in the form of literature.

3.5 Details of Field Survey arranged:

The baseline survey pertaining to livelihood and their acquaintance/ knowledge for functional foods, their preparation techniques etc. was conducted in the project area of District Shimla, Chamba, Kinnaur and Lahul& Spiti with the help of the KVKs and on the basis of survey trainings were conducted as per actual need and availability of resources

3.6 Strategic Planning for each Activities

The project was executed with a strategic planning for a period of three years as detailed below:

1st year

- Recruitment of staff
- Procurement of chemicals, equipments/instruments, renovation of labs
- Procurement of raw material
- Physico-chemical analysis of the raw material and ingredients to be used for the development of functional foods

- Standardization of techniques for the manufacture of functional foods from fruits, vegetables, flowers, spices, medicinal and aromatic plants, cereals, pulses and oilseeds commonly available in Himachal Pradesh
    a. Identification of bioactive principles in each raw material to be used for functional food development
    b. Pre-treatments time and type
    c. Dipping of pre-treated materials in preservatives/additives for colour, flavour, vitaminsand minerals retention
    d. Process identification and optimization
    e. Development of functional food by different combinations
    f. Sensory evaluation

- Shelf-life studies of different types of functional food products developed above in various packages and storage temperatures (ambient and refrigerated).

2nd year

- Standardization of process for the manufacture of more functional products to be continued as above
- Sensory, nutritional and storage studies
- Standardization of recipes for value added functional products from the waste for example pomace of fruits and vegetables:
- Shelf-life studies of different types of value added functional products in various packages and storage temperatures.
- Organization of 30 trainings of 3days duration at each selected Krishi Vigyan Kendra of the state to the women for transfer and adoption of developed technology for self-employment.

3rd year

- Storage studies continued.
- Organization of 30 trainings of 3 days duration at KVKs and off-KVKs.
- Exploring possibility of linkage with the mid day meal program implemented by the government (At least one product will be recommended for implementation).
- Recommendation/documentation of developed technologies.
- Publication and dissemination of literature (bulletin/pamphlet or monograph).
- Compilation and submission final report and grant utilization certificate

3.7 Activity wise Time frame followed [using Gantt/ PERT Chart (max. 1000 words)]

S. No.	Activity	1st year (Quarter)				2nd year (Quarter)				3rd year (Quarter)			
		1	2	3	4	1	2	3	4	1	2	3	4
1.	Recruitment of staff.												
2.	Procurement of chemicals, equipments/instruments, raw material, renovation of labs etc.												
3.	Selection of bioactive rich agriculture and horticulture raw materials, their analysis and development of functional food products and shelf-life studies. First year work report submission.												
4.	Development of functional food products will continue along with the packing and storage studies of the already developed functional foods.												
5.	Storage studies continued and analysis of data and report submission for 2nd year work.												
6.	Recommendation/documentation of developed technologies and working out feasibility of adoption of at least one functional food product into mid day meal scheme of the State government.												
7.	Publication of literature (bulletin/pamphlet/articles etc).												
8.	Dissemination of developed functional foods technologies to farm women by organizing training camps at HQ and different locations of the project districts. Submission of final report.												

4 KEY FINDINGS AND RESULTS

4.1 Major Research Findings:

Followings were the major research findings:

i) Extraction of dietary fibre from bamboo grown in Himachal Pradesh and its utilization for nutritional supplementation
ii) Development of beverages from wild jamun (*Syzygium cumini*L.)
iii) Studies on preparation and preservation of persimmon (*Diospyros kaki* L.) pulp and its utilization in dairy products
iv) Ready-to-serve (RTS) beverages from persimmon (*Diospyros kaki* L.)
v) Development and storage of granular powder from wild pomegranate (*Punica granatum* L.)
vi) Extraction and utilization of phenolic antioxidants from wild pomegranate (*Punica granatum* L.) fruits
vii) Utilization of apple pomace for the preparation of functional rolls
viii) Soybean enriched apple pomace flour roll
ix) Pseudocereals-based carrot pomace flour enriched bakery products
x) Dehydration of persimmon (*Diospyros kaki* L.) for product development
xi) Development of muffins from ripe pumpkin (*Cucurbita moschata)*
xii) Development of *anardana* from unmarketable fruits of commercial pomegranate
xiii) Carrot juice concentrate production and utilization
xiv) Extraction of isoflavone and development of functional food products from soybean (*Glycine max* L. Merrill)

4.2 Key Results covering all research activities

1. The maximum yield of total dietary fibre and functional properties was received from the enzyme incubation temperature and time combination of 100°C for 30 min in α-amylase, 45°C for60 min in protease and 40°C for 4 h in cellulase. The pasta supplemented with bamboo shoot powder and bamboo dietary fibre at a level of 92:8 and 92:8, respectively can be stored well upto 90 days in PET jars under ambient condition. The yoghurt can be enriched with bamboo shoot powder and bamboo dietary fibre at a level of 100:1.0 and 100:1.5, respectively and stored safely upto 10 days under refrigerated condition. Paneer can also beenriched with bamboo shoot powder and bamboo dietary fibre at a level of 100:2.5 and100:2.5, respectively and stored safely upto 10 days under refrigerated condition.
2. Fruit juice can be extracted successfully by using Pectinase enzyme (0.08% for 90 min) and further utilized for the preparation of value-added products like drink by using 16 per cent juice, 12°B TSS and 0.30 per cent titratable acidity, squash by using 35 per cent juice, 40° B TSS and 1.20 per cent titratable acidity, appetizer by using 35 per cent juice, 45°B TSS and 1.20 per cent titratable acidity along with spice extract and syrup by using 30 per cent juice, 65°B TSS and 1.50 per cent titratable acidity.
3. Among different treatments, persimmon pulp of treatment (pulp+KMS @ 2000ppm in glass jars) was found to retain the maximum *β*-carotene, ascorbic acid, total phenols and antioxidant activity during six months of storage period. The combination of *khoa* and persimmon pulp of treatment T_7 (70:30) for *burfi* preparation exhibited maximum scores for sensory attributes. Whereas, among different combinations of RTS beverage prepared using pulp of cold pulping method T1 (10°B TSS + 15% pulp+ 0.4% acidity), T2 (12°B TSS + 15% pulp+ 0.3% acidity) and T3 (15°B TSS + 15% pulp+ 0.3% acidity) were selected on the basis of higher sensory scores. Further, Osmo-dried persimmon slices can be developed by soaking in 50 °B hypertonic

solution + 4 h dipping time at 45 °C prior to drying. The concentration of 20 per cent ginger extract and 15 per cent mint extract was found to be the best for production of ginger flavoured and mint flavoured osmo-dried persimmon, respectively.

4. The pre-treated arils of wild pomegranate can be dried in mechanical cabinet drier (60±2°C) and ground to powder form (710 µm particle size). Highest amoun tof phenolic antioxidants were recorded in the flavedo part of the wild pomegranate fruit, which was further converted into powder form of 425 microns particle size with the help of pulverizer and microencapsulated with maltodextrin in the ratio of 1:2.
5. Functional fruit rolls prepared from the apple pomace slurry containing 10-15 per cent water/ juice, 25ºB total soluble solids and 0.65 per cent titratable acidity were adjudged the best. Storage studies revealed that soybean enriched apple pomace flour rolls could retain their nutritional quality up to 6 months of storage. Similarly, there was minimal change in sensory parameters during the storage period rendering the product to be tasty and palatable during the entire storage period.
6. Carrot juice was utilized for preparation of concentrates which were used in bakery products. The cookies and muffin prepared with 15 per cent orange carrot juice concentrate were adjudged the best on the basis of sensory characteristics. Similarly, cereal bar with 20 per cent carrot juice concentrate was optimized as the best.
7. The enrichment of biscuit and cake with 22 to 34 per cent carrot pomace flour substantially improved their nutritional and sensory qualities. Further, the partial replacement of pseudocereal flour with carrot pomace flour positively support the improvement of functional and quality attributes of the bakery products and serves as another alternative for the utilization of bio-waste (pomace) generated by the carrot juice-processing industry.
8. Pumpkin muffins can be developed by using pulp at a level of 70 per cent in each case using whole wheat, rice and barley flour and up to 80 per cent with semolina.
9. The encapsulation of isoflavone extract with 6 per cent maltodextrin possessed better encapsulation efficiency (77.59 %) and total isoflavones (7.14 mg/g). The encapsulated isoflavone extract can be stored safely for a period of six months in transparent as well as ambered glass vials under refrigerated and ambient conditions reflecting higher retention of quality under refrigerated condition when packed in ambered glass vials. Tofu (soya *paneer*) prepared from 1.50 per cent calcium chloride as coagulant obtained higher rating for sensory quality and contained sufficient amount of nutritional and functional components.

4.3 Conclusion of the study/ Experiments conducted

- Bamboo shoot is an excellent source of protein and dietary fibre having good property of water holding capacity, oil holding capacity, swelling capacity, bulk densityand storage stability and therefore, can be successfully utilized for production of protein aswell as dietary fibre rich functional food products.
- Wild jamun is one of the important minor fruitscontaining higher amounts of antioxidants and having excellent other quality characteristicscan be used for the development of various beverages.
- The astringent Hachiya persimmon *(Diospyros kaki* L.*)* can be converted into pulp and stored safely for a period of 6 months (by using chemical preservatives and heat treatment) with minimal chemical and sensory changes. Further, the pulp thus produced and preserved can be utilized to enhance the nutritional value of dairy products such as *burfi* and ice cream and beverages. The dried products like chips, osmo-dried, ginger and mint flavoured osmo-dried can be prepared which can be stored safely when packed in appropriate packaging material.
- The granular powder can be packed in aluminium laminated pouch with oxygen and moisture scavenger successfully and can be stored under ambient and refrigerated storage conditions

- The microencapsulated phenolic extract powder further can be utilized for enrichment of food products like yoghurt and mango drink. Both the products could be enriched with 2 per cent micro-encapsulated phenolic extract powder successfully.
- Apple pomace, a bio-waste of apple juice processing industry, has a comparable nutritional profile as that of fresh apple fruit. The waste by-product which otherwise has negligible value can successfully be utilized in its fresh as well as preserved form for the development of value-added products.
- Carrot pomace contains adequate amount of fibre and bioactive compounds such as carotenoids and polyphenolics and therefore, after drying the carrot pomace, flour could be used for the enrichment of biscuits, cakes and other bakery products.
- The ripe pumpkin which otherwise is processed to a limited extent, can be successfully and conveniently utilized for the development of functional and good quality muffins at a remunerative cost.
- *Harit* soya which otherwise has not been exploited for processing can successfully be utilized for extraction of isoflavones, production of value-added products such as milk, tofu, etc. as well as extracted isoflavone can be incorporated in these products to enhance their functional properties.

5 OVERALL ACHIEVEMENTS

5.1 Achievement on Project Objectives [Defining contribution of deliverables in overall Mission

- The baseline survey regarding the status of functional foods for nutrition and livelihood has been done and analysed during initial phase of the project. According to the base line survey, different location specific as well as need based R&D work was conducted. About 15 technologies/ process/ products were developed under the project. The list of significant R&D achievements is as under:

  - Technology for the extraction of dietary fibre from bamboo and its utilization for nutritional supplementation
  - Development of beverages from wild jamun (Syzygium cumini L.)
  - Preparation and preservation of persimmon (Diospyros kaki L.) pulp and its utilization in dairy products
  - Ready-to-serve beverages from persimmon (Diospyros kaki L.)
  - Development and storage of granular powder from wild pomegranate (Punica granatum L.)
  - Extraction and utilization of phenolic antioxidants from wild pomegranate (Punica granatum L.) fruits
  - Utilization of apple pomace for the preparation of functional rolls
  - Soybean enriched apple pomace flour roll
  - Pseudocereals-based carrot pomace flour enriched bakery products
  - Dehydration of persimmon (Diospyros kaki L.) for product development
  - Development of muffins from ripe pumpkin (Cucurbita moschata)
  - Development of anardana from unmarketable fruits of commercial pomegranate
  - Carrot juice concentrate production and utilization
  - Extraction of isoflavone and development of functional food products from soybean (Glycine max L. Merri

- As far as the transfer of technologies through training and demonstration is concernd, about 150 trainings and 02 exposure visit of farmers were conducted in which about 3250 were benefited including about 3100 farm women.
- 04 demonstration centre at KVK Tabo, KVK Rohru, KVK Sarbo and KVK Chamba were established for the benefit of local farmers

❖ 02 Nos. patent were filed on the technology developed, 12 papers published and 06 Nos. training booklets/ pamphlets of the developed technology were published during the project period.

5.2 Establishing New Database/Appending new data over the Baseline Data

- Processing and value addition of agri-horti produce into functional food products will improve the living standard and economic status of the farmers. There would be ample opportunities for employment generation for farm women and encouragement of the rural youth for setting-up processing unit at home and cottage scale.
- Diverting of agri-horti produce at remote locations of the state for value addition would automatically regulate the marketing of fresh produce for table purpose thus better price for the farmers by preventing glut in the markets.

5.3 Generating Model Predictions for different variables (if any)

➢ The farming community in the state is not much aware of the processing and value addition techniques. Therefore, technical guidance and skill development on functional food development from agri-horti produce into processed products will lead to create awareness among them, which can play a significant role in providing ample opportunities for business as self-help groups, improving their nutritional status and solving the unemployment problem to some extent.

➢ Besides, the proposed study is expected to provide a new avenue in the field of food processing industry. The nutritious functional foods having properties to combat deadly life-style diseases can be made available to the masses in the form of variety of processed products which will ultimately lead in improving the dietary standards.

➢ The farm women would be encouraged towards the better protection of wild fruits and the fruit plants growing in the barren land which will preserve the biodiversity. Moreover, developing various products of Indian palatability from various sources of natural antioxidants will ultimately prove remunerative to the growers and new product range to the industry.

5.4 Technological Intervention

- Development of low cost, simple and easily adoptable technology resulting in the remunerative price to the farmers.
- Value addition for inferior quality and unmarketable surplus agri-horti produce.
- Improvement in living standard and economic status of the farmers.
- Employment generation for rural youth by encouraging them for setting-up processing units at home and cottage scale.
- Prevention of glut and spoilage in the markets thus better price for the farmers' produce.
- Better care of wild fruits growing in barren lands and forests which ultimately will result in protection of environment.
- Availability of nutritive and good quality food products to the consumers at reasonable price.

5.5 On field Demonstration and Value-addition of Products

➢ Under the project, about 150 on field demonstration/ Trainings on processing and value addition were organized at 4 KVK's of Himachal Pradesh. Most of the trainings were of three days duration and in each training 20-30 farmers were benefited. The processed products like apple jam, apple murraba, tomato ketchup, mixed pickle, cauliflower preserve and sauerkraut, pear jam, dry fruit chutney, Barley (Sattu) cake

and laddoo etc. were prepared from locally grown fruits vegetables and cereals. All the trainees showed keen interest during the preparation of products and also helped along. The trainees were provided with pamphlets/booklets containing procedure of various functional foods. The trainees were also familiarized about the health benefits and procedure of preparation of various functional foods from locally grown fruits and vegetables. Besides, 04 exposure visits were also conducted to expose the farmers to different processing units. The detail of training and demonstration is given Annexures attached

5.6 Promoting Entrepreneurship in IHR

- The technologies developed shall be disseminated through various training programmes sponsored by the State/ Centre Govt. and through media (Radio, TV and newspapers) for wider publicity to attract the entrepreneurs in IHR to adopt the technologies.
- Efforts would be made for transfer of technologies (ToTs) by signing memorandum of understanding (MoU) with interested entrepreneurs in IHR
- Organization of specific Skill Development Trainings on processing and value addition under Skill Development Training Programmes of the State Govt. and PMFME scheme of the Centre Govt.

5.7 Addressing Cross-cutting Issues

- The team involved in the project is well experienced and have already implemented externally funded projects besides, there is well established system in the university regarding addressing the issues, so no such issues identified.

6 PROJECT'S IMPACTS IN IHR

6.1 Socio-Economic Development

- The state of Himachal Pradesh is situated in north-western Himalaya and the livelihood of more than 80% of the people is dependent on agriculture and horticulture. The state has attained the self-sufficiency in the staple food however, the population living in the tribal and remote locations of Himachal Pradesh do not have access for the nutritional food throughout the year which can take care of their health.
- Moreover, the government of India is making efforts to double the farm income by 2022 and also provide nutritional security to school going kids through mid-day meal scheme. Consequently, implementation of the proposed project will go a long way to cherish the efforts of the government for improving the socio-economic status of the people. However, these schemes of the government will be successful, if the farmers are educated about the importance of the food in relation to their health.
- Therefore, value addition of local produce will result in better care of fruit plants growing in the barren land and forests resulting in preserving the biodiversity of Himalayas besides, generating additional income to the farming community.

6.2 Scientific Management of Natural Resources In IHR

- In Indian Himalayan Regions (IHR), the women are the backbone of farming however, they are not much aware about the processing and value addition of agri-horti produce for nutritional security and livelihood. Skill development on converting their produce to shelf-stable functional food products can play a significant role in

providing ample opportunities for business as self-help groups, improving their nutritional status and solving the unemployment problem.

- The technological feasibility of the envisaged project adoption by the women as future entrepreneurs is assumed to be very high since the domestic and global demand for functional food products is increasing due to change in the life-style of the people.
- The nutritious functional food products based on fruits, vegetables, flowers, spices, medicinal and aromatic plant, cereals, pulses and oilseeds could be made available to the masses in the form of variety of processed products.
- Further, the farm women would be encouraged towards the cultivation of indigenous agri-horti crops having high natural antioxidants which ultimately will prove remunerative to them. In the past, no systematic approach has been envisaged on this aspect by the scientific community hence, the scientific investigations were required to develop, document and disseminate the appropriate functional foods technology to the farm women of Himachal Pradesh which were addressed in the present project.

6.3 Conservation of Biodiversity in IHR

- The value addition of local produce will result in better care of fruit plants growing in the barren land and forests resulting in preserving the biodiversity of Himalayas besides, generating additional income to the farming community.

6.4 Protection of Environment

- The project does not foresee any ecological and environmental degradation as it deals with products and technologies derived from vegetables, fruits and minor forest produce. In the activities of the project, no adverse effect on environmental and social safeguards is anticipated.

6.5 Strengthening Networking in IHR

- The university has a strong network with different SAUs, ICAR, line departments of the state and other states of IHR. During implementation of the project, linkage with other departments like rural development, local governing body etc. was also established.

7 EXIT STRATEGY AND SUSTAINABILITY

7.1 How effectively the project findings could be utilized for the sustainable development of IHR

- The project had a great impact in the selected districts and the success could be replicated in other districts with the funding from the state government besides, transmitting the developed technology to the line departments of the state government for incorporation into their developmental programmes. Further, the extension agencies of state, centre government as well as SAUs should include Postharvest management, processing and value addition as one of the components of all training programmes. In every KVK, there is position of Scientist (Home Science), who should start nutritional programmes to educate the local farmers about functional food and their health benefits. The value addition of local produce will result in better care of fruit plants growing in the barren land and forests resulting in preserving the biodiversity of IHR besides, generating additional income to the farming community. The nutritious functional foods having properties to combat deadly life-style

diseases will be made available to the masses in the form of variety of processed products which will ultimately lead in improving the dietary standards.

7.2 Identify other important areas not covered under this study needs further attention

- Provision for cool chain management, on-farm handling of crops is one of the important components to check the post harvest losses of perishables. So, cool chain management and on-farm processing centres should be established with permanent staff on the analogy of Incubation Centre or All India Coordinated Research Projects (AICRP)
- Establishment of two Regional Centres on functional food [One Regional Centre in Dr YS Parmar University at Solan with broader mandate of dissemination of the functional food technology to the North-Western Himalayan states comprising HP, UK and UTs of J&K and Leh-Ladakh and 2nd Regional Centre in North-Eastern Himalayan states] headed by a Director level position with long term projects of 15-20 years duration to make consistent efforts for the enhancement of nutritional and economic status of the farmers of Himalayan region states.
- Linkage between food manufacturers in urban settings and rural people in remote locations should be promoted.

7.3 Major recommendations for sustaining the outcome of the projects in future:

- The successful implementation of the project has lead to development of a variety of processed functional food products and gives a way for the establishment of more factories in private/co-operative/self-help group sector in remote locations of Himachal Pradesh and the adjoining areas of the state of J&K and Uttarakhand. This will improve the dietary standards, raise the income of the farmers, generate employment for the rural youth, inculcate entrepreneurship particularly in the women of the remote locations and prevent the post-harvest spoilage of 15-40% depending upon the type of agro-commodity.
- Encouragement of farmers to grow/cultivate food crops of functional importance on commercial scale. The R& D work on need based and area specific crops would be carried out in future with the help of state funds.
- Sustainable development of Himalayan people through adoption of home scale and cottage scale processing and value addition techniques by rural youth. Demonstration centres at local level should be established. Moreover, the government of India is making efforts to double the farm income and also provide nutritional security to school going kids through mid-day meal scheme. However, such schemes of the government will be successful, if the farmers are educated about the importance of the food in relation to their health. Consequently, the project will go a long way to cherish the efforts of the government for improving the socio-economic status of the people.
- Establishment of Regional Centres on functional food with broader mandate of dissemination of the functional food technology to the North-Western Himalayan states and North-Eastern Himalayan states headed by a Director level position with long term projects of 15-20 years duration to make consistent efforts for the enhancement of nutritional and economic status of the farmers of Himalayan region states.

8 ACKNOWLEDGEMENT

The Principal investigator and team gratefully acknowledge the the financial support given by National Mission on Himalayan Studies (NMHS), Ministry of Environment, Forest, and Climate Change (MoEF&CC) , Govt of India, New Delhi and GB Pant National Institute

of Himalyan Environment and Sustainable Development (GBPNIHESD), Koshi-Katarmal, Almora Uttarakhand . The help and support extended by the line departments is also acknowledged. We also acknowledge the support provided by the university authority in successful execution of the project.

APPENDICES

Appendix 1 to 13: – Details of Technology Developed/ New Products

Appendix 14 to 15: – Details of new strategy/ process developed

Appendix 16 – List of Patents filled/ published

Appendix 17 – List of publications and manuals published with copies attached

Appendix 18- Detail of trainings conducted under the project

Details of technologies developed/ New Products

Annexure - 1

Sub-Project: Studies on extraction of dietary fibre from bamboo grown in Himachal Pradesh and its utilization for nutritional supplementation

Study was conducted to extract dietary fibre from bamboo shoots and to utilize it in cereal and dairy products. The shoots of four species *viz*., *Dendrocalamus strictus*, *Dendrocalamus hamiltonii*, *Phyllostachys reticulate* and *Bambusa nutans* harvested at 30, 40, 50 and 60 cm height were used and analyzed for different quality attributes. *D. hamiltonii* at 60 cm length recorded the maximum crude fibre (2.15%) and hence was utilized for extraction of dietary fibre by enzymatic-gravimetric method. Among 27 treatments, the highest total dietary fibre yield (70.25%) was obtained from (enzymes incubation temperature and time combination of 100°C for 30 min in α-amylase, 45°C for 60 min in protease and 40°C for 4 h in cellulase). The bamboo shoot powder contained higher value for crude protein (10.49%), cellulose (89.07%) and hemicellulose (30.85%) while extracted dietary fibre contained higher amount of total dietary fibre (70.25), insoluble dietary fibre (63.41%), soluble dietary fibre (6.84%) and lignin (99.80%). Water holding capacity (15.39 mL/g), oil holding capacity (7.93 mL/g), swelling capacity (27.23 mL/g) and bulk density (0.652 g/cm^3) were significantly higher in extracted dietary fibre. The extracted dietary fibre packed in HDPE jars retained better quality at ambient condition during storage as compared to rest of the packaging materials. The bamboo shoot powder and extracted dietary fibre were incorporated in cereal and dairy products for enrichment. Dietary fibre can be supplemented at a level of 8 per cent while bamboo shoot powder at 6 per cent in cookies which can be stored upto 3 months in PET jars and LDPE pouches. However, the quality was better in PET jars. Out of 6 treatments of pasta, a level of 8 per cent for both bamboo shoot powder and dietary fibre gave the better product which can be stored for three months with minimal quality changes. The bamboo shoot powder and dietary fibre incorporated in yoghurt was found to be the best at a level of 1.0 and 1.5 per cent, respectively. For incorporation in paneer, a level of 2.5 per cent gave the product of better quality. The yoghurt and paneer packed in polystyrene cups and LDPE pouches, respectively can be stored upto ten days under refrigerated condition. The study revealed that incorporation of bamboo shoot powder and bamboo dietary fibre can enhance the nutritional (protein and fibre) quality. Incorporation of extracted dietary fibre can enhance the protein as well as dietary fibre in different products. However, the dietary fibre was higher in extracted dietary fibre incorporated products and protein in bamboo shoot powder incorporated products. Henceforth, it is concluded that bamboo shoot can be successfully converted into powder and dietary fibre can be extracted from the powder. These can be safely be utilized for the development of functional food products like cookies, pasta, yoghurt and paneer.

Details of experiments conducted:

Table-1 Detail of bamboo shoots of different species

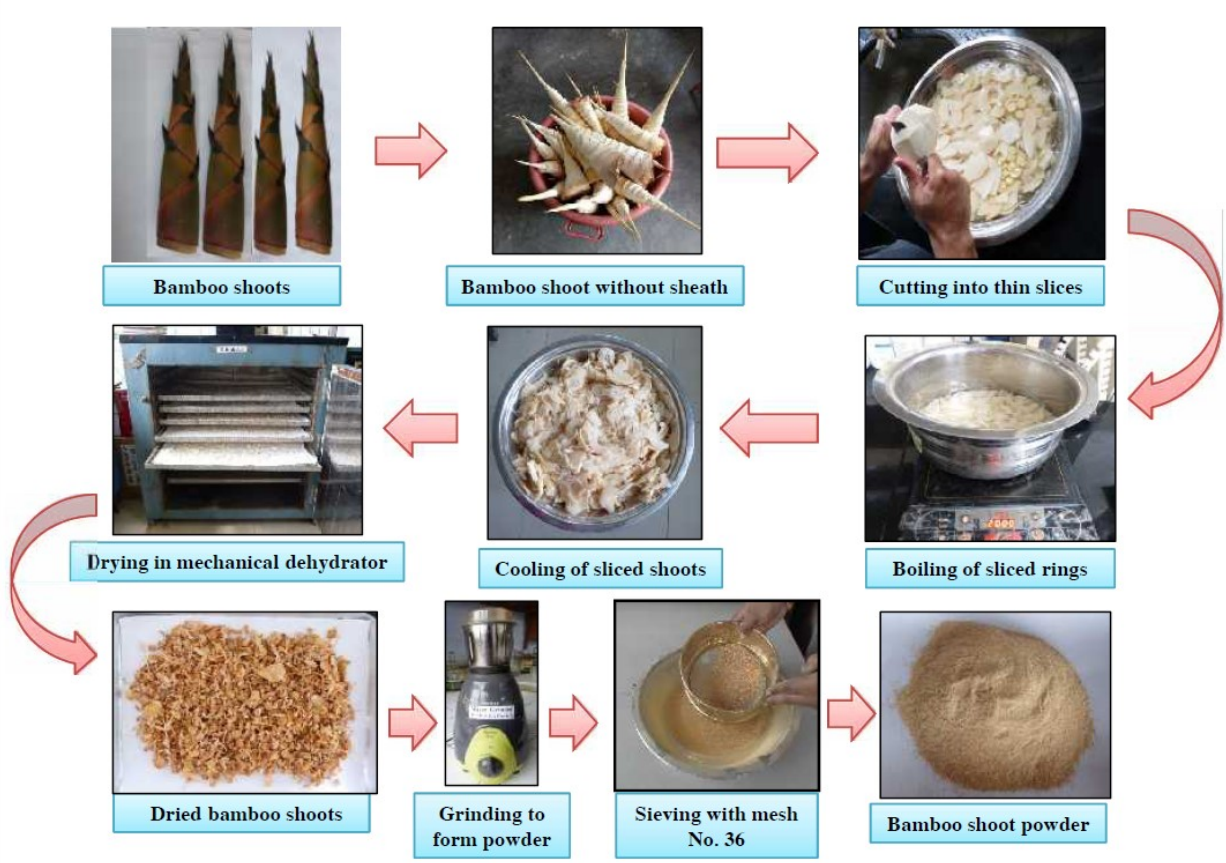
Species	Stage of harvesting of bamboo shoot (cm)
Dendrocalamusstrictus	30, 40, 50 and 60
Dendrocalamushamiltonii	30, 40, 50 and 60
Phyllostachys reticulata	30, 40, 50 and 60
Bambusa nutans	30, 40, 50 and 60

Bamboo shoots (with and without sheath) harvested at different heights

Objective2: Standardization of technique for preparation of bamboo shoot powder

The bamboo shoot containing highest crude fibre was taken for preparation of powder. The shoot with sheath was washed to remove any adhering dirt, dust or any other foreign material. The sheath was removed for extraction of tender shoot. The bamboo shoots were cut into thin slices. The fresh shoots contain hydrogencyanide (HCN), a toxic substance which needs to be removed prior to use for edible purposes. The bamboo shoot slices were soaked in water for 24 h. These slices were then boiled for 90 min. The water was drained and the slices wereallowed to cool down at room temperature. The bamboo shoot slices were dried in a mechanical dehydrator at 60±2°C for 5 h i.e. until it reached equilibrium moisture content. The slices were converted into powder with the help of a grinder. The powder was passed through a sieve of 36 mesh size and stored in polyethylene pouches with proper sealing until further use.

Unit operations for preparation of bamboo shoot powder

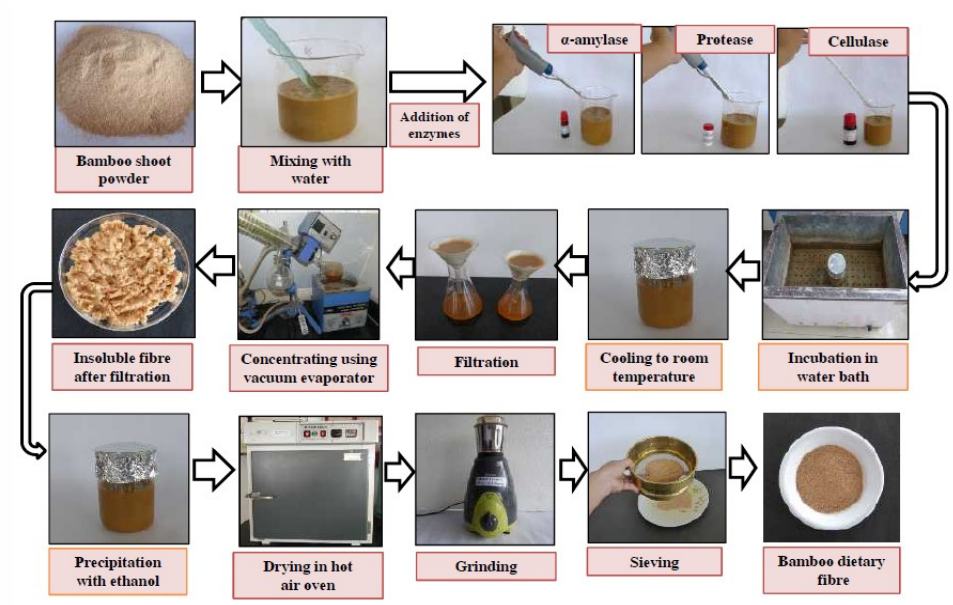


Preparation of bamboo shoot powder

Objective 3: Optimization of technique for isolation of dietary fibre from bamboo shoots

Bamboo shoot with highest crude fibre content was used for preparation of powder. The powder was prepared and utilized for isolation of dietary fibre. The dietary fibre was isolated by using enzymatic - gravimetric method. The extraction was carried out by using the enzymes *viz*. heat stable α - amylase, protease and cellulase (Table-2). The bamboo shoot powder was mixed with distilled water (a solid liquid ratio of 1:3) in a beaker and mixed well with a glass stirring rod. A 200 µL heat stable α - amylase (Activity ≥4000 U/gds) per gram sample was added into the beaker and incubated in a water bath. The pH of the mixture was then adjusted to 6.8 with 1 mol/L NaOH. A 2 mL neutral protease (Activity≥2000 U/gds) per gram sample was added into the beaker and incubated in a water bath. Subsequently, the pH was adjusted to 6.0 with 1 mol/L HCl. 1800 µL cellulose (Activity≥1800 U/gds) per gram sample was added into the beaker followed by incubation in a water bath. Then, the treated sample was filtered through a Whatman No. 1 filter paper and the filtrate was concentrated to one-third of its initial volume using a rotary evaporator at 50°C under vacuum. The concentrated sample was added into a quadruple volume of 95 per cent alcohol and kept undisturbed for 30 min. After removing the alcohol, the residue was collected and oven-dried at 60°C for 5 min order to obtain dietary fibre. The extracted dietary fibre was ground into fine powder using a grinder and sieved with stainless steel sieve (No. 36). The best time and temperature combination based on the performance of high dietary fibre yield and functional properties was selected. The ground dietary fibre powder was then stored in LDPE pouches for further use. The dietary fibre was extracted by using different time-temperature combination.

The best combination was selected on the basis of high yield and better functional properties. The dietary fibre thus produced was packed in LDPE pouches, Aluminum laminated pouches, PET jars and HDPE jars and kept for storage of 6 months.



Standardization of technique for isolation of dietary fibre from bamboo shoots

Objective 4: Utilization of bamboo shoot powder and bamboo dietary fibre in food products

The bamboo shoot powder and bamboo dietary fibre were incorporated in different cereal products such as cookies, pasta, and milk products such as yoghurt and paneer in order to enhance their functional properties. The standardization of ingredients, method of preparation and optimization of incorporation levels in these products are discussed here under:

4.1 Cookies

a) Standardization of recipe for cookie preparation

The ingredients such as refined wheat flour, vegetable ghee, powdered sugar, skim milk powder, salt and sodium bicarbonate were used to prepare the cookies. In all, five recipes (Table-2) were tried and the variations were done in the amount of vegetable ghee, powdered sugar and salt, while the amount of water was kept constant. The powdered sugar was mixed with vegetable ghee and the mixture was beaten until light and fluffy. The sieved refined wheat flour and sodium bicarbonate along with salt and skimmed milk powder were added to the fluffy mass and mixed thoroughly to form soft dough. The mixture was kneaded properly for about 10 minutes and wrapped in an aluminum foil. The dough was allowed to stand at room temperature for about 30 minutes and after that it was converted into small balls. The balls were flattened into sheet of about 0.6 cm thickness. The flattened sheet was cut into circular shapes with the help of cookie cutter having diameter of 4.0 cm. The cut shapes were placed on a baking tray lined with butter paper and baked in an oven at 200°C for 20 min. The time-temperature combination for baking was decided on the basis of preliminary experiments and overall baking quality of cookies. The recipe was taken as base recipe for incorporation of bamboo powder and extracted dietary fibre in subsequent experiments.

Table-2 Recipe for cookie preparation

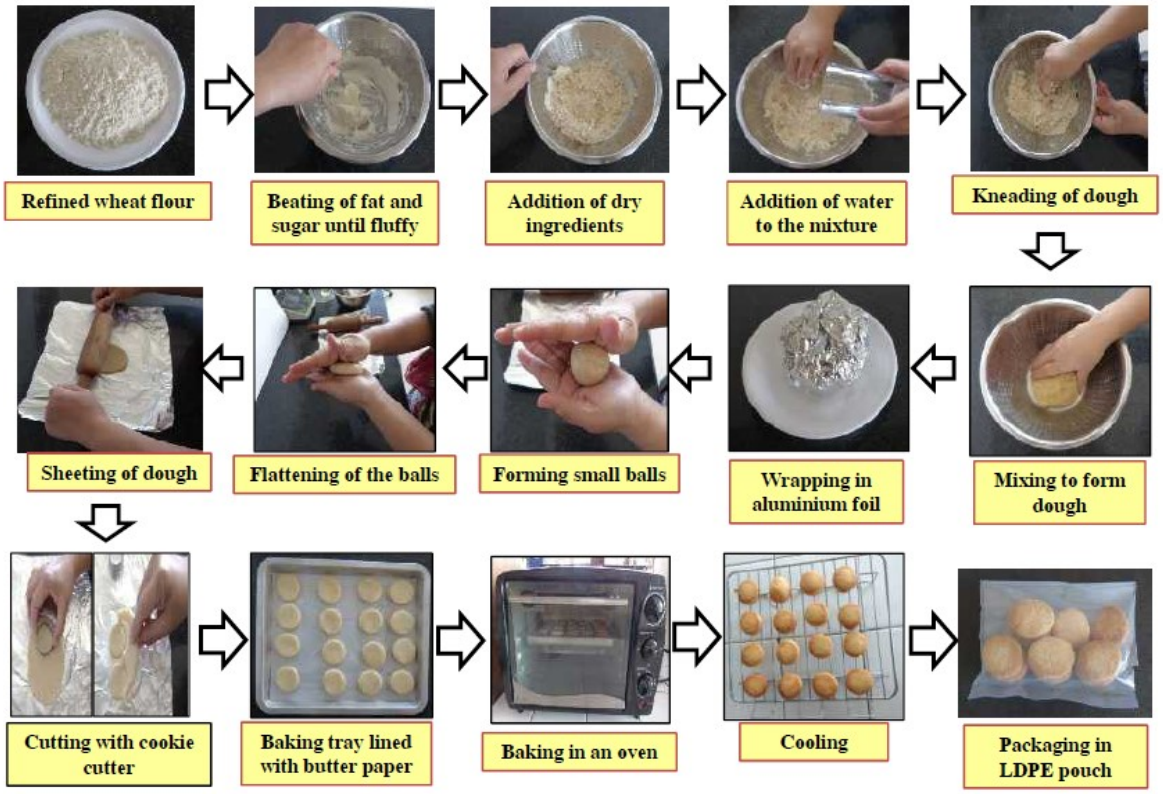
Ingredients	Recipe I	Recipe II	Recipe III	Recipe IV	Recipe V
Refined wheat flour (g)	100	100	100	100	100
Vegetable ghee (g)	40	40	40	45	50
Sugar powder (g)	35	35	35	45	50
Skim milk powder (g)	10	10	10	10	10
Salt (g)	0.75	0.8	0.85	0.9	1.0
Sodium bicarbonate (g)	1	1	1	1	1
Water (mL)	25	25	25	25	25

b) Optimization of level of bamboo shoot powder supplementation in cookies

The refined wheat flour in base recipe was replaced with bamboo shoot powder (Table-3) for preparation of bamboo shoot powder supplemented cookies. The cookies were prepared and subjected to sensory evaluation by a panel of ten judges. The best treatment was selected on the basis of highest sensory scores for further studies.

Table-3 Optimization of level of bamboo shoot powder supplementation in cookies

Treatment	Refined wheat flour : Bamboo shoot powder
T1	100:0
T2	98:2
T3	96:4
T4	94:6
T5	92:8
T6	90:10



Unit operations for preparation of cookies

c) Optimization of level of bamboo dietary fibre supplementation in cookies

The recipe standardized earlier was used as base recipe for supplementation of bamboo dietary fibre in cookies. The wheat flour was replaced with bamboo dietary fibre at different levels 0, 2, 4, 6, 8 and 10 % (Table-4). The cookies incorporated with six different levels of extracted dietary fibre were prepared and subjected to sensory evaluation by a panel of ten judges. The combination which got the highest sensory scores was selected for further studies.

Table 4: Optimization of level of bamboo dietary fibre supplementation in cookies

Treatment	Refined wheat flour : Bamboo dietary fibre
T_1	100:0
T_2	98:2
T_3	96:4
T_4	94:6
T_5	92:8
T_6	90:10

d) Detail of treatments of cookie selected for storage studies

The cookies of different selected treatments were prepared and packed in LDPE pouches and PET jars for quality evaluation at storage intervals of 0, 45 and 90 days. The detail of treatments of cookie selected for storage studies is presented in Table-5.

Table 5: Detail of treatments of cookie selected for storage studies

Treatment	Description
T_1	Cookies (100 % refined wheat flour)
T_2	Cookies supplemented with shoot bamboo powder
T_3	Cookies supplemented with bamboo dietary fibre

4.2 Pasta

a) Standardization of recipe and method for pasta preparation

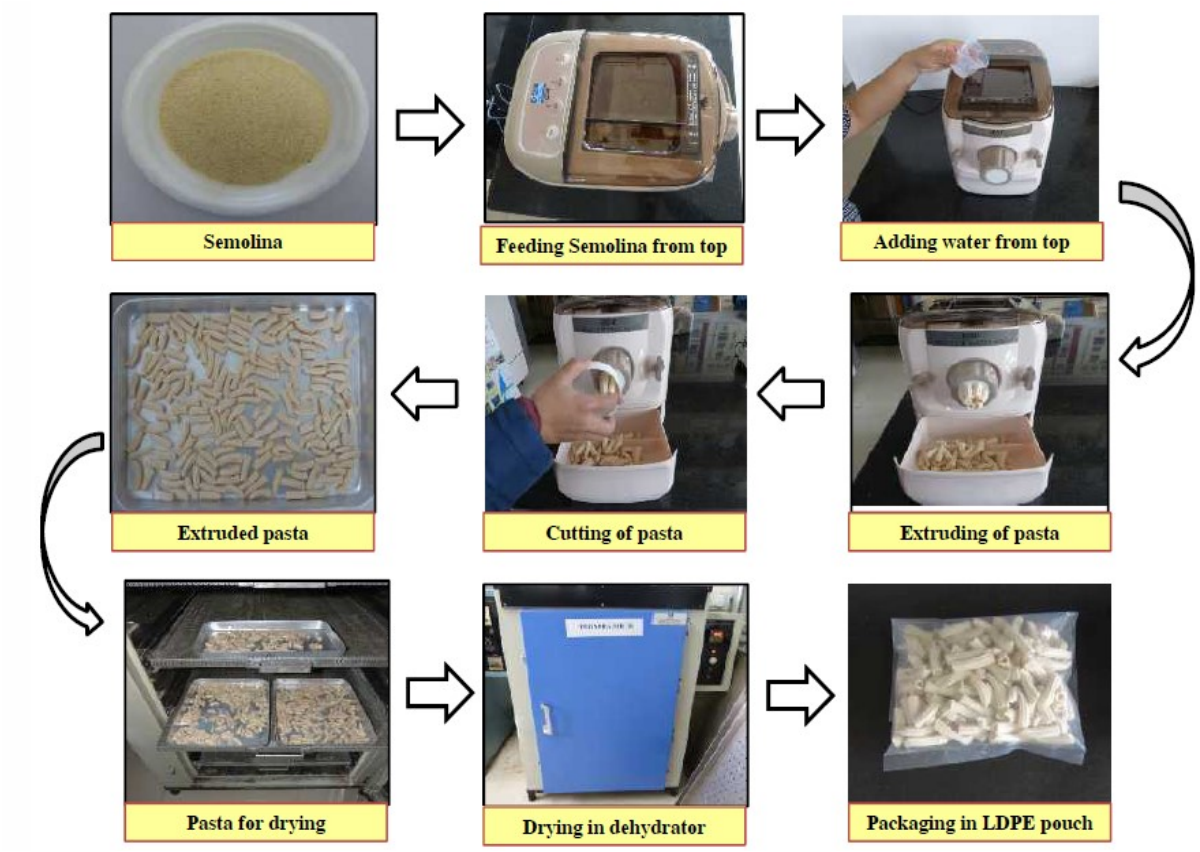
The pasta was prepared by using semolina and water. The preliminary studies were conducted by taking the constant amount of semolina with varied quantity of water for preparation of pasta (Table-6). The best three combinations were selected on the basis of extrusion quality texture of pasta. The detail of pasta preparation method is given below;

Table-6 Optimization of semolina: water combination for pasta preparation

Formulation	Semolina (g)	Water (mL)
F_1	200(g)	85(mL)
F_2	200 (g)	90(mL)
F_3	200 (g)	95(mL)

The weighed quantity of semolina was sieved and fed into the mixing chamber of Kent Noodle and Pasta Maker from the top. The lid of the appliance was closed and plugged in. The ‘Auto’ (automatic mode) key was pressed to start the appliance. The water was added in the right proportion after turning on the appliance. The mixing time was

standardized (6-8 min) to ensure proper mixing. The pastas were extruded through a die to obtain pipe rigate shape and manually cut into 2 cm length. The extruded pasta of various formulations was dried in a mechanical dehydrator at 60±2°C for about 5 h or till its weight became constant. For sensory evaluation, the pasta was cooked in salted water (2%) in the ratio of 1:5 for 15 min. After cooking, the water was immediately drained and the hot pasta was served to a panel of ten judges.



Unit operations for preparation of pasta

b) Optimization of level of bamboo shoot powder for supplementation in pasta

The recipe standardized earlier was used to prepare pasta supplemented with bamboo shoot powder. The semolina was replaced with bamboo shoot powder (Table-7). The pasta of different treatments was cooked and subjected to sensory evaluation by a panel of ten judges. The combination which got the highest sensory scores was selected for further studies.

Table-7 Optimization of level of bamboo shoot powder for supplementation in pasta

Treatment	Semolina : Bamboo shoot powder
T_1	100:0
T_2	98:2
T_3	96:4
T_4	94:6
T_5	92:8
T_6	90:10

c) Optimization of level of bamboo dietary fibre for supplementation in pasta

The basic recipe selected earlier was followed for preparation of pasta supplemented with bamboo dietary fibre. The semolina was replaced with bamboo dietary fibre at different levels (Table-8). The pasta of different combinations was cooked and served to a panel of 10 judges for sensory evaluation. The best combination which got the highest sensory scores was selected for further studies.

Table-8 Optimization of level of bamboo dietary fibre supplementation in pasta

Treatment	Semolina : Bamboo dietary fibre
T_1	100:0
T_2	98:2
T_3	96:4
T_4	94:6
T_5	92:8
T_6	90:10

d) Detail of treatments of pasta selected for storage studies

The best treatments were selected for storage studies. The pastas of different treatments were prepared and packed in LDPE pouches and PET jars. The products were evaluated for various quality parameters at storage intervals of 0, 45 and 90 days. The detail of treatments of cookie selected for storage studies is presented in Table-9.

Table-9 Detail of treatments of pasta selected for storage studies

Treatment	Description
T_1	Pasta (100 % semolina)
T_2	Pasta supplemented with bamboo shoot powder
T_3	Pasta supplemented with bamboo dietary fibre

4.3 Yoghurt

a) Standardization of recipe for yoghurt preparation

The standardized Amul tetra pack cow's milk (Fat-4.5% and SNF-8.5%) was boiled and allowed to cool to room temperature. The milk was poured into polystyrene cups (1000 mL capacity) uniformly. Then the combined culture of *Lactobacillus delbrueckii* subsp. *bulgaricus* and *Streptococcus thermophilus* @ 1 per cent was added to the milk (Table-10) with continuous stirring to ensure proper mixing of the combined culture with milk. The cups were covered with aluminum foil for incubation. The cups were incubated for 4 to 6 h at 43°C. The yoghurt prepared was refrigerated (5°C). These yoghurts inoculated with different levels of combined culture were subjected to sensory evaluation by a panel of ten judges. The best formulation was selected on the basis of highest sensory scores and was referred for further studies.

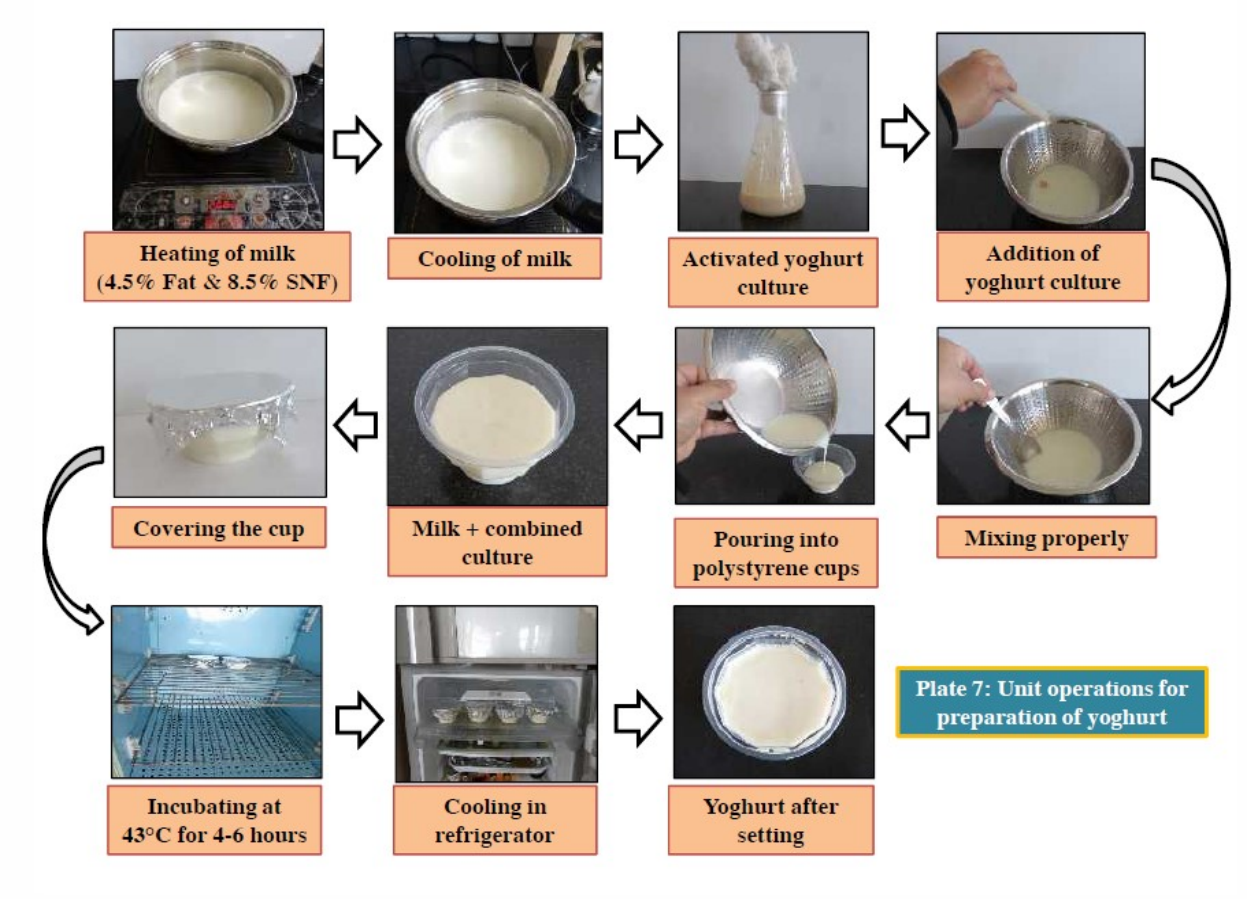


Plate 7: Unit operations for preparation of yoghurt

Table-10 Optimization of level of combined culture for yoghurt preparation

Formulation	Milk (mL)	Combined culture (mL)
F_1	1000(mL)	1.0(mL)
F_2	1000 (mL)	1.5(mL)
F_3	1000 (mL)	2.0(mL)

b) Optimization of level of bamboo shoot powder enrichment in yoghurt

The procedure followed for preparation of yoghurt enriched with bamboo shoot powder was similar as described earlier. The bamboo shoot powder enriched yoghurt of different treatments (Table-11) was subjected to sensory evaluation by a panel of ten judges. The best treatment was selected on the basis of highest sensory scores.

Table-11 Optimization of level of bamboo shoot powder enrichment in yoghurt

Treatment	Bamboo shoot powder (%)
T_1	0
T_2	0.5
T_3	1.0
T_4	1.5
T_5	2.0
T_6	2.5

c) Optimization of level of bamboo dietary fibre enrichment in yoghurt

The best combination of milk and combined culture selected earlier was used for preparation of yoghurt enriched with extracted bamboo dietary fibre. The milk was heated then allowed to cool at room temperature. The bamboo dietary fibre was added at different levels (Table-12) followed by addition of combined culture and mixing thoroughly for proper homogenization with milk. The milk was poured uniformly into polystyrene cups which were covered with aluminum foil. The best treatment was selected on the basis of sensory evaluation and referred for further studies.

Table-12 Optimization of level of bamboo dietary fibre enrichment in yoghurt

Treatment	Bamboo dietary fibre (%)
T_1	0
T_2	0.5
T_3	1.0
T_4	1.5
T_5	2.0
T_6	2.5

d) Detail of treatments of yoghurt selected for storage studies

The yoghurt of different treatments selected earlier was prepared and kept for storage at refrigerated condition (5°C). The products (Table-13) were evaluated for various quality parameters at 0, 5 and 10 days of storage intervals.

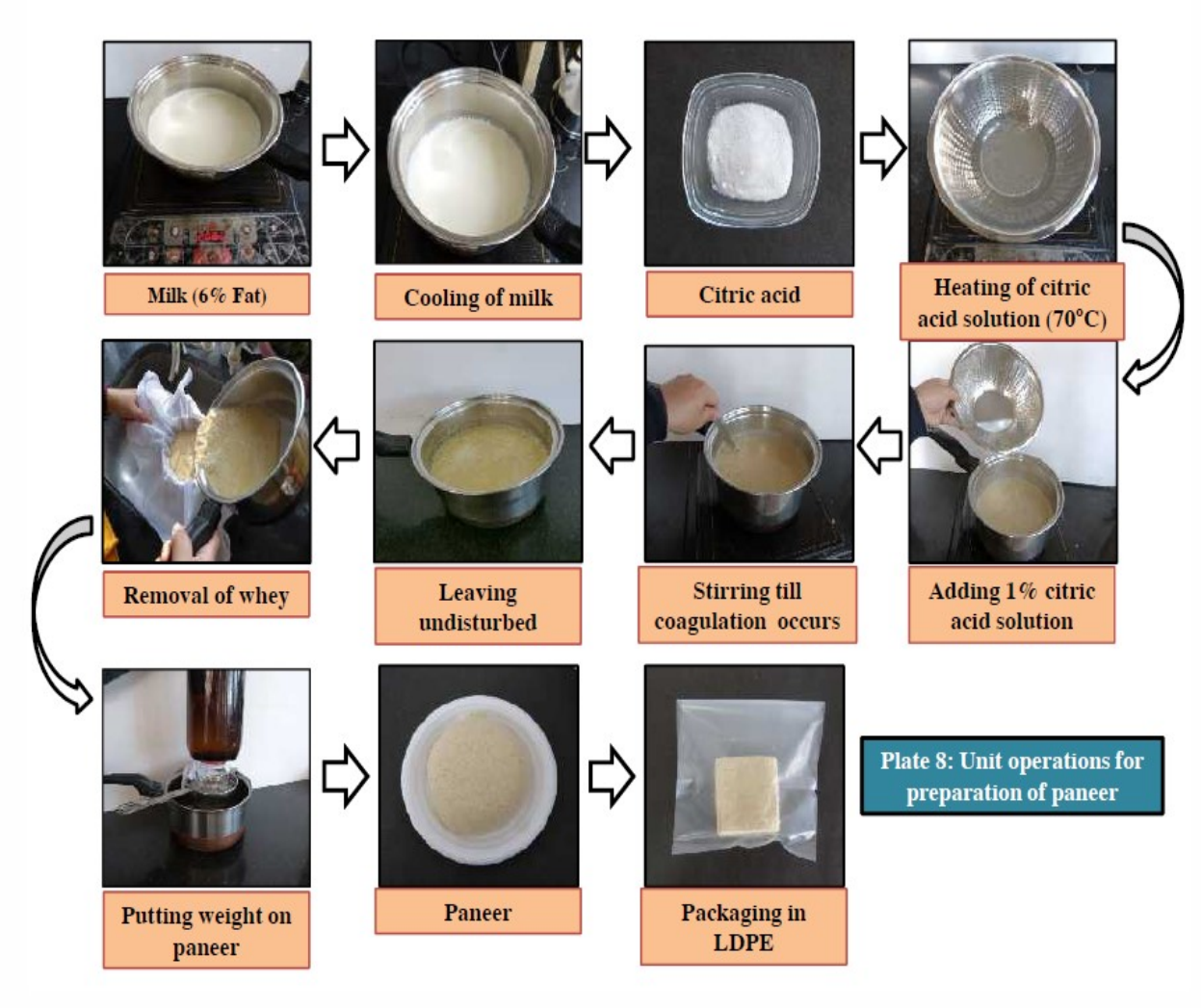
Table-13 Detail of treatments of yoghurt selected for storage studies

Treatment	Description
T_1	Yoghurt (without enrichment)
T_2	Yoghurt enriched with bamboo shoot powder
T_3	Yoghurt enriched with bamboo dietary fibre

4.4 Paneer

a) Standardization of recipe for preparation of paneer

The paneer was prepared by using cow's milk and citric acid. The whole milk (Verka packet milk - 6 % fat) 1000 ml was heated to 82°C for 5 minutes and then allowed to cool to 70°C. At the same time, citric acid solution of different proportions (Table-14) was heated to 70°C and added to the milk with continuous stirring till coagulation and clear transparent greenish yellow whey separated.



After coagulation, the contents were left undisturbed for 5 min and filtered in order to remove the whey. The coagulum was transferred to hoops and pressure was applied for about 15 min. The best milk and citric acid combination were selected on the basis of highest sensory scores.

Table-14 Optimization of level of citric acid solution for paneer preparation

Combination	Whole milk (mL)	Citric acid (%)
C_1	1000	1.0
C_2	1000	1.5
C_3	1000	2.0

b) Optimization of level of bamboo shoot powder enrichment in paneer

The similar procedure was followed as has been explained earlier for preparation of paneer enriched with bamboo shoot powder at different levels (Table-15).The paneer of different treatments was subjected to sensory evaluation by a panel of ten judges. On the basis of highest sensory scores, the best treatment was selected and referred for further studies.

Table-15 Optimization of level of bamboo shoot powder enrichment in paneer

Treatment	Bamboo shoot powder (%)
T_1	0
T_2	0.5
T_3	1.0
T_4	1.5
T_5	2.0
T_6	2.5

c) Optimization of level of bamboo dietary fibre enrichment in paneer

For preparation of paneer enriched with bamboo dietary fibre, the best proportion of milk and citric acid solution selected earlier was used. The rehydrated bamboo dietary fibre (1g sample in 10 mL water) at different levels as depicted in Table-16 were added before milk heat treatment and mixed thoroughly followed by lowering the milk temperature. The citric acid solution was mixed to the milk and bamboo dietary fibre mixture and left undisturbed. The best treatment which got the highest sensory scores was selected and referred for further studies.

Table-16 Optimization of level of bamboo dietary fibre enrichment in paneer

Treatment	Bamboo dietary fibre (%)
T_1	0
T_2	0.5
T_3	1.0
T_4	1.5
T_5	2.0
T_6	2.5

d) Detail of treatments of paneer selected for storage studies

The paneer of different treatments selected earlier were prepared and packed in LDPE pouches. The product (Table-17) was stored at refrigerated condition (5°C) and evaluated for various quality parameters at storage intervals of 0, 5 and10 days.

Table-17 Detail of treatments of paneer selected for storage studies

Treatment	Description
T_1	Paneer (without enrichment)
T_2	Paneer enriched with bamboo shoot powder
T_3	Paneer enriched with bamboo dietary fibre

Conclusion and Recommendation

1. The harvesting stage, edible portion and crude fibre content of bamboo shoots, enzymes incubation temperature and time combinations had a major impact on yield and functional properties of dietary fibre.
2. The maximum yield of total dietary fibre and functional properties was received from the enzyme incubation temperature and time combination of 100°C for 30 min in α-amylase, 45°C for 60 min in protease and 40°C for 4 h in cellulase.
3. The extracted dietary fibre packed in HDPE jars retained good quality characteristics at ambient condition during storage as compared to other packaging material. The cookies can be supplemented with bamboo shoot powder and bamboo dietary fibre

at a level of 94:6 and 92:8, respectively and stored safely upto 90 days in PET jars under ambient condition.

4. The pasta supplemented with bamboo shoot powder and bamboo dietary fibre at a level of 92:8 and 92:8, respectively can be stored well upto 90 days in PET jars under ambient condition. The yoghurt can be enriched with bamboo shoot powder and bamboo dietary fibre at a level of 100:1.0 and 100:1.5, respectively and stored safely upto 10 days under refrigerated condition.
5. Paneer can also been enriched with bamboo shoot powder and bamboo dietary fibre at a level of 100:2.5 and 100:2.5, respectively and stored safely upto 10 days under refrigerated condition.
6. Henceforth, it is concluded that bamboo shoot is an excellent source of protein and dietary fibre having good property of water holding capacity, oil holding capacity, swelling capacity, bulk density and storage stability and therefore, can be successfully utilized for production of protein as well as dietary fibre rich functional food products. As the requirement of dietary fibers is steadily increasing in the country, this approach can consequently solve the problem of new sources required for extraction to meet the growing demand in food industry.
7. Protein fortification in the products can increase the level of protein daily intake of growing children while dietary fibre fortification can help the target consumers who have diabetes, congenital heart disease and obesity by increasing their dietary fibre intake.

Annexure – 2

Sub-Project: Development of beverages from wild jamun (*Syzygium cumini* L.)

Studies were carried out for the development of various beverages from wild jamun, which can be exploited on commercial scale in the state for its proper utilization. Wild jamun is a minor fruit growing in certain pockets of Himachal Pradesh that can be of great importance because of its higher antioxidants, colour pigments and other quality parameters along with medicinal properties. Wild jamun fruits were subjected to various physical and chemical juice extraction methods due to high pectin content in the fruit pulp. Juice was extracted by hot pulping without crushing followed by enzyme treatment (Pectinase @ 0.08 per cent and 90 min holding time at 50˚C temperature) was found best method for the juice extraction from its fruit. Best quality beverages without the addition of colour and flavour were prepared *viz.,* drink (16% juice, 12˚B total soluble solids and 0.30% titratable acidity), squash (35% juice, 40˚B total soluble solids and 1.20% titratable acidity), appetizer (35% juice, 45˚B total soluble solids and 1.20% titratable acidity along with spice extract) and syrup (30% juice, 65˚B total soluble solids and 1.50% titratable acidity) from its juice. All the products after packing in glass and PET containers were stored successfully in refrigerated storage (4-7˚C) for six months. However, quality of the products packed in glass bottles was retained better in refrigerated storage conditions as compared to the polyethylene teraphthalate (PET) stored at ambient temperature conditions (18–22˚C). The cost of the products prepared from wild jamun fruit juice was comparable to the cost of the similar products in the market.

Details of Experiments conducted:

Objective1-Extraction of pulp: Fresh fruits of wild jamun were washed and pulp was extracted by four different methods:

1.1 Crushing followed by heating then pulping: 5 kg of jamun fruits were randomly selected and crushed with the help of grater. The crushed material was heated for about 10 min then pulping was carried out by brush type pulper.

1.2 Crushing and pulping: 5 kg of jamun were randomly selected and crushed with the help of grater followed bypulping with brush type pulper.

1.3 Hot pulping without crushing: 5 kg of jamun were randomly selected and cooked under pressure in their own juice in low flame of LPG stove (719.64 KJ/kg) for 10 min until pulp becomes loose enough for further pulping by brush type pulper.

1.4 Cold pulping without crushing: Pulping of 5 kg of jamun fruits was done by putting them directly in the pulper.

The suitability of all these four methods of pulp extraction was compared on the basis of juice yield and quality. Best selected method was used for juice extraction from fruits on large scale. Extracted juice was strained before it was used for preparation of respective products.

Objective 2 -Extraction of juice: After the extraction of pulp it was further treated by the use of different enzymes. Different concentrations of enzymes were used to treat the pulp for different time period at 45^{o}C temperature. Details of the treatments are given in Table 1, 2 and 3.

Table 1: Treatment details of juice extraction using Pectinase enzyme

Treatment	T1	T2	T3	T4	T5	T6	T7	T8	T9
Concentration (%)	0.02	0.02	0.02	0.04	0.04	0.04	0.08	0.08	0.08
Time (Min)	60	90	120	60	90	120	60	90	120

Table 2: Treatment details of juice extraction using Viscozyme enzyme

Treatment	T1	T2	T3	T4	T5	T6	T7	T8
Concentration (%)	0.05	0.05	0.1	0.1	0.5	0.5	1.0	1.0
Time (Min)	30	60	30	60	30	60	30	60

Table 3: Treatment details of juice extraction using the combination of Viscozyme + Pectinase (3:1) enzymes

Treatment	T1	T2	T3	T4	T5	T6	T7	T8
Concentration (%)	0.05	0.05	0.1	0.1	0.5	0.5	1.0	1.0
Time (Min)	30	60	30	60	30	60	30	60

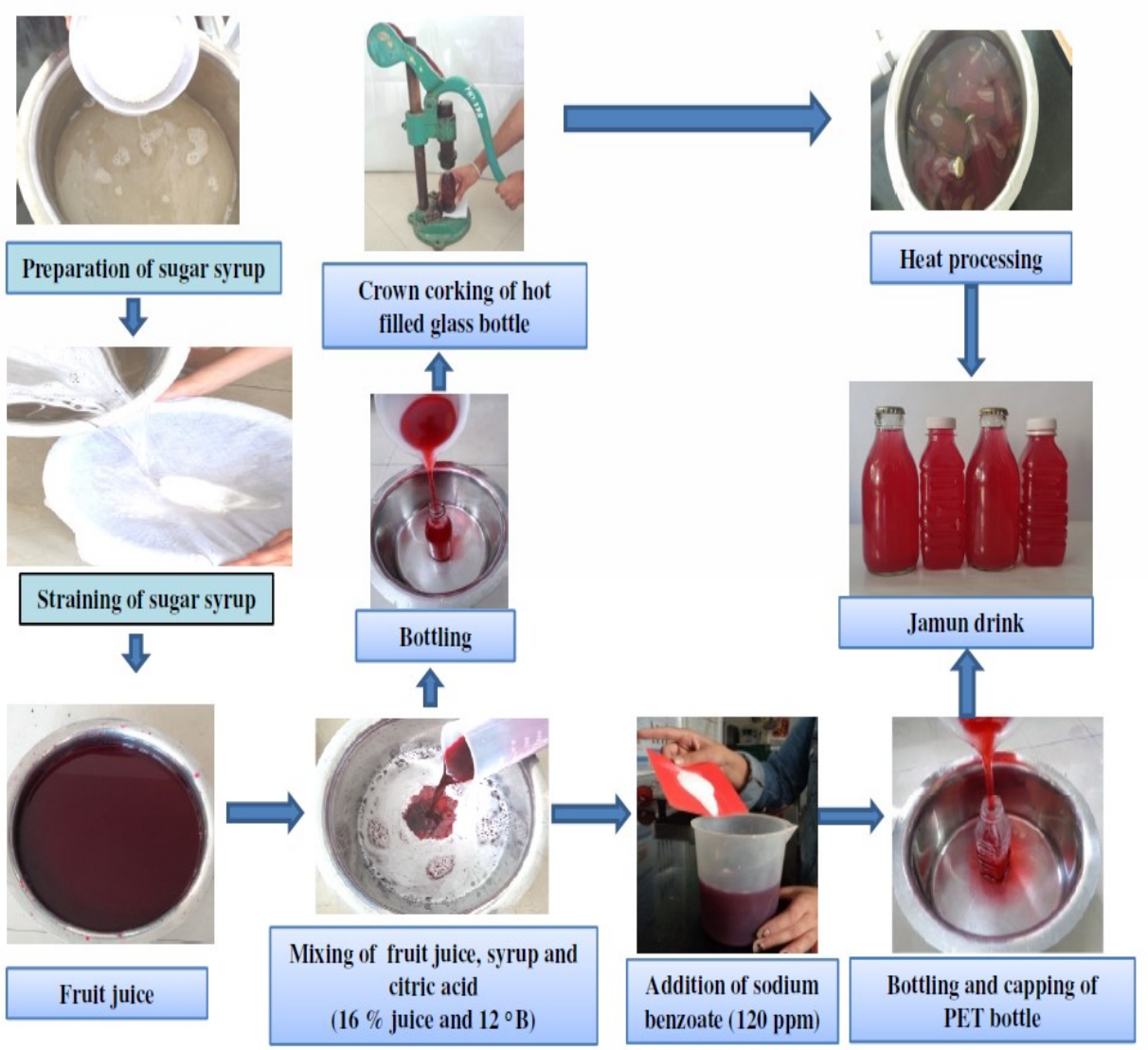
Juice extracted by all these methods was compared on the basis of juice yield, viscosity and total soluble solids (TSS). The best selected enzyme combination (concentration and time) was used further for juice extraction from fruits on large scale. Extracted juice was stored in PET jars in deep freezer at -18^{o}C before making the different products. Further, this juice after thawing at room temperature was used for the preparation of various beverages later.

Objective 3 -Development of beverages: Different treatment combinations of juice were tried to develop beverages like drink, squash, appetizer and syrup. As this fruit contains sufficient amount of natural flavor and colour in its juice so no artificial flavour and colour were added to any of developed products.

3.1 Drink: Fruit drink was prepared by mixing different proportions of wild jamun juice in different combinations of sugar syrup as given in Table 4. To get the desirable concentration of acid (0.30%) in fruit drink, citric acid was added in different treatment combinations. Sodium benzoate (120 ppm) was added in all the treatments as a preservative. The drink was packed in pre-sterilized glass and PET bottles, each of 200 mL capacity. The drink was stored in ambient (20- 25^{o}C) and refrigerated temperature (4-7ºC) conditions for six months. The physico-chemical and sensory characteristics of drink were carried out at zero, three and six months of storage.

Table 4: Treatment detail of fruit drink

Treatment	D_1	D_2	D_3	D_4	D_5	D_6	D_7	D_8
Juice (%)	10	12	14	16	10	12	14	16
TSS (°B)	12	12	12	12	15	15	15	15

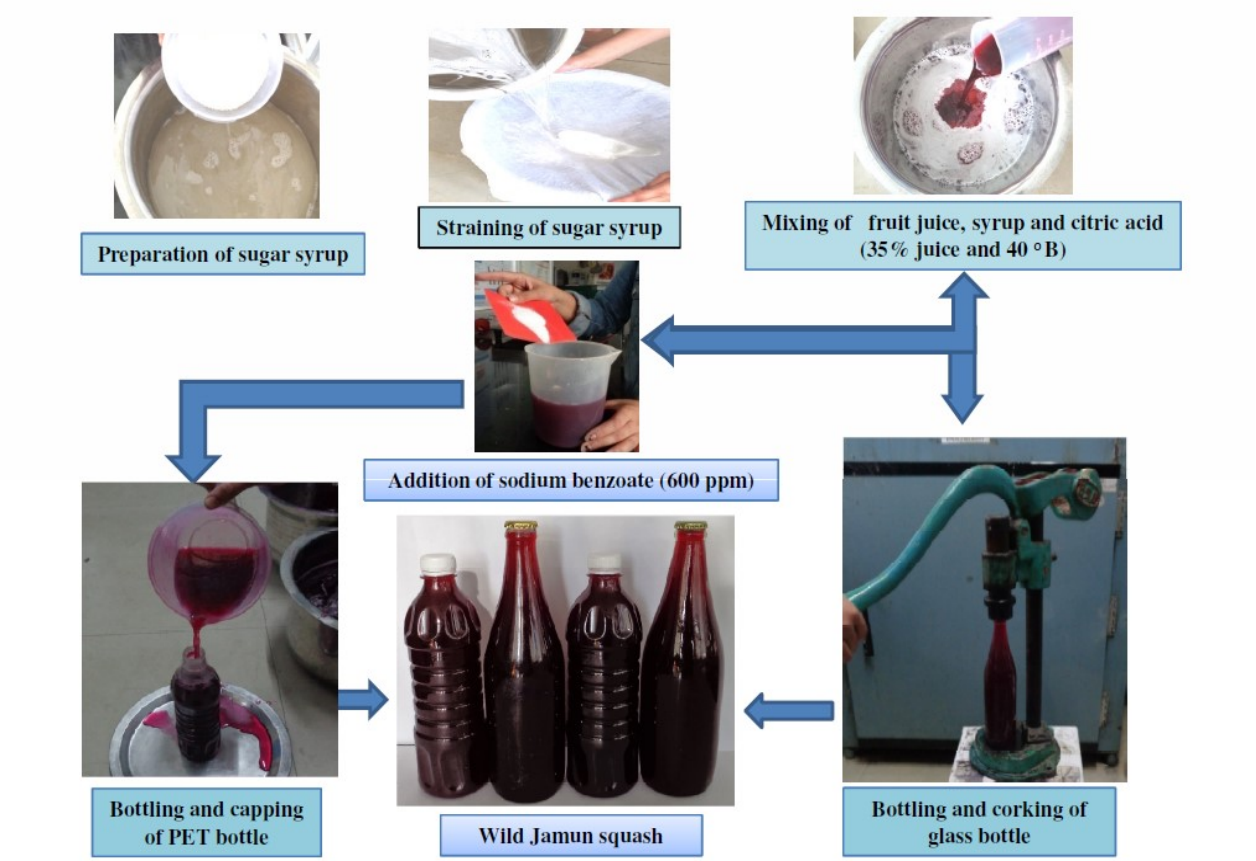


Unit operations for the preparation of wild jamun drink

3.2 Squash: Wild jamun squash was prepared by mixing juice and sugar syrup in different combinations as mentioned in Table 5. To get the desirable concentration of acid (1.2%) in fruit squash, citric acid was added in different treatment combinations. Sodium benzoate (600 ppm) was added in all the treatments as a preservative. The squash was packed in pre-sterilized glass and PET bottles (700 mL capacity). All the packed products were properly labelled and stored in ambient (20- 25°C) and refrigerated temperature (4-7ºC) conditions for six months. The physico-chemical and sensory characteristics of squash was carried out at zero, three and six months of storage.

Table 5: Treatment detail of fruit squash

Treatment	S_1	S_2	S_3	S_4	S_5	S_6	S_7	S_8
Juice (%)	25	30	35	40	25	30	35	40
TSS (°B)	40	40	40	40	45	45	45	45

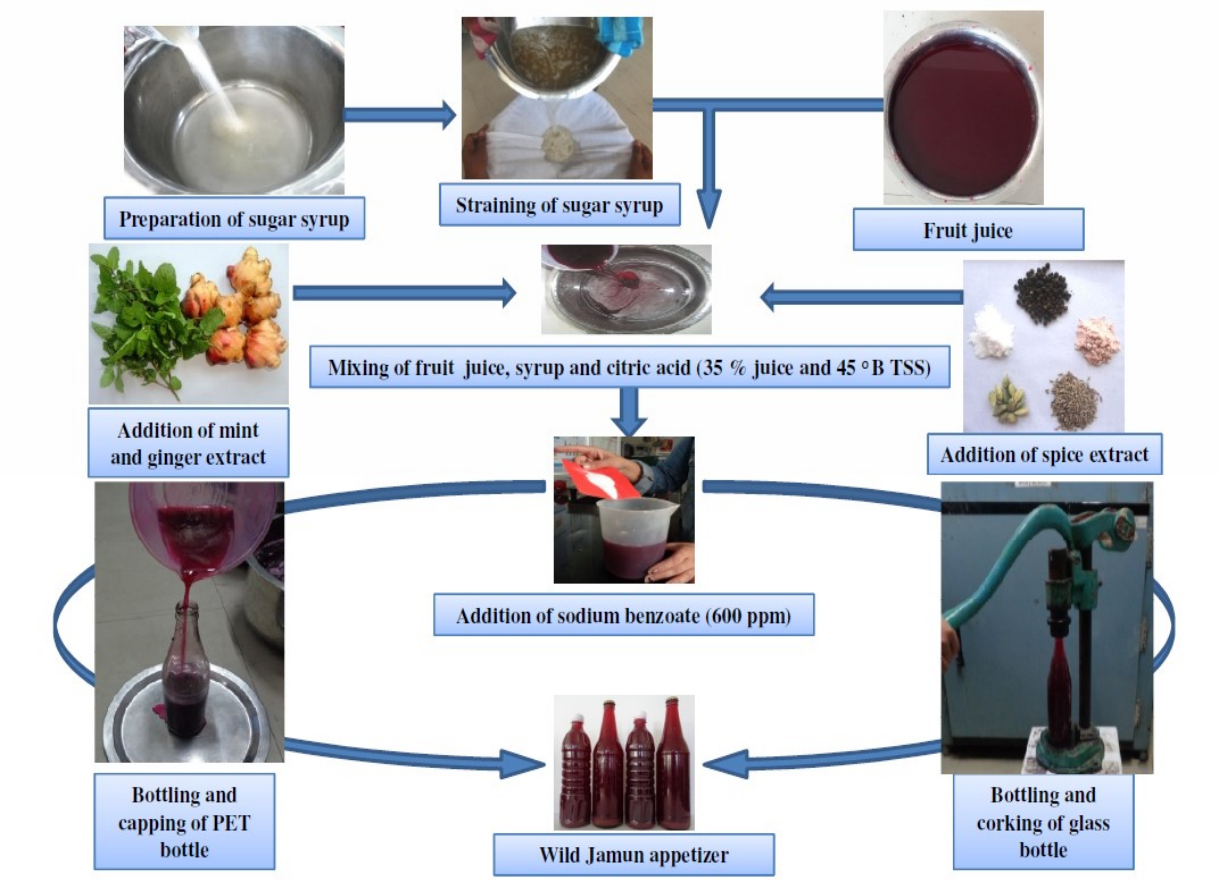


Unit operations for the preparation of wild jamun squash

3.3 Appetizer: Wild jamun appetizer (spiced squash) was prepared by mixing its juice with sugar syrup in different combinations as given in Table 6. Spice extract was prepared by boiling a ground mixture of pre-determined quantities of spices like cardamom (1 g), cumin (2.5 g) black pepper (2.5 g) in 200 mL of water, common salt (5 g), black salt (5 g) then straining and mixing the extract with mint extract (10 mL) and ginger extract (15 mL). To get the desirable concentration of acid (1.20%) in appetizer, citric acid was added in different treatment combinations. Sodium benzoate (600 ppm) was added at the end of product preparation of appetizer in all the treatments. The appetizer was packed in pre-sterilized glass and PET bottles (700 mL capacity) and stored in ambient (20-25^{o}C) and refrigerated temperature (4-7ºC) conditions for six months. The physico-chemical and sensory characteristics of appetizer was carried out at zero, three and six months of storage.

Table 6: Treatment detail of appetizer

Treatment	**A_1**	**A_2**	**A_3**	**A_4**	**A_5**	**A_6**	**A_7**	**A_8**
Fruit extract (%)	25	30	35	40	25	30	35	40
TSS (°B)	40	40	40	40	45	45	45	45

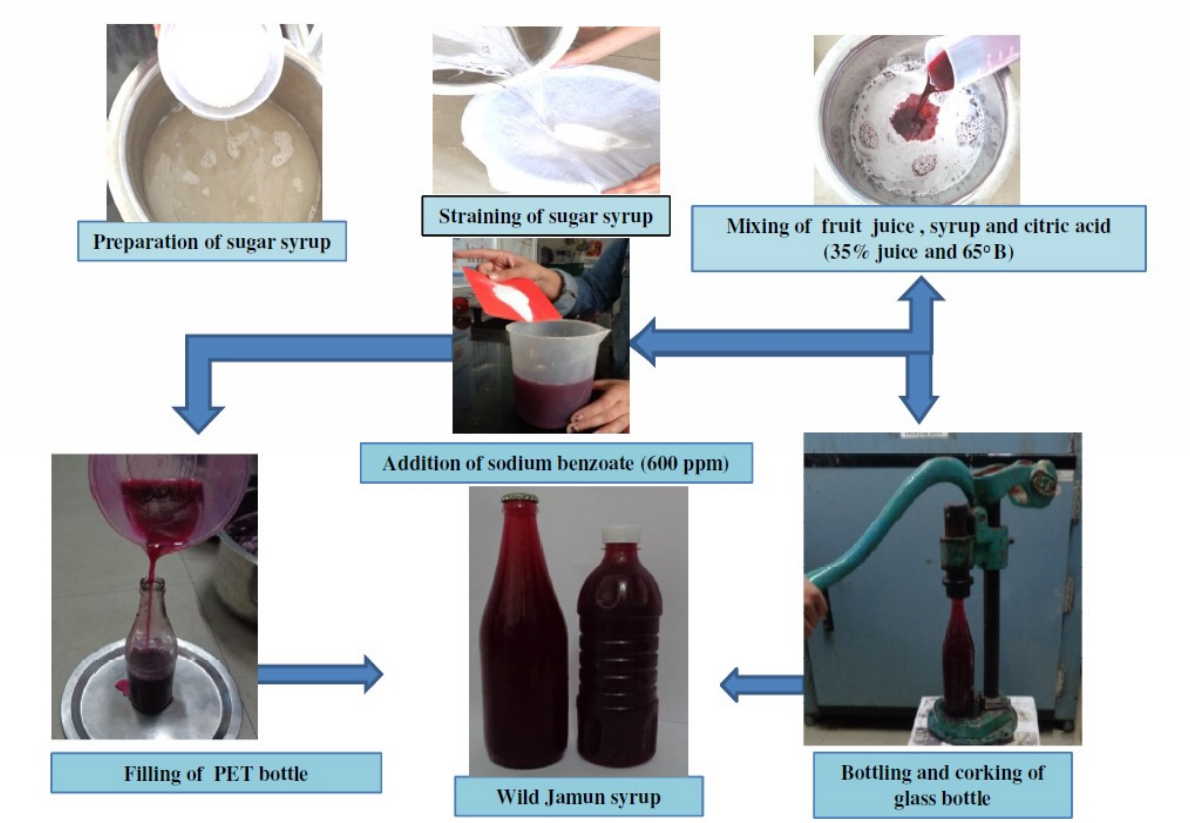


Unit operations for the preparation of wild jamun appetizer

3.4 Syrup: Wild jamun syrup was prepared by mixing juice with sugar syrup in different combinations as given in Table 7. To get the desirable concentration of acid (1.50%) in syrup, citric acid was added in different treatment combinations. Sodium benzoate (600 ppm) was added to all the treatments as a preservative. The syrup was packed in pre-sterilized glass and PET bottles (700 mL capacity). The packed syrup was properly labeled and stored in ambient (20- 25°C) and refrigerated temperature (4-7ºC) conditions for six months. The physico-chemical and sensory characteristics of all the products were carried out at zero, three and six months of storage.

Table 7: Treatment detail of syrup

Treatment	P_1	P_2	P_3	P_4	P_5	P_6	P_7	P_8
Juice (%)	25	30	35	40	25	30	35	40
TSS (°B)	65	65	65	65	70	70	70	70



Unit operations for the preparation of wild jamun syrup

Experimental results

1. **Physical and chemical characteristics of wild jamun and extraction of pulp:** Physical and chemical characteristics of wild jamun fruit were estimated and among the various quality characteristics like weight and volume of fruit were found as 4.70 g and 6.39 mL, respectively, whereas, the pulp and seed percentage of the same were recorded as 74.89 and 25.11 per cent, respectively. The moisture content of fruit was recorded as 86.36 per cent and total solids as 13.64 per cent, whereas, TSS content of fruit was recorded as 13.54^{o}B. The reducing and total sugars content of fruit were recorded as 5.15 and 7.26 per cent, respectively. Wild jamun fruit contained 1.04 per cent acidity and pH content of the same was found to be 3.43. The ascorbic acid, anthocyanins contents of the same were found to be as 26.90 and 276.09 mg/100 g, respectively. Wild jamun fruit contained 0.13 per cent crude fiber and 1.57 per cent ash content. The pectin, antioxidant activity and total phenols content of this fruit were recorded as 1.15 per cent, 82.50 per cent and 350.32 mg/ 100g, respectively. Among different methods of pulp extraction, hot pulping without crushing (T_3) with comparable characteristics of pulp yield as 80.15%, 'L' value as 29.56, 'a' value as 10.84, 'b' value as -6.16, TSS as 14.50^{o}B and apparent viscosity as 2.55 min was observed as the best treatment. The fruit pulp extracted by hot pulping without crushing had reducing sugars, total sugars, acidity and pH contents as 5.86 per cent, 7.84 per cent, 1.07 per cent and 3.30, respectively. The ascorbic acid and anthocyanins content of the same were found to be as 20.10 mg/100g and 180.00 mg/100g, respectively. However, the antioxidant activity and total phenols content of pulp were recorded as 80.00 per cent and 374.14 mg/100 g respectively. The sensory scores of the pulp on 9-point Hedonic scale were recorded as 7.90, 7.60, 7.54, 7.67 and 7.54 for colour, body, taste, aroma and overall acceptability, respectively.

2. Extraction of juice: Among different enzymatic treatments for juice extraction [Pectinase, Viscozyme and Viscozyme+Pectinase (1:1)] with different concentrations (0.04–1.0%) and varying holding time (60–150 min.) at 50° C temperature, the pectinase enzyme with 0.08 % concentration for 90 min. (T_6) of holding gave economically higher (84.36%) juice yield and lower (2.19 min.) apparent viscosity with quality parameters like TSS content as 14.78°B and colour in terms of 'L', 'a' and 'b' values were found to be as 28.32, 11.95 and -6.94, respectively with highest sensory characteristics scores of colour (7.88), body (8.02), taste (7.69), aroma (7.74) and overall acceptability (8.56)on 9-point Hedonic scale.

3. Development of Beverages and their storage study

3.1 Jamun Drink: Out of eight combinations of juice and TSS tried, wild jamun drink prepared with 16 per cent juice, 12°B TSS and 0.30 per cent acidity was found best on the basis of various physico-chemical and sensory parameters. Wild jamun drink could be stored safely for a period of six months under both storage conditions (ambient and refrigerated) and also in both packaging material (glass and PET bottles) with minimum changes in chemical and sensory attributes. However, comparatively fewer changes in drink packed in glass bottle stored under refrigerated storage conditions were observed as compared to PET bottle. The cost of production as calculated on the basis of current market prices of all the ingredients used indicated that good quality and commercially viable products can be prepared profitably from wild jamun fruit. The cost of production of drink was observed as Rs. 14.10 per bottle.

3.2 Jamun Squash: For the preparation of squash eight different treatment combinations of juice and TSS were tried, wild jamun squash prepared with 35 per cent juice, 40°B TSS and 1.20 per cent acidity was found best on the basis of various quality parameters. During storage period of six months wild jamun squash was found to be in acceptable condition `under both the storage conditions (ambient and refrigerated) in both packaging material (glass and PET bottles) with comparatively minimal changes in glass bottle under refrigerated storage condition as compared to PET bottle. The cost of production of squash was observed as Rs. 87.86 for per bottle.

3.3 Jamun Appetizer: Eight combinations for the preparation of wild jamun appetizer were tried and on the basis of various quality parameters appetizer prepared with 35 per cent juice, 45°B TSS, 1.20 per cent acidity and with a spice extract of cardamom (1 g), cumin (2.5 g) black pepper (2.5 g), mint juice (10 mL) and ginger juice (15 mL), black salt (5 g), common salt (5 g) was found to be the best. The appetizer could be stored safely for a period of six months under both storage conditions (ambient and refrigerated) and also in both packaging material like PET and glass bottles. However, comparatively fewer changes in appetizer packed in glass bottle and stored under refrigerated storage conditions were observed as compared to PET bottle. The cost of production of appetizer was observed as 94.46 per bottle.

3.4 Jamun Syrup: Out of eight different combinations of juice and TSS tried, syrup prepared with 30 per cent juice, 65°B TSS and 1.50 per cent acidity was found the best on the basis of sensory and some physico-chemical characteristics of the product. Syrup could be stored safely for a period of six months under ambient and refrigerated storage conditions and also in both the packaging materials (glass and PET bottles). However, minimum changes were observed in the syrup packed in glass bottle and stored under refrigerated storage conditions as compared to other packaging material. The cost of production of syrup was observed as Rs. 95.59 per bottle.

Conclusion and Recommendation

1. Wild jamun is one of the important minor fruits containing higher amounts of antioxidants and having excellent other quality characteristics can be used for the development of various beverages.

2. Fruit juice can be extracted successfully by using Pectinase enzyme (0.08% for 90 min) and further utilized for the preparation of value-added products like drink by using 16 per cent juice, 12°B TSS and 0.30 per cent titratable acidity, squash by using 35 per cent juice, 40° B TSS and 1.20 per cent titratable acidity, appetizer by using 35 per cent juice, 45°B TSS and 1.20 per cent titratable acidity along with spice extract and syrup by using 30 per cent juice, 65°B TSS and 1.50 per cent titratable acidity.

3. All the products packed in glass as well as in PET packaging material can be stored successfully for a period of six months under refrigerated temperature conditions. However, changes in quality parameters were faster in PET material under ambient storage conditions.

4. The cost of the beverages prepared from wild jamun was comparable to the cost of similar products in the market.

Annexure - 3

Sub-Project: Studies on preparation and preservation of persimmon (*Diospyros kaki* L.) pulp and its utilization in dairy products

The study was conducted to prepare and preserve persimmon pulp using different preservation methods (chemical, heat treatment and freezing) along with their evaluation for quality and storage stability. Fully ripened 'Hachiya' persimmon fruit with peel was found to be a good source of *β*-carotene (0.69 mg/ 100 g), ascorbic acid (9.14 mg/ 100 g), crude fibre (0.39%), total phenols (6.69 mg/ 100 g) and antioxidant activity (71.80%). The maximum pulp recovery of 88.30 per cent was obtained by hot pulping of ripe persimmon fruits with peel. Hot pulping of ripe persimmon fruits with peel treatment selected for further studies on the basis of higher sensory scores possessed 0.61 mg/100g *β*-carotene, 8.71 mg/100g, ascorbic acid, 2.91 per cent crude fibre, 6.41 mg/ 100g total phenols and 62.35 per cent antioxidant activity. The preservation of pulp reflected that the persimmon pulp of treatment (pulp + KMS @ 2000 ppm in glass jars) retained higher ascorbic acid (6.76 mg/ 100g), *β*-carotene (0.52 mg/ 100g), total phenols (4.69 mg/ 100g) and antioxidant activity (61.69%) during six months of storage period. Among seven different combinations of *khoa* and persimmon pulp, the *burfi* of treatment (70:30) exhibited highest value for crude fibre (1.30%), carbohydrates (44.51%), ascorbic acid (6.05 mg/ 100 g), *β*-carotene (0.068 mg/ 100 g), total phenols (1.92 mg/ 100 g) and antioxidant activity (16.02%) followed by (75:25), (80:20), (85:15), (90:10), (95:05) and (100:0) treatments. Out of four varied combinations of cream and persimmon pulp used for preparation of ice cream, (50:50) possessed higher values for crude fibre (1.46%), carbohydrates (37.61%), ascorbic acid (6.29 mg/ 100g), *β*-carotene (0.39 mg/ 100g), total phenols (3.65 mg/ 100g) and antioxidant activity (37.51%) while lower value for protein (5.25%) and fat (15.65%) as compared to (60:40), (70:30) and (100:0) treatments. The *burfi* packed in PET boxes can be safely stored under ambient as well as refrigerated conditions and ice cream under refrigerated condition for a period of 14 days with minimal changes in various parameters.

Details of Experiments conducted:

Objective1 - Evaluation of persimmon for physico-chemical characteristics: The fruits of persimmon (Table-1) were analyzed for different physico-chemical properties. Ten randomly selected fully ripened fruits were evaluated for physical characteristics. The matured as well as fully ripened fruits with and without peel were analyzed for different chemical parameters by following standard methods.

Table-1 Detail of forms of persimmon fruits for chemical evaluation

Treatment (T)	Detail of treatments
1	Firm/mature fruit with peel
2	Firm/mature fruit without peel
3	Fully ripened fruit with peel
4	Fully ripened fruit without peel

Glimpses of persimmon fruits from harvesting till fully ripened stage

Objective 2: Preparation and preservation of pulp from fully ripened persimmon

2.1 **Preparation of ripe persimmon pulp:** The pulp was extracted by employing cold and hot pulping methods. The fully ripe persimmon fruits with peel and the fruits without peel were used to extract pulp. The procedure for extraction of pulp by hot and cold pulping method is detailed below:

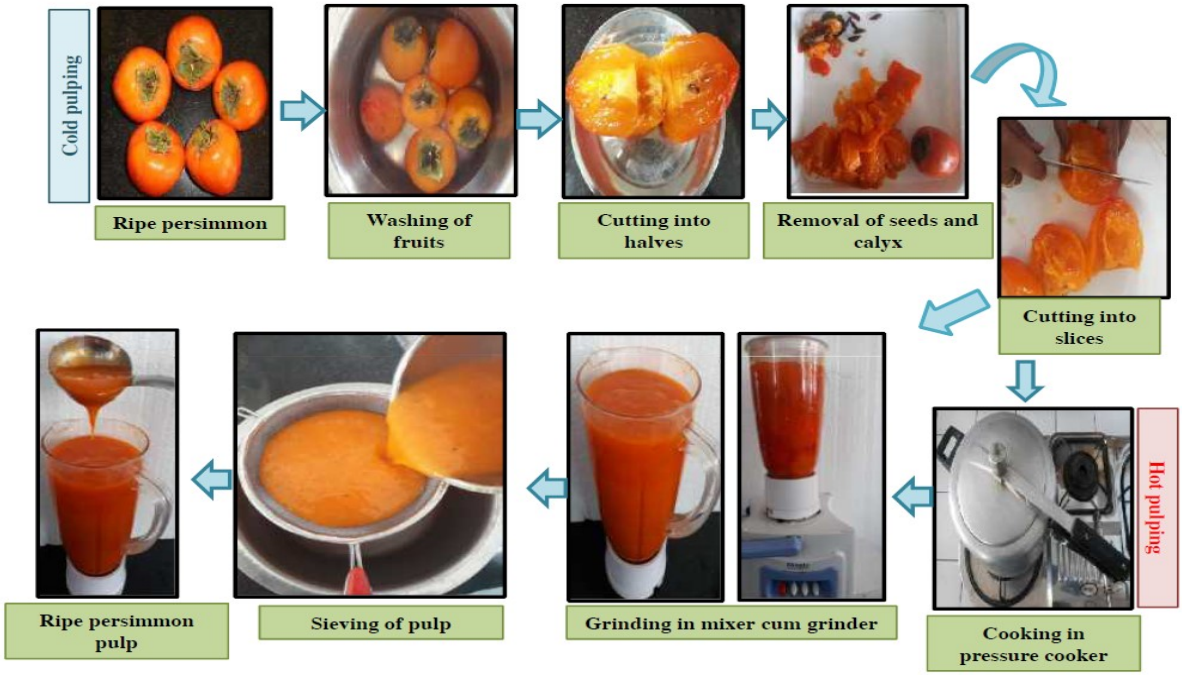
i) **Cold pulping:** The ripe persimmons were thoroughly washed. The calyx was removed manually with the help of stainless-steel knife and cut into halves. The seeds and the peel (only in case of pulp without peel) were also removed manually. The fruits after cutting into small pieces were converted into pulp by grinding in a mixer cum grinder.

ii) **Hot pulping:** The procedure followed for extraction of pulp by hot pulping method was the same as discussed above except that the fruit pieces were heated in a pressure cooker (5 kg capacity) on a domestic gas stove with the addition of water @ 10% for 5 min and allowed to cool prior to grinding.

2.2 **Selection of best treatment:** The pulp of persimmon fruits with and without peel (Table-2) thus obtained by using hot and cold pulping methods were analyzed for different chemical and sensory parameters. The best treatment was selected keeping in view the retention of nutrients as well as higher sensory scores for further studies.

Table-2 Standardization of method for preparation of ripe persimmon pulp

Treatment (T)	Detail of treatments
T_1	Cold pulping of fruits with peel
T_2	Cold pulping of fruits without peel
T_3	Hot pulping of fruits with peel
T_4	Hot pulping of fruits without peel



Unit operations for the preparation of persimmon pulp by using different methods

Objective 3 - Preservation of ripe persimmon pulp: The pulp of treatment selected earlier was prepared. Persimmon is a low acid fruit therefore the pulp was acidified by adding citric acid to a level of 0.4 per cent. The acidified pulp was preserved by using different methods (Table-3) as detailed below. Standard procedures were followed for preservation of pulp by different methods. The pulp was packed in different packaging material such as PET jars, glass jars, glass bottles and cans as per the method of preservation. The pulp was evaluated for quality at different storage intervals of 0, 3 and 6 months.

Table-3 Treatment detail for preservation of ripe persimmon pulp

Treatment (T)	Detail of treatments
T_1	Pulp + KMS (2000 ppm) in glass jars
T_2	Pulp + sodium benzoate (2000 ppm) in glass jars
T_3	Pulp + KMS (1000 ppm) + sodium benzoate (1000 ppm) in glass jars
T_4	Pulp + KMS (2000 ppm) in plastic jars
T_5	Pulp + sodium benzoate (2000 ppm) in plastic jars
T_6	Pulp + KMS (1000 ppm) + sodium benzoate (1000 ppm) in plastic jars
T_7	Pulp + pasteurization in glass bottles
T_8	Pulp + pasteurization + sodium benzoate (1000 ppm) in glass bottles
T_9	Pulp + pasteurization +KMS (1000 ppm) in glass bottles
T_{10}	Pulp + pasteurization + KMS (1000 ppm) + sodium benzoate (1000 ppm) in glass bottles
T_{11}	Canning
T_{12}	Freezing

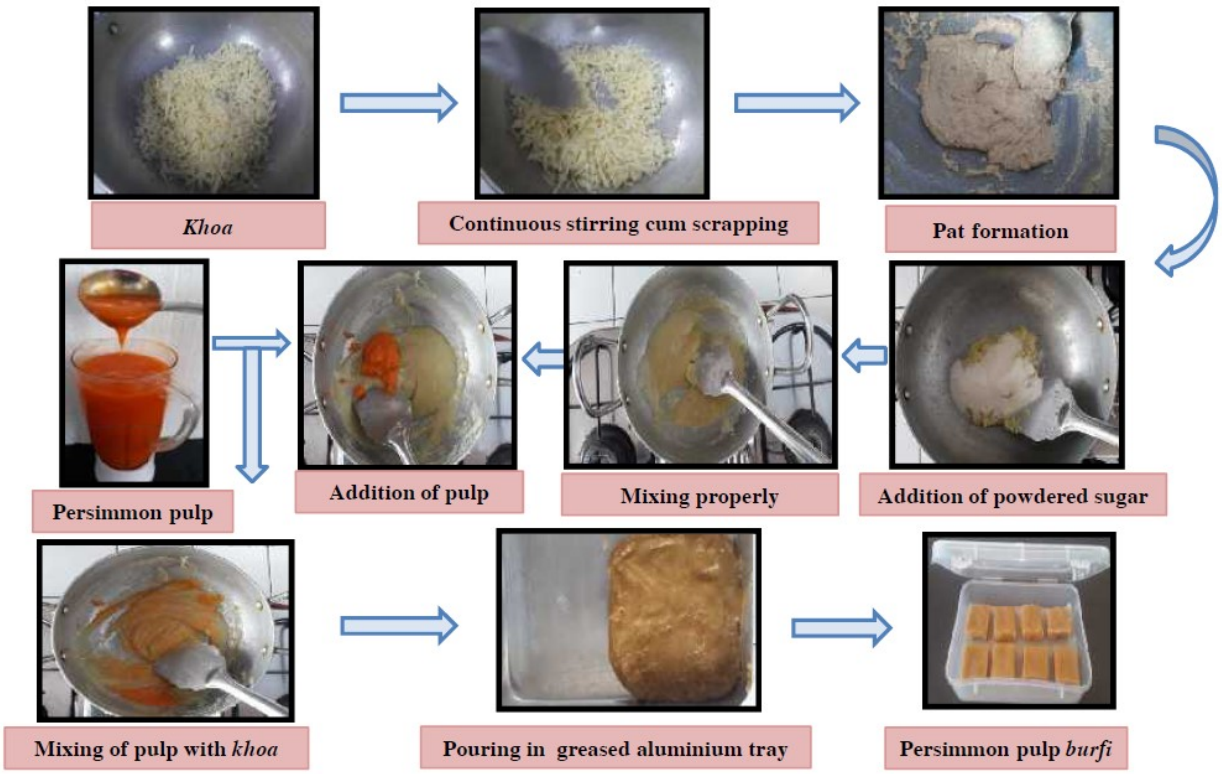
Objective 4: Utilization of persimmon pulp in dairy products for the enhancement of the nutritional quality

4.1 Incorporation of persimmon pulp in *burfi* (Fudge)

Persimmon *burfi* was prepared by heating concentrated milk solids (*khoa*) in a pan with continuous stirring till pat formation. Then powdered sugar @ 30 per cent was added to it. The mixture of concentrated milk solids (*khoa*) and sugar was heated to near homogenous consistency followed by cooling and cutting into small cuboids and this sample was kept as control. For preparation of persimmon pulp *burfi*, different combinations (Table-4) of persimmon pulp (%) and *khoa* (%) were used. In all the combinations the concentration of sugar was kept constant (30%). When the homogenous consistency of *khoa* and sugar was obtained then the pulp was added heated for 5 minutes with continuous stirring cum scrapping. The prepared product was allowed to cool and then cut into small cuboids. The persimmon pulp *burfi* prepared of different combinations was subjected to sensory evaluation by a panel of ten judges. The product was kept for storage under ambient and refrigerated conditions and evaluated for quality at storage intervals of 0, 7 and 14 days.

Table-4 Treatment detail of persimmon pulp *burfi* (fudge)

Treatment (T)	Khoa (%)	Persimmon pulp (%)
T_1	100	0
T_2	95	5
T_3	90	10
T_4	85	15
T_5	80	20
T_6	75	25
T_7	70	30



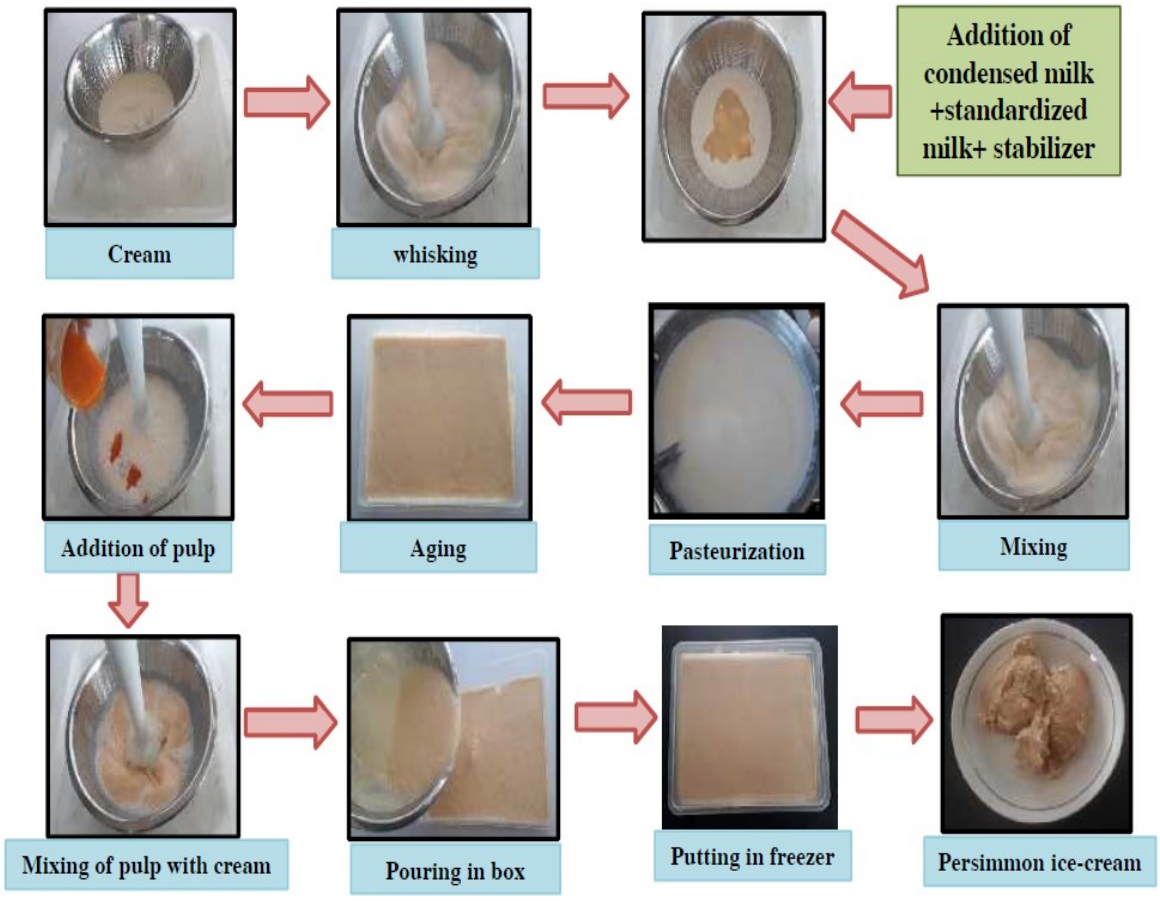
Unit operations for the preparation of *burfi* incorporated with persimmon pulp

4.2 Incorporation of persimmon pulp in ice cream

The ice-cream was prepared using various ingredients whipping cream, condensed milk (300 ml) and persimmon pulp. The amount of condensed milk was kept at constant proportion whereas cream and persimmon pulp were used in different concentrations. Cream was taken in a bowl and whisked properly for 2-3 min and then condensed milk, standardized milk and stabilizer (@ 0.5%) were added to the cream and blended properly with cream. The mixture was then pasteurized at 85˚C for 25 s and allowed to cool down to room temperature. The mixture was poured in PET boxes and kept for aging in refrigerator was done at 4˚C for 24 h and then the extracted pulp was added and mixed uniformly with the help of blender. The prepared mixture was poured in PET boxes and kept in the freezer (-15˚C). The ice cream was evaluated for quality at storage intervals of 0, 7 and 14 days.

Table 5: Treatment detail of persimmon pulp ice cream

Treatment (T)	Whipping cream (%)	Persimmon pulp (%)
T_1	100	0
T_2	70	30
T_3	60	40
T_4	50	50



Unit operations for the preparation of ice-cream incorporated with persimmon pulp

Experimental results

1. **Physical and chemical characteristics of ripe persimmon: '**Hachiya' variety persimmon (*Diospyros kaki L.*) fruits possessed an average weight of 241.70±22.11g. The mean length and diameter were observed to be 9.89±0.97 and 6.40±1.20 cm, respectively. As per the Royal Horticulture Society Colour Chart, the colour of flesh of persimmon matched Yellow-orange (22A) while peel came under Orange (28A) group. The recovery of pulp, peel and seed was found to be 89.26±0.81, 9.27±0.52 and 0.99±0.11 per cent, respectively. Firm/mature fruits with and without peel had moisture content of 69.75 and 69.01 per cent, respectively whereas, fully ripened fruits with and without peel exhibited the value of 78.76 and 77.81 per cent, respectively. The fully ripened fruits with and without peel contained TSS of 17.69±0.19 and 17.49±0.03°B, respectively while the firm/mature fruits possessed lower value of 16.61±0.05°B (with peel) and 16.53±0.13°B (without peel). The titratable acidity in firm/mature fruits was observed to be 0.25±0.03 per cent (with peel) and 0.21±0.03 per cent (without peel) whereas, fully ripened fruits recorded the value of 0.15±0.02 per cent (with peel) and 0.13±0.03 per cent (without peel). Fully ripened fruits with and without peel contained total sugars of 15.82 and 14.69 per cent, respectively while the firm/mature fruits comprised of 12.11 per cent (with peel) and 12.03 per cent (without peel). The reducing sugars of 8.79 per cent (with peel) and 8.41 per cent (without peel) were present in fully ripened fruits and the firm/mature fruits with and without peel possessed 6.16 and 6.09 per cent, respectively. The ascorbic acid and *β*-carotene content in fully ripened fruits with and without peel exhibited a value of 9.14 and 8.89 mg/ 100 g and 0.69 and 0.62 mg/ 100 g, respectively. Fully ripened fruits possessed fibre content of 3.66 per cent in with peel and 3.57 per cent in without peel. The ash content was higher in fully ripened fruits with a value of 0.39 per cent (with peel) and 0.34 per cent (without peel). Total phenols in fully ripened fruits with and without peel recorded a value of 6.69 and 6.50 mg/ 100 g, respectively. The value recorded for antioxidant activity in fully ripened fruits was noticed to be 71.80 per cent (with peel) and 71.18 per cent (without peel).
2. **Extraction of ripe persimmon pulp:** Among four different treatments, the persimmon pulp extracted by hot pulping method showed the maximum pulp recovery of 88.30 per cent with the use of fruits with peel. The pulp of treatment (hot pulping of fruits with peel) was awarded highest score on 9-point Hedonic scale for aroma (8.36), consistency (7.86) and overall acceptability (8.48) which possessed 0.61 mg/ 100g *β*-carotene, 8.71 mg/ 100g ascorbic acid, 2.91 per cent crude fibre, 6.41 mg/ 100g total phenols and 62.35 per cent antioxidant activity and was selected for further storage studies.
3. **Preservation of ripe persimmon pulp:** The preservation of pulp reflected that the treatment (pulp+KMS @ 2000ppm in glass jars) retained higher ascorbic acid (6.76 mg/ 100g), *β*-carotene (0.52 mg/ 100g), total phenols (4.69 mg/ 100g) and antioxidant activity (61.69%) during six months of storage period. The persimmon pulp can be preserved safely for a period of 6 months with minimal changes in sensory and chemical attributes. The cost of production of persimmon pulp preserved by different methods ranged from Rs. 67.20 to 24.68. The highest cost of Rs. 67.20 was worked out in cans of 850 g capacity.

4. Utilization of persimmon pulp in dairy products

4.1 *Burfi* (fudge) incorporated with ripe persimmon pulp: Among seven combinations of *khoa* and persimmon pulp, the *burfi* of treatment (70:30) exhibited highest value for crude fibre (1.30 %), carbohydrates (44.51 %), ascorbic acid (6.05 mg/ 100 g), *β*-carotene (0.068 mg/ 100g), total phenols (1.92 mg/ 100g) and antioxidant activity (16.02%) followed by (75:25), (80:20), (85:15), (90:10), (95:05) and (100:0) treatments. The sensory evaluation of *burfi* 9-point Hedonic scale showed that

(70:30) was awarded with maximum score for colour (7.55), texture (8.68), flavour (7.78) and overall acceptability (7.71) followed by (75:25), (80:20), (85:15), (90:10), (95:05) and (100:0) treatments. The *burfi* packed in PET boxes can be stored safely under ambient and refrigerated conditions up to a period of 14 days with minimal changes in chemical and sensory attributes.

4.2 Ice cream incorporated with ripe persimmon pulp: Out of four different combinations of cream and persimmon pulp used for preparation of ice cream, (50:50) possessed higher values for crude fibre (1.46%), carbohydrates (37.61%), ascorbic acid (6.29 mg/ 100g), *β*-carotene (0.39 mg/ 100g), total phenols (3.65 mg/ 100g) and antioxidant activity (37.51%) while lower value for protein (5.25%) and fat (15.65%) followed by (60:40), (70:30) and (100:0). The sensory evaluation of persimmon ice cream revealed that the highest score for colour (8.32), texture (8.32), flavour (8.72), and overall acceptability (8.55) was awarded to treatment (60:40) followed by (50:50), (70:30), and (100:0) treatments. Storage studies showed that however, the values for different quality attributes observed a decreasing trend in ice cream enriched with persimmon pulp but the product can be safely stored for a period of 14 days under refrigerated conditions with minimal changes in different quality parameters. The production cost of 200 g of ice cream packed in PET boxes was worked out to be Rs. 102.48 for (100:0), Rs. 91.80 for (70:30), Rs. 88.27 for (60:40) and Rs. 84.68 for (50:50) treatments.

Conclusion and Recommendation

1. The present studies summarized above revealed that the fully ripened fruits with peel contained the highest moisture (78.76%), TSS (17.69˚B), total (15.82%) and reducing sugars (8.79%). The fully ripened fruits with peel contained maximum functional components such as ascorbic acid (9.14 mg/ 100g) and *β*-carotene (0.69 mg/ 100g) while total phenols (9.3 mg/ 100g) and antioxidant activity (75.32%) was more in firm/mature fruits with peel.
2. Hot pulping method gave the maximum pulp recovery (88.30%) using fruits with peel. The pulp of this treatment possessed 0.61 mg/ 100g of *β*-carotene, 8.71 mg/ 100g of ascorbic acid, 2.91 per cent of crude fibre, 6.41 mg/ 100g of total phenols and 62.35 per cent antioxidant activity.
3. Among different treatments, persimmon pulp of treatment (pulp+ KMS @ 2000ppm in glass jars) was found to retain the maximum *β*-carotene, ascorbic acid, total phenols and antioxidant activity during six months of storage period.
4. The combination of *khoa* and persimmon pulp of treatment T_7 (70:30) for *burfi* preparation exhibited maximum crude fibre (1.30%), carbohydrates (44.51%), ascorbic acid (6.05 mg/ 100g), *β*-carotene (0.068 mg/ 100g), total phenols (1.92 mg/ 100g) and antioxidant activity (16.02%) and higher scores for sensory attributes.
5. Out of four different combinations of cream and persimmon pulp used for preparation of ice cream, T_4 (50:50) possessed higher values for crude fibre (1.46%), carbohydrates (37.61%), ascorbic acid (6.29 mg/ 100g), *β*-carotene (0.39 mg/ 100g), total phenols (3.65 mg/ 100g) and antioxidant activity (37.51%) while lower value for protein (5.25%) and fat (15.65%).
6. The sensory evaluation of ice cream prepared by using 60:40 ratio of cream and persimmon pulp showed maximum scores. Henceforth, it is concluded that persimmon fruit is a highly nutritious crop but is utilized to a very limited extent for processing.
7. The astringent Hachiya persimmon *(Diospyros kaki* L.*)* can be converted into pulp and stored safely for a period of 6 months (by using chemical preservatives and heat treatment) with minimal chemical and sensory changes.

Annexure - 4

Sub-Project: Ready-to-serve (RTS) beverages from persimmon (*Diospyros kaki* L.)

Studies were conducted on persimmon for the development of beverages. Ripe persimmon fruit with or without peel possessed 78.83±1.3 and 79.34±0.88 per cent moisture, 16.16±0.90 and 15.95±0.86 °B TSS, 0.13±0.01 and 0.12±0.01 per cent acidity, 15.90±0.65 and 14.99±0.61 per cent ascorbic acid, 250±0.08 and 190±0.01 µg/100g carotene, 3.87±0.07 and 3.75±0.08 mg/100g total phenols, 0.69±0.16 ± and 0.66±0.13 per cent fibre and 49.13±1.06 and 45.82±1.02 per cent antioxidant activity, respectively. Fruits were utilized for production of pulp and RTS beverages. Pulp obtained from cold and hot pulping method contained 220 and 150 µg/100g carotene, 15.12 and 9.43 mg/ 100 g ascorbic acid, respectively. Among six treatments employed for pulp preservation, (pulp+pasteurization+KMS) in glass bottles was found to be best for pulp of cold and hot pulping methods on the basis of higher retention of functional components i.e. ascorbic acid (13.733 and 8.043 mg/100 g), carotene (173 and 86 µg/100g) and total phenols (3.093 and2.873 mg/100g) during storage of 6 months. Among different combination of RTS beverage prepared using pulp of cold pulping method (10° B TSS + 15% pulp+ 0.4% acidity), (12 °B TSS + 15% pulp+ 0.3% acidity) and (15° B TSS + 15% pulp+ 0.3% acidity) were selected on the basis of higher sensory score. The treatment (10° B TSS + 15% pulp+ 0.4% acidity) exhibited a higher value of ascorbic acid (1.222 mg/100 g), carotene (24 µg/ 100 g). RTS beverage combinations for pulp extracted by hot pulping selected were (10° B TSS + 20% pulp+ 0.3% acidity), (12° B TSS + 15% pulp+ 0.3% acidity) and (15° B TSS + 15% pulp+ 0.3% acidity) which had carotene 56, 38 and 24 µg/100g, ascorbic acid 1.145, 0.718 and 0.698 mg/100g and total phenols 0.508, 0.365 and 0.337 mg/100g. In flavoured RTS beverage of treatment (pulp+ginger-mint extract) recorded the highest functional components 2.715 mg/100g, 23 µg/100g, 0.393 in ascorbic acid, carotene and total phenols as compared to (pulp+ginger extract) i.e. ascorbic acid (2.446 mg/ 100 g), carotene (22 µg/100g) and total phenol (0.370 mg/ 100 g). The study indicated that the processed products can be stored safely for a period of six months with minimal changes in chemical and sensory attributes.

Details of Experiments conducted:

Objective 1: Evaluation of ripe persimmon fruit for physico-chemical characteristics

The ripe persimmons fruits with and without peel were analyzed for different quality characteristics. Ten randomly selected fruits were evaluated for different physical characteristics and the data was recorded. The fruits with and without peel were also analyzed for different chemical parameters using standard methods.

Objective 2: Standardization of method for persimmon pulp preparation

The pulp was extracted by employing cold and hot pulping methods. The persimmon fruits were divided into two lots comprising of fruits with peel and the fruits without peel. The pulp was extracted from fruits of both the lots by following the procedures as detailed below.

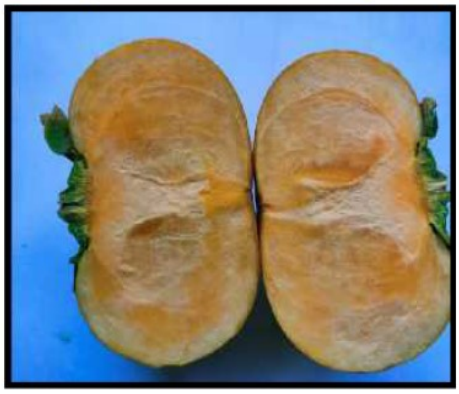
2.1 Extraction of persimmon pulp by cold pulping method:

The ripe persimmons were thoroughly washed. The calyx was removed manually with the help of stainless-steel knife and cut into halves. The seeds and the peel (only in case of pulp without peel) were also removed manually. The fruits were cut into small pieces and converted into pulp by grinding in a mixer cum grinder. The amount of water to be added for the preparation of ripe persimmon pulp was standardized. The different treatment

combinations having varied quantity of water (5, 10 and 15%) were used for standardization of cold pulping method for preparation of ripe persimmon pulp.

Persimmon fruits or tree

Harvested persimmon

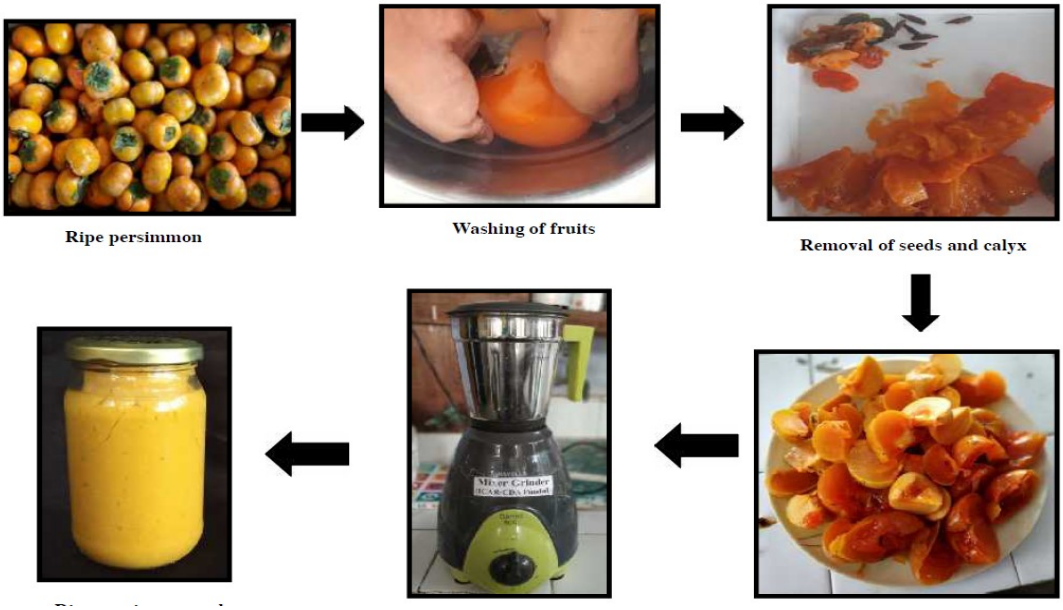


Ripe persimmon fruits

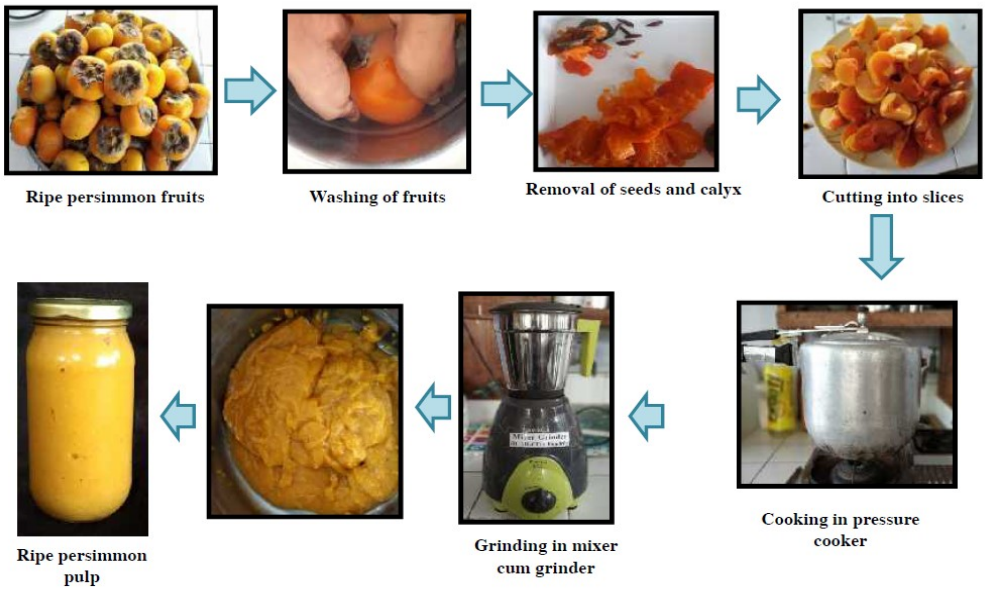
2.1.1 Selection of best treatment for pulp extraction by cold pulping: The pulp prepared by using different concentrations of water was analyzed for various chemical parameters and subjected to sensory evaluation by a panel of judges. The best treatment was selected on the basis of highest sensory scores and better chemical characteristics.

2.2 Extraction of persimmon pulp by hot pulping method:

The procedure followed for extraction of pulp by hot pulping method was the same as discussed earlier except that the fruit pieces were heated in a pressure cooker (5 kg capacity) on a domestic gas stove. The different treatment combinations (Table-1) having varied quantity of water (5, 10 and 15%) and cooking time (5, 10, 15 min) were used for standardization of hot pulping method for preparation of ripe persimmon. The pulp of each combination was prepared by following different unit operations.



Preparation of ripe persimmon pulp by using cold pulping method



Preparation of ripe persimmon pulp by using hot pulping method

Table 1: Standardization of method for extraction of pulp by hot pulping method

Treatment	Water (%)	Cooking Time (min.)
T_1	5	5
T_2	5	10
T_3	5	15
T_4	10	5
T_5	10	10
T_6	10	15
T_7	15	5
T_8	15	10
T_9	15	15

2.2.1 Selection of best treatment for pulp extraction by hot pulping: The pulp prepared by using different combinations of water (%) and cooking time (min) was evaluated for various chemical attributes and also subjected to sensory evaluation. The best combination was selected on the basis of highest sensory scores and better chemical characteristics.

Objective 3: Standardization of method for preservation of persimmon pulp

The pulp of best treatment selected earlier for cold pulping method (Table-2) and hot pulping method (Table-3) was prepared and preserved by different methods. As per preservation method, the pulp was packed in glass jars and glass bottle. The product was properly labeled and kept at ambient temperature for storage studies. The quality evaluation studies were conducted at 0, 3 and 6 months of storage.

Table-2: Treatment details for preservation of persimmon pulp prepared by cold pulping

Treatment (T)	Description
T_1	Pulp with peel + cold pulping + KMS (@ 2000 ppm) in glass jars
T_2	Pulp with peel + cold pulping + sodium benzoate (@ 2000 ppm) in glass jars
T_3	Pulp with peel + cold pulping + KMS(@ 1000 ppm) + sodium benzoate (@ 1000 ppm) in glass jars
T_4	Pulp with peel + cold pulping + pasteurization in glass bottles
T_5	Pulp with peel + cold pulping + pasteurization + KMS (@ 1000 ppm) in glass bottles
T_6	Pulp with peel + cold pulping + pasteurization + sodium benzoate (@ 1000 ppm) in glass bottles

Table-3: Treatment details for preservation of persimmon pulp prepared by hot pulping

Treatment (T)	Description
T_1	Pulp with peel + hot pulping + KMS (@ 2000 ppm) in glass jars
T_2	Pulp with peel + hot pulping + sodium benzoate (@ 2000 ppm) in glass jars
T_3	Pulp with peel + hot pulping + KMS(@ 1000 ppm) + sodium benzoate (@1000 ppm) in glass jars
T_4	Pulp with peel + hot pulping + pasteurization in glass bottles
T_5	Pulp with peel + hot pulping + pasteurization + KMS (@ 1000 ppm) in glassbottles
T_6	Pulp with peel + hot pulping + pasteurization + sodium benzoate (@ 1000ppm) in glass bottles

Objective 4: Utilization of persimmon pulp for development of Ready-to-Serve (RTS) beverages:

The ripe persimmon pulp was prepared as per the method selected earlier for cold pulping and for hot pulping and utilized for the development of RTS beverages. FSSAI specifications were followed for preparation of beverages. Different combinations of persimmon pulp (%), TSS (°B) and acidity (%) were tried to prepare the beverages. The prepared product was hot filled in sterilized glass bottles of 200 mL capacity and sealed by using crown corking machine. Then the product was heat processed at 85°C for 30 min. The

bottles were allowed to cool at room temperature. The RTS beverage of different combinations was subjected to sensory evaluation by a panel of ten judges. The combination which got the highest score for overall acceptability was selected for further studies.

4.1 Persimmon based RTS beverages

i) Persimmon based RTS beverages using pulp extracted by cold pulping

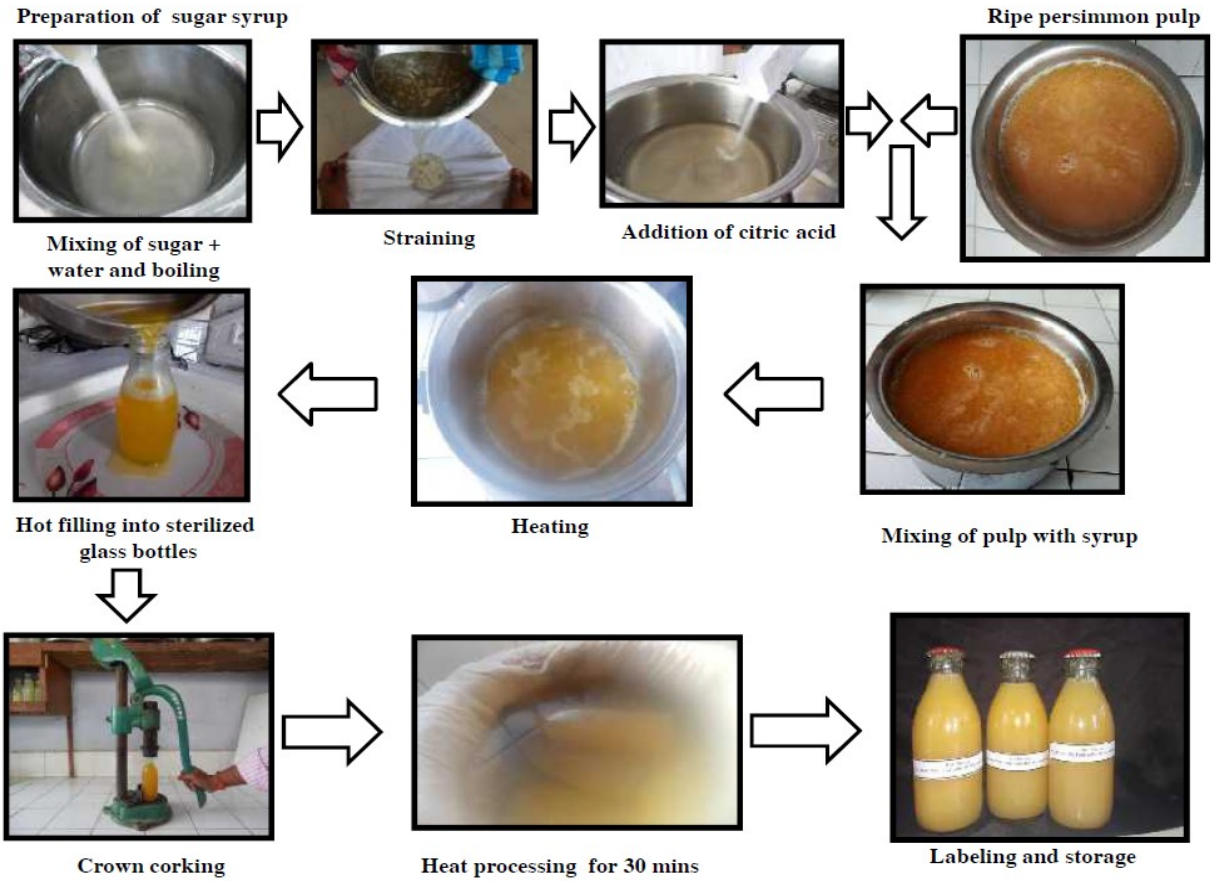
The RTS beverages were prepared by using pulp extracted by cold and hot pulping method. The beverages having TSS of 10°B (Table-4), 12°B (Table-5) and 15°B (Table-6) were prepared. In each section the TSS of beverage was kept constant while varied combinations of pulp and acidity were employed. The RTS beverages in each experiment were subjected to sensory evaluation by a panel of judges to select the best one on the basis of higher sensory scores.

Table 4: Treatment combinations for RTS beverage of 10°B TSS using persimmon pulp extracted by cold pulping

Treatment code	TSS (°B)	Persimmon pulp (%)	Acidity (%)
C_1	10	10	0.3
C_2	10	15	0.3
C_3	10	20	0.3
C_4	10	10	0.4
C_5	10	15	0.4
C_6	10	20	0.4
C_7	10	10	0.5
C_8	10	15	0.5
C_9	10	20	0.5

Table 5: Treatment combinations for RTS beverage of 12°B TSS using persimmon pulp extracted by cold pulping

Treatment code	TSS (°B)	Persimmon pulp (%)	Acidity (%)
C_1	12	10	0.3
C_2	12	15	0.3
C_3	12	20	0.3
C_4	12	10	0.4
C_5	12	15	0.4
C_6	12	20	0.4
C_7	12	10	0.5
C_8	12	15	0.5
C_9	12	20	0.5



Preparation of persimmon RTS beverage

Table 6: Treatment combinations for RTS beverage of 15°B TSS using persimmon pulp extracted by cold pulping

Treatment code	TSS (°B)	Persimmon pulp (%)	Acidity (%)
C_1	15	10	0.3
C_2	15	15	0.3
C_3	15	20	0.3
C_4	15	10	0.4
C_5	15	15	0.4
C_6	15	20	0.4
C_7	15	10	0.5
C_8	15	15	0.5
C_9	15	20	0.5

ii) Persimmon based RTS beverages using pulp extracted by hot pulping

Similar experiments as discussed above for pulp extracted by cold pulping were laid out for use of pulp extracted by hot pulping method. The detail of treatments in each experiment is presented from Table 7 to 9. In each experiment the best treatment was selected on the basis of sensory evaluation.

Table 7: Treatment combinations for RTS beverage of 10°B TSS using persimmon pulp extracted by hot pulping

Treatment code	TSS (°B)	Persimmon pulp (%)	Acidity (%)
H_1	10	10	0.3
H_2	10	15	0.3
H_3	10	20	0.3
H_4	10	10	0.4
H_5	10	15	0.4
H_6	10	20	0.4
H_7	10	10	0.5
H_8	10	15	0.5
H_9	10	20	0.5

Table 8: Treatment combinations for RTS beverage of 12°B TSS using persimmon pulp extracted by hot pulping

Treatment code	TSS (°B)	Persimmon pulp (%)	Acidity (%)
H_1	12	10	0.3
H_2	12	15	0.3
H_3	12	20	0.3
H_4	12	10	0.4
H_5	12	15	0.4
H_6	12	20	0.4
H_7	12	10	0.5
H_8	12	15	0.5
H_9	12	20	0.5

Table 9: Treatment combinations for RTS beverage of 15°B TSS using persimmon pulp extracted by hot pulping

Treatment code	TSS (°B)	Persimmon pulp (%)	Acidity (%)
H_1	15	10	0.3
H_2	15	15	0.3
H_3	15	20	0.3
H_4	15	10	0.4
H_5	15	15	0.4
H_6	15	20	0.4
H_7	15	10	0.5
H_8	15	15	0.5
H_9	15	20	0.5

4.1.1 Quality evaluation of RTS beverages during storage

The ripe persimmon pulp was extracted as per the procedure discussed above by cold pulping and hot pulping method. The RTS beverages of different combinations were prepared as per procedure described above. The treatment details for preparation of RTS beverages is presented in Table 10 for beverages prepared with pulp of cold pulping method and Table 11 for pulp of hot pulping method. The products were bottled and appropriately

labeled and kept for storage under refrigerated and ambient conditions. The evaluation studies for chemical, sensory and microbial parameters were conducted at 0, 3, 6 months of storage.

Table 10: Treatment detail for storage studies of RTS beverage prepared using pulp extracted by cold pulping

Treatments	Description
T_1	Best RTS combination of 10°B with pulp of cold pulping method
T_2	Best RTS combination of 12°B with pulp of cold pulping method
T_3	Best RTS combination of 15°B with pulp of cold pulping method

Table 11: Treatment detail for storage studies of RTS beverage prepared using pulp extracted by hot pulping

Treatments	Description
T_1	Best RTS combination of 10°B with pulp of hot pulping method
T_2	Best RTS combination of 12°B with pulp of hot pulping method
T_3	Best RTS combination of 15°B with pulp of hot pulping method

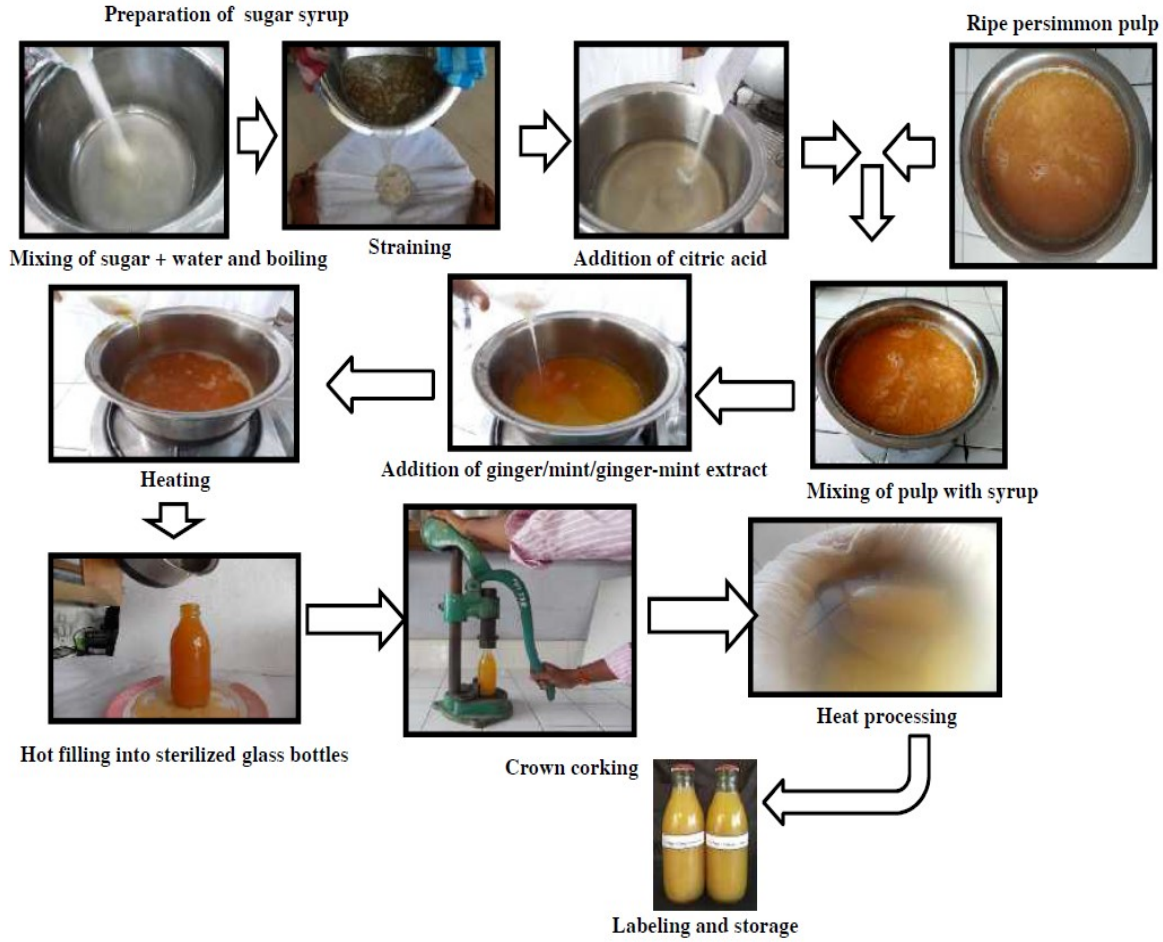
4.2 Persimmon based flavoured RTS beverage: The RTS beverages of different combination as selected under section 4.1 (i) for cold and 4.1 (ii) for hot pulping method were prepared and subjected to sensory evaluation. The recipe which got the highest sensory evaluation scores by a panel of judges was selected. This combination was used for preparation of flavoured RTS beverages.

i) Ginger flavoured persimmon RTS beverage

For preparation of ginger flavoured RTS beverage, ginger extract was prepared. The fresh ginger rhizomes were washed and peeled followed by further washing. After grating the ginger manually, the shreds were ground in a mixer and grinder by adding water in the ratio of 1:2. The juice was obtained by squeezing the mixture through double layer cheesecloth. The RTS beverage was prepared by replacing the persimmon pulp with ginger extract indifferent proportion. The RTS beverages of these combinations were prepared (Table-12) and subjected to sensory evaluation. The best combination was selected on the basis of highest sensory scores.

Table 12 Treatment detail of ginger flavoured persimmon RTS beverage

Treatment (G)	Ginger extract (%)
G_1	1
G_2	3
G_3	6
G_4	9



Preparation of flavoured persimmon RTS beverage

ii) Mint flavoured persimmon RTS beverage

The mint extract was prepared by using fresh mint leaves. The leaves were washed and ground in a mixer cum grinder. The juice was extracted by passing the mass through double layered muslin cloth. The pulp was replaced with mint extract for preparation of beverages. The RTS beverages with various concentrations of mint extract were prepared (Table-13) and sensory evaluation was conducted. The best recipe was selected on the basis of highest sensory scores.

Table 13: Treatment detail of mint flavoured persimmon RTS beverage

Treatment (M)	Mint extract (%)
M_1	2
M_2	4
M_3	6
M_4	8

iii) Ginger-mint flavoured persimmon RTS beverage

The pulp of base recipe was replaced with different concentrations of ginger-mint extract (Table-14). The RTS beverage prepared by using these combinations was subjected to sensory evaluation by a panel of ten judges. The combination which got the highest overall acceptability score was selected for further studies.

Table 14: Treatment detail of ginger-mint flavoured persimmon RTS beverage

Treatment (GM)	Mint extract (%)	Ginger extract (%)
GM_1	6	7
GM_2	4	5
GM_3	2	3
GM_4	1	1

4.2.1 Quality evaluation of flavoured RTS beverage

After selecting the best combination of flavoured RTS beverages {under section 4.2 i), ii) and iii)} by subjecting these to a panel of ten judges, the beverages were prepared and preserved. The products were properly labeled and kept under ambient and refrigerated conditions. The quality evaluation studies were conducted at 0, 3 and 6 months of storage interval.

Experimental results

1. **Physical and chemical characteristics of ripe persimmon:** Fuyu persimmon (*Diospyros kaki L.*) fruits possessed an average weight of 115.6±17g with mean length and diameter of 46.15±1.63 and 64.17±3.90 mm, respectively. The firmness in ripe fruits was 7.98 kg/cm^2.The colour of ripe persimmon peel matched Orange (28 A) while that of flesh with Yellow-orange (22 A) group of Royal Horticulture Society Colour Chart. The flesh, peel and seed were recorded as 85.82, 10.90 and 2.0 per cent, respectively. The moisture, TSS, titratable acidity and pH in persimmon fruits with peel was 78.83per cent, 16.16±0.90 °B, 0.13±0.01 per cent and 3.87±0.07, respectively whilethe corresponding value was noticed as 79.34 per cent, 15.95±0.86 °B, 0.12±0.01per cent and 3.75±0.08 in fruits without peel. Lower value in calcium (15.80), potassium (50.20) and magnesium (1.452 mg/100 g), respectively was found for fruits without peel.
2. **Preparation of ripe persimmon pulp:** Among various combinations of water with fruit, cold pulping extracted by adding 10% water was selected for persimmon with peel as well as without peel on the basis of chemical and sensory parameters. The pulp of cold pulping method (T_2: 10% water) fruits with peel exhibited higher pulp recovery (77.87), *β*-carotene (220µg/100 g), ascorbic acid (15.12mg/100 g) and total phenols (3.77mg/100 g). The same treatment received higher sensory scores for colour (8.48), body (8.01), taste (8.35), aroma (7.49) and overall acceptability (8.48).Among various combination of water and cooking time treatment (10% water for 10 min) in pulp extracted by hot pulping with peel while treatment (10% water for 15 min) for fruits without peel on the basis of higher quality characteristics.
3. **Ripe persimmon pulp preservation:** Out of 6 treatments used for pulp preservation in each case i.e. cold and hot pulping the treatment (pulp + pasteurization + KMS in glass bottle) was found to be the best on the basis of chemical characteristics. This method showed higher retention of *β*-carotene (78.94%) and total phenols (79.13%) as compared to (70%) and (77.70%) in hot pulping method during 6 months of storage under ambient condition. The ripe persimmon pulp extracted by hot and cold pulping can be preserved safely for a period of 6 months with minimal changes in chemical and sensory attributes.

4 Development of RTS beverages

4.1 Persimmon Ready-to- Serve (RTS) beverage: The best pulp selected from hot and cold pulping method was used for the preparation of RTS beverage. Different recipes were standardized for the preparation of RTS beverage using different level of pulp

(10, 15 and 20%) extracted with cold and hot pulping at varying TSS (10, 12 and 15 °B) and acidity (0.3 and 0.4%) was selected on the basis of sensory evaluation for conducting further studies. Persimmon RTS beverage prepared using pulp extracted by cold pulping at 10°B (15% persimmon pulp and 0.4% acidity), 12° B (15% persimmon pulp and 0.3% acidity) and 15° B (15% persimmon pulp and 0.3% acidity). The functional components i.e. ascorbic acid was 1.456 mg/100g in T_1, 1.445 mg/100g in T_2 and 1.432 mg/ 100g in T_3 while total phenols in T_1, T_2 and T_3 was 0.363, 0.353 and 0.333 mg/100g, respectively. However, the change in functional component showed a significant decrease in ascorbic acid (2.257 to 0.955 mg/100g), carotene (38 to 9 µg/100g) and total phenols (0.573 to 0.143) but its sensory attribute of all the treatments remained above acceptable limit during 6 months of storage. Sensory evaluation of persimmon RTS beverages from cold pulping revealed highest overall acceptability scores of 7.88, 7.83, 7.79, respectively for T_1, T_2 and T_3.In hot pulping method different combinations was used at 10°B (20% persimmon pulp and 0.3% acidity), 12°B (15% persimmon pulp and 0.3% acidity) and 15°B (15% persimmon pulp and 0.3% acidity). The sensory attribute of all the treatments remained above acceptable limit during 6 months of storage. These combinations contain overall acceptability of 7.79, 7.88, and 7.83, respectively in T_1, T_2 and T_3.The production cost of persimmon RTS beverage packed in glass bottle (200 mL capacity) was worked out to be Rs. 9.31, 8.30 and 8.57 in RTS beverage prepared using pulp by hot pulping and Rs. 8.53, 8.58 and 8.84 in RTS beverage prepared using pulp by cold pulping, respectively for T_1, T_2 and T_3.The persimmon RTS beverage could be stored safely for a period of six months under ambient and refrigerated conditions in glass bottles with minimal changes in quality attributes.

4.2 Flavoured persimmon RTS beverage: The RTS beverage prepared using hot pulp (12°B TSS, Pulp 15% and 0.3% acidity) was selected for further preparation of flavoured RTS beverage. Among different ratios of flavouring extracts used, recipe G_2 (12% pulp+3% ginger extract) for ginger flavoured RTS beverage and recipe GM_3 (12% pulp+2% ginger+3% mint extract) for ginger-mint flavoured RTS beverage were selected on the basis of sensory evaluation for storage studies and referred, respectively as T_1 and T_2. However, the change in functional component indicated a significant decrease in ascorbic acid (2.913 to 2.123 mg/100g), carotene (37 to 3 µg/100g) and total phenols (0.593 to 0.171 mg/100g) but its sensory attribute of all the treatments remained above acceptable limit during 6 months of storage. Sensory evaluation of flavoured persimmon RTS beverage indicated highest overall acceptability score (7.648) for T_2 followed by T_1 (7.385). Flavoured persimmon RTS beverage packed in glass bottles (200 mL capacity) can be produced at the cost of Rs. 8.39 (T_1: ginger flavoured persimmon RTS beverage) and8.42 (T_2: ginger-mint flavoured persimmon RTS beverage).

Conclusion and Recommendation

1. The present studies summarized above revealed that ripe persimmon fruit is a good source of ascorbic acid, *β*-carotene, total phenols and fibre.
2. The pulp can be extracted from fruits by cold pulping (T_2: with addition of 10 per cent water) as well as hot pulping (T_5: 10 per cent water and cooking time for 10 min) method which gave a pulp recovery of 77.87 and 83.50 per cent, respectively. The ascorbic acid of 15.12 mg/ 100g and 9.43 mg/ 100g while carotene 220 µg/ 100g and 150 µg/ 100g, respectively were noticed in pulp extracted with cold and hot pulping method.
3. During preservation of pulp, among different treatments, T_5 (pulp+ pasteurization+ KMS in glass bottles) was found to be best in both the pulp (cold and hot pulping) and retained the maximum carotene 78.94 and 70 per cent during storage.
4. Among different combinations of RTS beverage prepared using pulp of cold pulping method T_1 (10°B TSS + 15% pulp+ 0.4% acidity), T_2 (12°B TSS + 15% pulp+ 0.3%

acidity) and T_3 (15°B TSS + 15% pulp+ 0.3% acidity) were selected on the basis of higher sensory scores. T_1 (10°B TSS + 15% pulp+ 0.4% acidity) exhibited a higher value of ascorbic acid (1.222 mg/ 100g) and carotene (24µg/ 100g).

5. RTS beverage combinations for pulp extracted by hot pulping selected were T_1 (10°B TSS + 20% pulp+ 0.3% acidity), T_2 (12°B TSS + 15% pulp+ 0.3% acidity) and T_3 (15°B TSS + 15% pulp+ 0.3% acidity) which contained functional components i.e. carotene 56, 38 and 24 µg/ 100g, ascorbic acid 1.145, 0.718 and 0.698 mg/ 100g and total phenols 0.508, 0365 and 0.337 mg/100 g.
6. Among flavoured RTS beverage combinations, T_2 (pulp + ginger-mint extract) recorded higher value of 2.715 mg/ 100g, 23 µg/ 100g and 0.393 mg/ 100g for ascorbic acid, carotene and total phenols, respectively as compared to T_1 (pulp + ginger extract) which had the value of 2.446 mg/ 100g, 22 µg/ 100g and 0.370 mg/ 100g, respectively.
7. The persimmon which is very rarely used for processing purposes but as per the results of present investigation, the ripe fruits of persimmon can successfully be utilized for the production of good quality and nutritionally enriched beverages of remunerative cost.

Annexure - 5

Sub-Project: Development and storage of granular powder from wild pomegranate (*Punica granatum* L.)

Investigations were conducted to develop granular powder from wild pomegranate (*Punica granatum* L.) commonly called as “Daru” in Himachal Pradesh and considered as one of the commercial fruits. The granular powder was developed for instant use by using different drying modes and their combinations to increase its shelf life by incorporating oxygen and moisture scavengers as it is very sensitive to oxidation. The edible part of its fruit is arils, which are rich in organic acids including various antioxidants such as anthocyanins, phenols, ascorbic acid etc. Arils were pre-treated (steam blanching for 30 s followed by sulphur fumigation @ 0.30% for 60 min) and subjected to different drying modes and their combinations for the preparation of granular powder (particle size of 710 µm). The granular powder from the best drying mode (mechanical cabinet drier; 60±2°C) possessing maximum desirable sensory and physico-chemical characteristics were packed and stored in five different packaging treatments including polyethylene pouch (PEP), aluminium laminated pouches (ALP), ALP with oxygen scavenger, ALP with oxygen and moisture scavenger and ALP with moisture scavenger and stored for six months under ambient (18-22 °C) and refrigerated (4-7 °C) temperature conditions. The granular powder packed in ALP with oxygen and moisture scavenger under refrigerated storage condition retained the best quality of granular powder. Whereas, the quality of granular powder packed in same packaging treatment was also good under ambient storage condition but the changes in the quality was found faster as compared to refrigerated storage conditions.

Details of Experiments conducted:

Objective1 - Preparation of Anardana: Wild pomegranate arils were steam blanched for 30 s followed by sulphuring with 0.30 per cent sulphur powder for 60 min in sulphur fumigation chamber before carrying out the drying. The following drying modes were used for the preparation of A*nardana*.

1.1 Sun drying: The pre-treated arils (3 kg) were spread on the perforated aluminium trays and kept in the open sun in an inclined position for drying. The material was kept till the sunset before shifting it back in the laboratory for night. Arils were dried in the sun till they attain a constant weight. The mean temperature during these studies was in the range of 18 to 31^{o}C.

1.2 Solar tunnel drying: The pre-treated arils (3 kg) were spread on the perforated aluminium trays and put on the stands inside a solar tunnel drier of dimensions 297 × 204 × 207 cm. This drier has been made of polyethylene sheet of thickness 0.31 mm and the temperature recorded in this drier during these studies was in the range of 21 to 39^{o}C. The pre-treated arils were dried till they attain a constant weight.

1.3 Mechanical cabinet drying: The pre-treated arils (3 kg) were spread on the perforated steel trays of dimension 76 × 56 cm in 0.50 cm layer and dried at constant temperature at 60±2^{o}C inside the mechanical cabinet drier having internal dimensions of 78 × 58 × 128 cm upto a constant weight. The trays were shifted inside the drier by rotation to ensure uniform heat transmission to all the trays.

1.4 Solar tunnel drying + Mechanical cabinet drying: The pre-treated arils (3 kg) were spread on the perforated aluminium trays and put on the stands inside a solar tunnel drier (30^{o}C) until they attain a constant weight. After that these solar tunnel dried arils were further spread on the perforated steel trays and dried at constant temperature at 60±2^{o}C inside a mechanical cabinet drier upto a constant weight.

1.5 Sun drying + Solar tunnel drying: The pre-treated arils (3 kg) were spread on the perforated aluminium trays and kept in open sun (24.5°C) for drying. Arils were dried in the sun till they attain a constant weight. The sun-dried arils were further dried in solar tunnel drier (30°C) upto a constant weight.

1.6 Sun drying + Solar tunnel drying + Mechanical cabinet drying: The pre-treated arils (3 kg) were spread on the perforated aluminium trays and kept in open sun (24.5°C) for drying until they attain a constant weight. These sun-dried arils were Wild pomegranate fruits further dried in solar tunnel drier (30°C) followed by mechanical cabinet drying (60°C). When the arils attain a constant weight in solar tunnel drier then these were shifted to mechanical cabinet drier for further drying upto their constant weight.

Objective 2: Preparation of granular powder from dried arils (A*nardana*): The wild pomegranate arils dried by different drying modes were ground to powdered form in a laboratory scale grinder and then further passed through 22 mesh (710 µm) sieve. The *Anardana* powder selected on the basis of best physico-chemical and sensory characteristics was used for further storage studies

Objective 3:Packaging and storage: The *Anardana* granular powder from best selected drying mode was packed in different packaging materials viz Polyethylene pouch (PEP) (T_1), Aluminium laminated pouch (ALP) (T_2), Aluminium laminated pouch with oxygen scavenger (T_3), Aluminium laminated pouch with oxygen scavenger and moisture scavenger (T_4) and Aluminium laminated pouch with moisture scavenger (T_5). The A*nardana* granular powder in different packaging treatment was stored under ambient temperature (18-22°C) and refrigerated temperature (4-7°C) for a period of 6 months and was analyzed for changes in various physico-chemical and sensory quality attributes at different intervals (0, 3 and 6 months) of storage.

Experimental results

1. Physicochemical analysis of wild pomegranate and preparation of *Anardana*

1.1 Composition of raw material (Wild pomegranate): Among various physico-chemical characteristics of wild pomegranate fruits studied, the average length, breadth and weight were found to be 58.40 mm, 52.10 mm and 92.73 g, respectively. The colour of fruits and arils was observed to be yellowish green and red purple (60 A), respectively. The weight of arils per fruit and weight of 100 arils was observed to be 51.80 g and 15.80 g, respectively. Arils were found to contain moisture and total solids as 71.53 per cent and 28.47 per cent, respectively. The titratable acidity of the arils was 3.84 per cent, whereas, the pH was 2.72. Arils also contained 7.39 per cent, 9.15 per cent, 19.79 mg/100g and 9.06 mg/100g of reducing sugars, total sugar, ascorbic acid and anthocyanins, respectively. The total phenols content of arils was 105.40 mg GAE/100g and antioxidant activity was observed to be 42.18 per cent.

Wild pomegranate fruits

Wild pomegranate arils

1.2. Comparison of different drying modes were used for the preparation of *Anardana*: Before drying, the arils were steam blanched for 30 sec followed by sulphur fumigation (0.3% for 60 min). While comparing different drying modes, mechanical cabinet dried arils possessed maximum TSS (45.20°B), titratable acidity (11.40%), ascorbic acid (11.70 mg/100g), reducing sugars (21.91%), total sugars (25.45%), anthocyanins (33.76 mg/100g), phenols (126.05 mg/100g), crude fibers (35.91%), oil (8.89%) and antioxidant activity (65.22%). It took minimum time (26 h) to dry a given tray load (3 kg), had minimum NEB (0.06 OD), furfural (11.89 ppb) and HMF (0.90 ppm). Mechanical cabinet dried arils were rated best among all drying modes on the basis of highest sensory scores of colour (8.00), texture (8.00), taste (8.56) and overall acceptability (8.55).

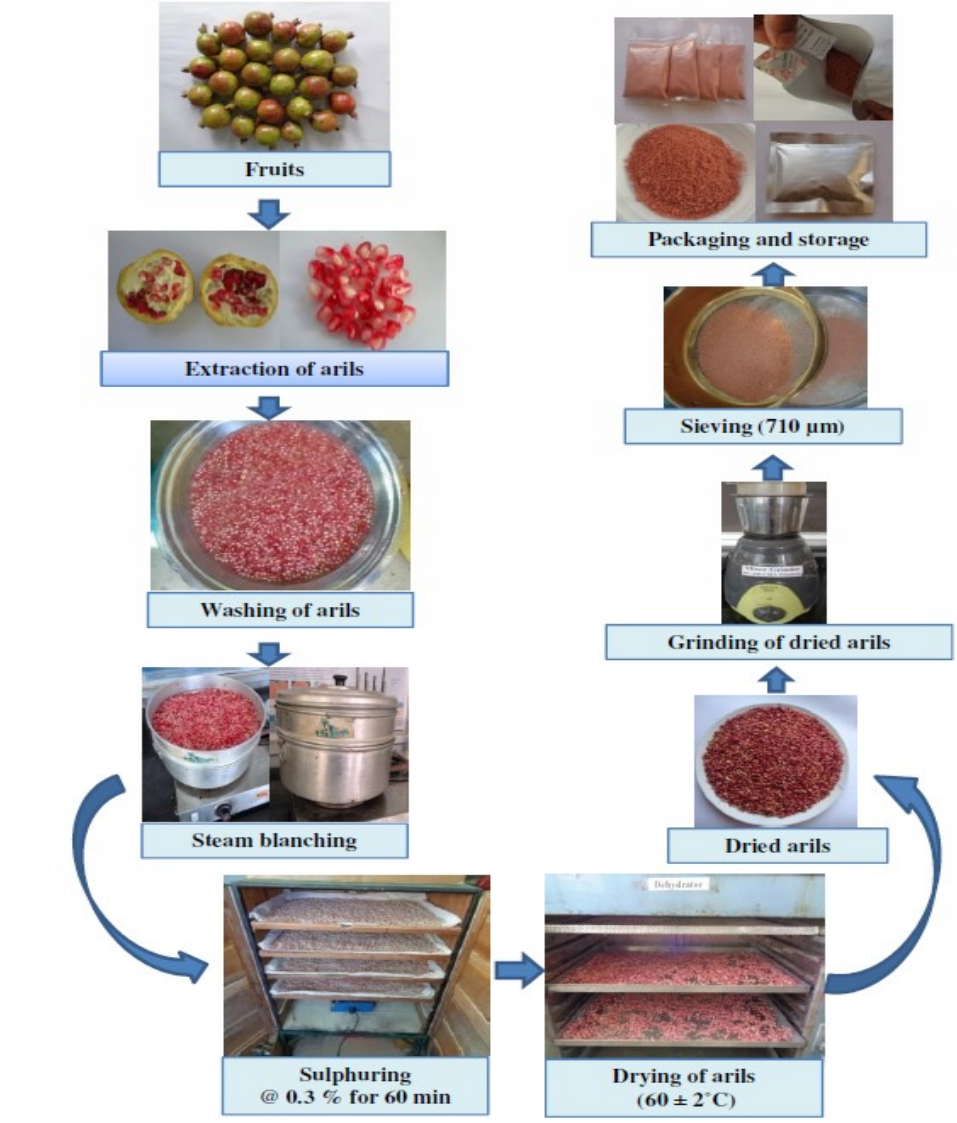
Solar tunnel drier

Sun drying

Mechanical cabinet drier

2. Comparison of granular powder prepared from dried arils (A*nardana*) using different drying methods:

Arils dried in different drying modes were ground to granular powder form in laboratory scale grinder and passed through 22 mesh sieves (710 µm). While comparing the physico-chemical characteristics of granular powder prepared from mechanical cabinet dried arils possessed maximum TSS (44.90°B), titratable acidity (11.25%), ascorbic acid (11.21 mg/100g), reducing sugars (21.36%), total sugars (25.06%), anthocyanins (33.09 mg/100g), phenols (125.61 mg/100g), crude fibers (35.85%), oil (8.67%) and antioxidant activity (64.98%) and minimum NEB (0.08 OD), furfural (12.29 ppb) and HMF (0.98 ppm). Powder prepared from mechanical cabinet dried arils were rated best among all drying modes on the basis of highest sensory scores of colour (8.45), texture (8.00), taste (8.50) and overall acceptability (8.55).



Unit operations for the preparation of granular powder from wild pomegranate arils

3. Storage study of granular powder from dried arils (A*nardana*): Granular powder prepared from mechanical cabinet dried arils was packed in PEP (polyethylene pouches), ALP (Aluminium laminated pouches), ALP with oxygen scavenger, ALP with oxygen and moisture scavenger, ALP with moisture scavenger and stored for 6 months under ambient as well as refrigerated temperature conditions. More or less

all physico-chemical characteristics of powder exhibited some changes during storage. However, minimum changes were observed in powder packed in ALP with oxygen and moisture scavenger (T_4) with respect to colour properties besides slight increase in moisture from 5.85 to 5.89 per cent, water activity from 0.179 to 0.185, pH from 2.96 to 2.97, reducing sugars from 21.21 to 21.28 per cent, NEB from 0.052 to 0.057 OD, HMF from 0.96 to 1.16 ppm and furfural from 12.12 to 16.97 ppb during storage. Whereas, minimum decrease was observed in titratable acidity from 10.85 to 10.78 per cent, total sugars from 25.01 to 24.96 per cent, TSS from 44.60 to 44.52°B, ascorbic acid 11.10 to 10.91 mg/100g, anthocyanins 34.21 to 33.49 mg/100g, total phenols from 125.14 to 124.13 mg/100g and antioxidant activity 64.48 to 64.03 per cent in the same packaging material ALP with oxygen and moisture scavenger (T_4) during storage of six months. Sensory characteristics scores of powder decreased for colour from 8.51 to 8.10, texture from 8.00 to 7.84, taste from 8.50 to 8.30 and overall acceptability from 8.50 to 8.07 during storage. So, granular powder in ALP with oxygen and moisture scavenger (T_4) exhibited superior quality in terms of physico-chemical and sensory properties when compared to other packaging treatments. The cost of production of per kg powder in best packaging treatment i.e. ALP with oxygen and moisture scavenger (T_4) was recorded as Rs. 343.66, whereas, it was recorded as Rs.342.40 in next best treatment (ALP with moisture scavenger).

Conclusion and Recommendation

8. *Anardana* is the commercial product prepared from wild pomegranate arils which is a rich source of organic acids and antioxidants besides other chemical constituents.

9. The present studies were conducted with the aim to exploit its properties for the preparation of granular powder for instant use. The pre-treated arils of wild pomegranate can be dried in mechanical cabinet drier (60±2°C) and ground to powder form (710 µm particle size).

10. The granular powder can be packed in aluminium laminated pouch with oxygen and moisture scavenger successfully and can be stored under ambient and refrigerated storage conditions, since the presence of both the scavengers retained the quality of granular powder and enhanced the product stability to a greater extent.

11. The cost of production of granular powder prepared in mechanical cabinet drier and packed in ALP with oxygen and moisture scavenger was comparable to the cost of the similar product available in the market. The prepared granular powder can be utilized instantly and more conveniently for various culinary preparations.

Annexure–6

Sub-Project: Soybean enriched apple pomace flour roll

In the present investigation, functional food rolls were developed by incorporating soybean powder into apple pomace flour along with investigating the quality and safety of the developed roll during storage. Apple pomace is a bio-residue left after extraction of juice from grated fruits and represents 25 - 40 per cent of total apple bio-waste, which currently has less use as most of it is dumped into landfills and this contributes to pollution. Apple pomace has good nutritional value however, contains minimal amount of protein and can therefore, be blended with soybean to increase its protein content and enrich it with isoflavones like genistein. Apple pomace flour is rich in dietary fibre (43.89%), ascorbic acid (10.30 mg/ 100 g), total polyphenols (8.97 mg/ 100 g) and antioxidant activity (67.63%). Soybean powder has good nutritional quality, unsprouted soybean contains 49.70 %, 12.34 mg/ 100 g and 1.86 mg/ 100 g while sprouted soybean contains 54.80 %, 25.90 mg/ 100 g and 1.90 mg/ 100 g of protein, ascorbic acid and total flavonoids, respectively. For the preparation of rolls, apple pomace was blended with both sprouted and unsprouted soybean powder. The proportions 75: 25 of apple pomace flour to unsprouted soybean powder and 65: 35 of apple pomace flour to sprouted soybean powder were optimized by sensory evaluation. The developed rolls were analysed for physico- chemical, sensory evaluation and microbial analysis during 6 months storage. Results showed that there were minimal changes in the physico-chemical and sensory attributes of rolls during storage however, highest retention of nutritional quality was observed in rolls packed in aluminium laminated pouches under refrigeration. Further, maximum changes in quality parameters were observed in rolls packed in polyethylene pouches at ambient condition. The rolls were also shelf-stable and safe for consumption during 6 months of the study period. The present study has also proved that apple pomace could be enriched with soybean especially, sprouted soybean to yield a nutrient dense functional roll with high protein content and additional bioactive compounds like total flavonoids. This developed technology has commercial application to solve the utilization issues of large amounts of apple pomace generated by the apple juice processing industry. Accordingly, it has the benefit of generating extra income for the apple juice processing industry entrepreneurs besides, providing a new functional food item to the health-conscious consumers.

Details of Experiments conducted:

Objective 1: Preparation of Apple Pomace Flour, unsprouted soybean powder and sprouted soybean powder

The fresh apple varieties (Gale Gala, Golden Delicious, Jermaine, Red Cap Valtod, Red Gold, Redlum Galla and Red Velox) were procured from the Department of Fruit Science, Dr Yashwant Singh Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh. Soybean was procured from the local market at Solan. Other material such as jaggery, aluminium foil (AF), aluminium laminated pouches (ALP), and polyethylene pouches (LDPE) were purchased from the Solan market.

1.1 Preparation of Apple Pomace Flour

Apple fruits were selected and washed thoroughly. The washed fruits were then cut into halves by using stainless steel knives and the halved apples were passed through a Grater. Juice was then extracted from the grated apples with a hydraulic press. Pomace obtained was steam blanched for 6 min. The blanched apple pomace was dried in a mechanical cabinet dryer at 60 ± 2˚C for 18 h. After drying the pomace was ground in a

grinder and sieved through a 30-mesh sieve (500 µm) to obtain flour. The flour was then packed in aluminium pouches and stored under refrigerated conditions.

1.2 Preparation of unsprouted soybean powder and sprouted soybean powder

1.2.1 Unsprouted soybean powder

Unsprouted soybean powder was processed with some modifications. Soybean seeds were cleaned and soaked in water overnight. Soaking water was decanted and the soybean was boiled open lid for 30 min. Boiled soybean was washed several times with clean water and drained followed by drying in a mechanical dehydrator at 60 ± 2˚C for 15 h. The dried soybean was milled in a grinder and passed through a 30-mesh sieve (500 µm) to obtain powder. The powder was packed in aluminium pouches and stored under refrigerated conditions.

1.2.2 Sprouted soybean powder

For the preparation of sprouted soybean powder, soybean seeds were cleaned and soaked in water overnight. The soaked beans were drained, spread on muslin cloth and covered with another one. The seeds were left to germinate for 72 h and were sprinkled with tap water once a day. The sprouted soybeans were steam blanched for 3 min to inactivate the enzymes followed by drying in a mechanical cabinet dryer at 60 ± 2˚C for 15 h. The dried sprouted soybean was milled in a grinder and passed through a 30-mesh sieve (500 µm) to obtain powder. The powder was packed in aluminium pouches and stored under refrigerated conditions.

2. Standardization of different proportion of apple pomace flour and soybean flour

2.1 Preparation of soybean enriched apple pomace flour roll

Apple pomace flour and soybean powder (sprouted/ unsprouted) were mixed and water was added as per the treatment details mentioned in Tables 1 and 2. The mixture was mixed properly with a blender and analyzed for total soluble solids (TSS) and titratable acidity. For maintaining the total soluble solids (10, 15, 20 and 25^{o}B), jaggery was added as per the treatment's requirement. The acidity was kept constant i.e. 0.40 per cent as malic acid in all the treatments. After addition of jaggery and citric acid, the mixture was further blended for proper homogenization and heated on medium heat for 10 min with constant stirring. The prepared mixture was spread on stainless steel trays covered with lightly greased aluminium foil. The mixture was dried at 60 ± 2˚C for 10 h in a mechanical dehydrator until it was easily removed from the aluminium foil and had a shiny, smooth and leather like finish. The prepared rolls were subjected to sensory evaluation by a panel of ten judges on 9-point Hedonic scale. The best treatment was selected on the basis of score awarded for colour, flavour, texture and overall acceptability.

Table 1. Treatments for the preparation of unsprouted soybean enriched apple pomace flour roll

Treatment	Apple pomace flour (%)	Unsprouted soybean powder (%)	Total soluble solids level raised with jaggery (°B)
T_0	100	0	Natural
T_1	90	10	10, 15,20 and 25
T_2	85	15	10,15,20 and 25
T_3	80	20	10,15,20 and 25
T_4	75	25	10,15,20 and 25
T_5	70	30	10,15,20 and 25
T_6	65	35	10, 15,20 and 25

Table 2. Treatments for the preparation of sprouted soybean enriched apple pomace flour roll

Treatment	Apple pomace flour (%)	Sprouted soybean powder (%)	Total soluble solids level raised with jaggery (°B)
T_0	100	0	Natural
T_1	90	10	10, 15, 20 And 25
T_2	85	15	10, 15, 20 And 25
T_3	80	20	10, 15, 20 And 25
T_4	75	25	10, 15, 20 And 25
T_5	70	30	10, 15, 20 And 25
T_6	65	35	10, 15, 20 And 25
T_7	60	40	10, 15, 20 And 25

2.2 Packaging and storage of soybean enriched apple pomace flour rolls

The best rated soybean (unsprouted and sprouted) enriched apple pomace flour rolls were packed in LDPE pouches and aluminum laminated pouches (ALP). The product was stored under ambient (1.9 – 29.7˚C) and refrigerated (4 - 7˚C) conditions for a period of 6 months and were analyzed for changes in various chemical, sensory and microbiological characteristics at different storage intervals (0, 3 and 6 months).

Experimental results

1. Composition of raw material

1.1 Apple pomace flour: Apple pomace powder utilized in this study was found to contain moisture (6.72%), total soluble solids (25.73ºB), pectin (6.02%), dietary fibre (43.89%), ascorbic acid (10.30mg/ 100 g), total polyphenols (8.97 mg/ 100 g) and antioxidant activity (67.63%).

1.2 Soybean (unsprouted/ sprouted) powder: The various physico-chemical characteristics of unsprouted soybean powder used in present study were moisture (6.72%), protein (49.70%), fat (23.79%) and carbohydrates (16.32%). The ascorbic acid, total polyphenols and total flavonoids were recorded as 12.34mg/ 100 g, 13.2

mg/ 100 g and 1.86 mg/ 100 g, respectively. However, average moisture, protein, fat and carbohydrates in sprouted soybean powder were recorded to be 6.92%, 54.80%, 16.72% and 16.66%, respectively. Further, it contained a higher amount of ascorbic acid (25.90 mg/ 100 g), total polyphenols (21.07 mg/ 100 g) and total flavonoids (1.90 mg/100 g).

2 Standardization of different proportions of apple pomace flour and soybean flour

2.1 Soybean (unsprouted/ sprouted) enriched apple pomace flour rolls

Among different combinations tried, the roll prepared by using 75 per cent of apple pomace flour and 25 per cent of unsprouted soybean power (75:25) was adjudged the best by the panelists in terms of colour, texture, taste and overall acceptability scores and this proportion was selected for the preparation of rolls. Similarly, a ratio of 65:35 (apple pomace flour: sprouted soybean powder) was finalized for the preparation of soybean enriched apple pomace flour rolls.

2.2 Proximate composition of soybean enriched apple pomace flour rolls

2.2.1 Unsprouted soybean enriched apple pomace flour rolls: The following observations were recorded in unsprouted soybean enriched apple pomace flour roll, moisture (15.33%), protein (17.57%), dietary fibre (40.02%) ascorbic acid(12.32 mg/ 100 g), titratable acidity (1.34%), pH (4.32), reducing sugars (27.34%), total sugars (56.46%), total flavonoids (1.52 mg/ 100 g), antioxidant activity (67.38%), total polyphenols (11.54 mg/ 100 g) and pectin (6.85%).

2.2.2 Sprouted soybean enriched apple pomace: In sprouted soybean enriched apple pomace flour roll, moisture (15.38%), protein (18.51%), dietary fibre (32.18%) ascorbic acid (15.67 mg/ 100 g), titratable acidity (1.47%), pH (4.70), reducing sugars (23.24%), total sugars (52.35%), total flavonoids (1.85 mg/ 100g), antioxidant activity (77.73%), total phenols (13.56 mg/ 100 g) and pectin (6.52%) were observed.

2.3. Effect of storage and packaging material on physico-chemical characteristics and sensory attributes of soybean (unsprouted/ sprouted) enriched apple pomace flour rolls

The soybean (unsprouted/ sprouted) enriched apple pomace flour rolls exhibited a slight increase in total soluble solids, reducing sugars and pH whereas, other parameters i.e. moisture, protein, fat, dietary fibre, total sugars, ash, ascorbic acid, total polyphenols, antioxidant activity, total flavonoids, titratable acidity and pectin were slightly decreased in both unsprouted and sprouted soybean enriched apple pomace flour rolls. The rolls could be stored safely for a period of 6 months under ambient and refrigerated storage conditions and also in both the packaging materials i.e. aluminium laminated pouches and polyethylene pouches. However, minimal chemical changes were observed in rolls packed in aluminium laminated pouches under refrigerated storage while, the maximum changes occurred in rolls packed in polyethylene pouches under ambient condition. Microbial examination showed that the rolls were shelf-stable and safe for consumption up to 6 months of storage under both storage conditions. A slight decline in sensory scores was observed, however, the rolls were palatable after 6 months storage with overall acceptability scores of more than 7 on a 9-point hedonic scale.

Conclusion and Recommendation

12. Apple pomace, a bio-waste of apple juice processing industry can be dried to maintain its quality and improve its shelf-stability. In its powder form, apple pomace has a good nutritional profile and is a potent source of phytochemicals. The present study has also proved that apple pomace can be enriched with soybean especially, sprouted soybean to yield a nutrient dense functional roll with high protein content and additional bioactive compounds like total flavonoids. The development of soybean enriched apple pomace flour roll technology provides another alternative of apple pomace value-addition and utilization which otherwise is a bio-waste of the apple juice processing industry.

13. Storage studies revealed that soybean enriched apple pomace flour rolls could retain their nutritional quality up to 6 months of storage. Similarly, there was minimal change in sensory parameters during the storage period rendering the product to be tasty and palatable during the entire storage period.

14. The cost of production elucidates that the protein and phytochemicals rich soybean enriched apple pomace flour rolls could be manufactured and sold at a reasonable price. This developed technology has commercial application both in the country and globally to solve issues of large amounts of apple pomace generated by the apple juice processing industry.

Annexure–7

Sub-Project: Pseudocereals-based carrot pomace flour enriched bakery products

The study was aimed at the development of pseudocereals-based biscuit and cake by incorporating carrot pomace flour and evaluating its safety and quality attributes during storage. Pseudocereals such as buckwheat, amaranth and quinoa are gluten-free grains rich in essential nutrients and phenolic acids which render them effective against many degenerative diseases such as cancer, CVD, diabetes etc. Buckwheat flour is an excellent source of phenols exhibiting total phenol content of 309.36 mg GAE/ 100 g and antioxidant activity of 80.60%. Quinoa is also a good source of total phenols (79.58 mg/ 100 g) and protein (13.69%). Amaranth, on the other hand contains highest protein content of 14.31% and ash content of 2.98%, among pseudocereals. Alternatively, carrot pomace flour is an excellent source of carotenoids (17.81 mg/ 100 g), crude fibre (15.87 %) and total sugars (17.34 %). The development of pseudocereal-based biscuit and cake involved blending of carrot pomace flour with buckwheat, quinoa and amaranth flour in different proportions and best combination was used for further studies. Buckwheat-based biscuit and cake were prepared by blending buckwheat flour and carrot pomace flour in ratios of 78:22 and 72:28, respectively while for quinoa-based biscuit and cake, quinoa flour and carrot pomace flour in the ratio of 72:28 were used. Similarly, amaranth-based biscuit and cake were prepared by blending the flours in the ratio of 66:34. Biscuit were safe for consumption up to 90 days of storage, while the cake stored under refrigerated condition were shelf-stable and palatable up to 30 days however, under ambient conditions could be stored safely up to 20 days. Therefore, the developed products are the perfect example of bio-waste utilization and holds potential for commercial application.

<u>Details of Experiments conducted</u>:

Objective1: Preparation of pseudocereals and carrot pomace flour

Pseudocereal grains i.e. buckwheat, quinoa and amaranth were procured from National Bureau of Plant Genetic Resources (NBPGR) Research Station, Shimla, while carrots were purchased from fruit and vegetable market at Solan, Himachal Pradesh. The ingredients required such as sugar, refined oil, salt, baking powder, baking soda, eggs and polyethylene pouches were procured from local market at Nauni, Solan. The pseudocereal flours were prepared by grinding the grains in the grinder and passing through a 30-mesh sieve. The flours acquired were then packed in polyethylene pouches and stored under ambient conditions for future use. Similarly, the carrot pomace flour was prepared by following different unit operations like sorting, washing, peeling, grating and extracting the juice using hydraulic press. After taking out the juice, the left-over bio-waste known as carrot pomace, was subjected to steam blanching for 4 min and treated with 1000 ppm potassium metabisulphite (KMS). Pomace was shifted to drying trays and dried in mechanical cabinet drier for 15 h at 60 ± 5°C. The dried pomace was grinded and sieved through 30 mesh-sieve. Carrot pomace flour thus obtained was packed in laminated aluminium pouches and stored under refrigerated conditions until further use.

Preparation of carrot pomace flour

Objective 2: Standardization of recipe for the preparation of bakery products

2.1 Preparation of pseudocereal-based biscuit

Biscuit were prepared using ingredients in different combinations and recipe as mentioned in Table-1. Fat (refined oil) and powdered sugar were mixed together and beaten until the mixture became creamy. Other ingredients were mixed properly and the above prepared creamy mixture was added to the ingredients and made into dough using required amount of water. The prepared dough was kneaded thoroughly for 10 min and after wrapping in aluminium foil, was kept at room temperature for 30 min. Dough was sheeted manually using a rolling pin to form a uniform sheet of 0.5 cm thickness. The sheet was then cut into shapes using a cookie/ biscuit cutter. The cut pieces were transferred to baking trays lined with butter paper and baked at 150°C in an oven for 25 min. The prepared product was allowed to cool at room temperature, before packaging.

Table 1 Formulations of biscuit

Ingredient	Composition (g)
Pseudocereal flour	100
Fat	40
Sugar powder	35
Baking powder	2
Xanthan gum powder	1

2.2 Preparation of pseudocereal-based cake

The cake was prepared by following the standardized recipe (Table-2), with slight modifications. Fat (refined oil) and powdered sugar were mixed together and beaten until the mixture became light and fluffy. Eggs were beaten separately and added to the above mixture with continued mixing. Dry ingredients i.e. flour and baking powder were mixed properly and added to the fluffy mass. The whole mixture was whipped constantly to achieve a batter of desired consistency. The prepared batter was poured in pre-greased baking mould and after proper leveling and setting, was baked in pre-heated oven at 200˚C temperature for 30 min. Cake after baking was allowed to cool at room temperature, prior to packaging.

Table 2 Formulations of cake

Ingredient	Composition (g)
Pseudocereal flour	100
Eggs (without shells)	120
Fat	50
Sugar powder	60
Baking powder	2

Objective 3: Standardization of different proportion of pseudocereals and carrot pomace flour for the preparation of bakery products (biscuit and cake)

3.1 Biscuit

Three types of biscuit were prepared using each, buckwheat (Table-3), quinoa flour (Table-4) and amaranth (Table-5). Weighed quantity of selected flour was supplemented with different proportions of carrot pomace flour ranging from 0 - 40 per cent depending upon the pseudocereal flour. The biscuit prepared were evaluated in terms of sensory parameters by a panel of 10 judges on a 9-point Hedonic scale and the treatment having highest overall acceptability was selected for the future studies. Details of the treatments are given below:

Table 3 Detail of treatments for the preparation of buckwheat-based biscuit

Treatment	Buckwheat flour (%)	Carrot pomace flour (%)
T_0	100	0
T_1	90	10
T_2	84	16
T_3	78	22
T_4	72	28
T_5	66	34
T_6	60	40

Table 4 Detail of treatments for the preparation of quinoa-based biscuit

Treatment	Quinoa flour (%)	Carrot pomace flour (%)
T_0	100	0
T_1	90	10
T_2	84	16
T_3	78	22
T_4	72	28
T_5	66	34
T_6	60	40

Table 5 Detail of treatments for the preparation of amaranth-based biscuit

Treatment	Amaranth flour (%)	Carrot pomace flour (%)
T_0	100	0
T_1	90	10
T_2	84	16
T_3	78	22
T_4	72	28
T_5	66	34
T_6	60	40

3.1.1 Packaging and storage of carrot pomace enriched biscuit

Biscuit were packed in polyethylene pouches (0.75 mm gauge), heat sealed and stored under ambient (19 - 29.7°C) and refrigerated (4˚C) conditions to evaluate their quality during storage period of 90 days. Biscuit were analyzed every 30 days for 3 months for its chemical, microbiological and sensory characteristics.

3.2 Cake

Three types of cake were prepared using each, buckwheat (Table-6), quinoa flour (Table-7) and amaranth (Table-8). In each case, pseudocereal flour was substituted with different levels of carrot pomace powder (0, 10, 16, 22, 28, 34 and 40%) depending upon the pseudocereal flour, prepared cakes were evaluated in terms of sensory parameters by a panel of 10 judges using a 9-point Hedonic scale. The combination/ treatment having highest overall acceptability was selected for the further studies. Details of the treatments are given below:

Table 6 Detail of treatments for the preparation of buckwheat-based cake

Treatment	Buckwheat flour (%)	Carrot pomace flour (%)
T_0	100	0
T_1	90	10
T_2	84	16
T_3	78	22
T_4	72	28
T_5	66	34
T_6	60	40

Table 7 Detail of treatments for the preparation of quinoa-based cake

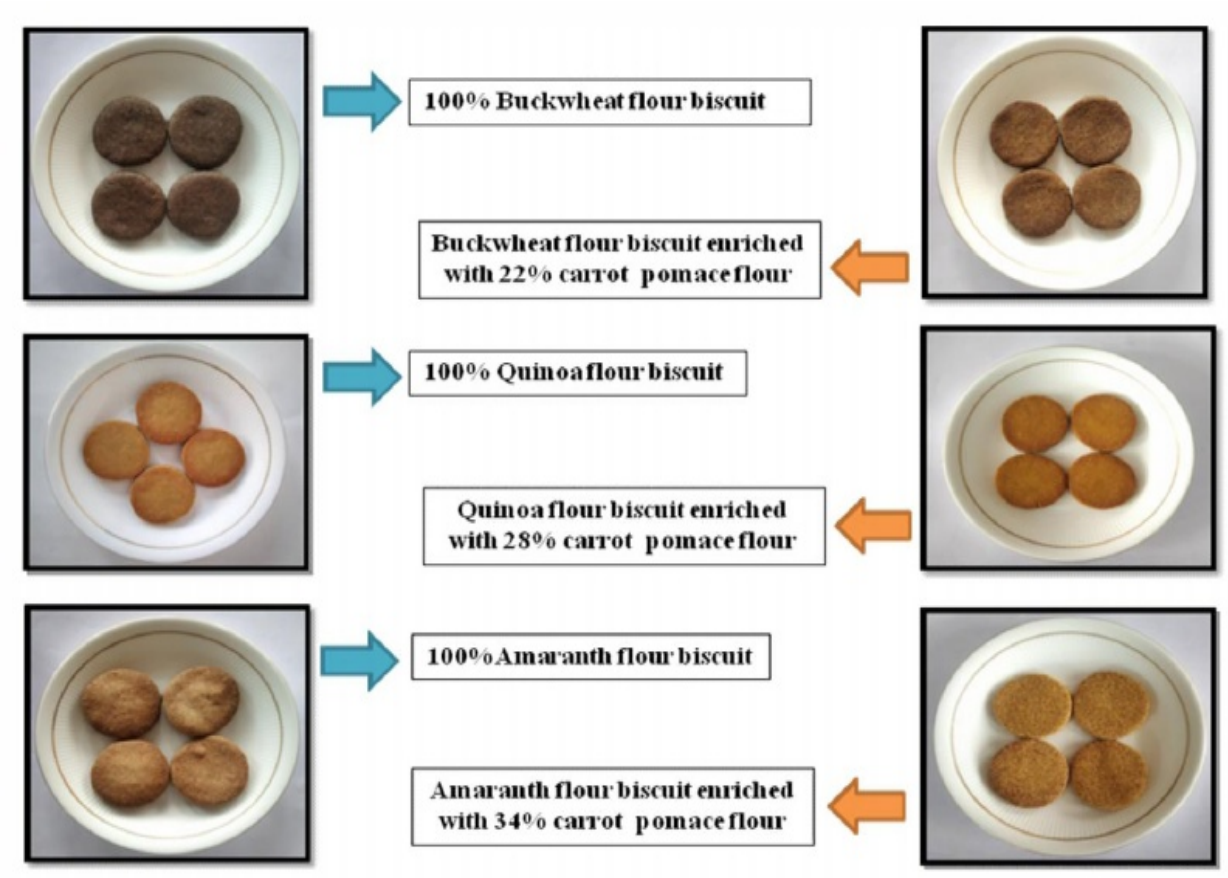
Treatment	Quinoa flour (%)	Carrot pomace flour (%)
T_0	100	0
T_1	90	10
T_2	84	16
T_3	78	22
T_4	72	28
T_5	66	34
T_6	60	40

Table 8 Detail of treatments for the preparation of amaranth-based cake

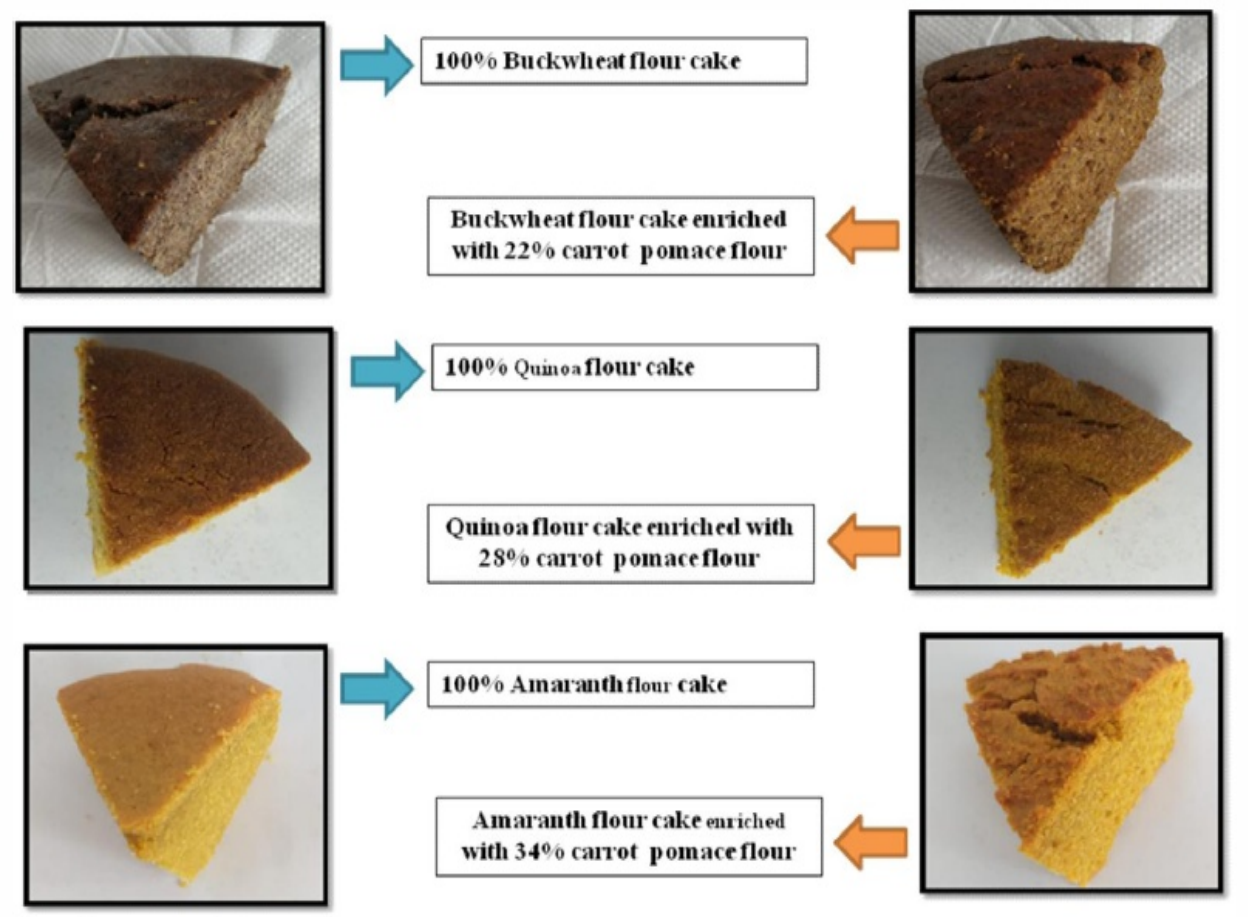
Treatment	Amaranth flour (%)	Carrot pomace flour (%)
T_0	100	0
T_1	90	10
T_2	84	16
T_3	78	22
T_4	72	28
T_5	66	34
T_6	60	40

3.2.1 Packaging and storage study of carrot pomace flour enriched cake

Cakes were packed in polyethylene pouches (0.75 mm gauge) and were analyzed for their storage stability under ambient (1.9 - 29.7˚C) and refrigerated (4˚C) conditions. The prepared product was subjected to physico-chemical evaluation at an interval of 0, 10, 20 and 30 days.



Pseudocereal-based biscuit enriched with carrot pomace flour



Pseudocereal-based cake enriched with carrot pomace flour

Experimental results

1. Composition of raw material

1.1 Buckwheat flour : Buckwheat flour utilized in the study recorded 10.93 per cent moisture, 1.76 per cent ash, 2.28 per cent fat, 3.54 per cent crude fibre, 12.36 per cent protein, 69.13 per cent carbohydrate, 0.66 per cent reducing sugars, 2.12 per cent total sugars, 309.36 mg GAE/ 100 g total phenols and 80.60 per cent antioxidant activity.

1.2 Quinoa flour : Quinoa flour contained 12.02 per cent moisture, 2.48 per cent ash, 5.27 per cent fat, 3.56 per cent crude fibre, 13.69 per cent protein, 62.98 per cent carbohydrate, 0.70 per cent reducing sugars, 2.34 per cent total sugars, 79.58 mg GAE/ 100 g total phenols and showed an antioxidant activity of 58.26 per cent.

1.3 Amaranth flour : Amaranth flour exhibited moisture (9.10%), ash (2.98%), fat (6.17%), crude fibre (4.75%), protein (14.31%), carbohydrate (62.69%), reducing sugars (0.64%), total sugars (1.91%) and total phenols (28.40 mg GAE/ 100 g) having an antioxidant activity of 13.94 per cent.

1.4 Carrot pomace: Fresh carrot pomace recorded 87.35 percent moisture, 1.56 per cent ash, 7.12 per cent crude fibre, 4.30 per cent total soluble solids, 1.56 per cent reducing sugars, 4.46 per cent total sugars and 0.11 per cent titratable acidity. Further, its pomace contained bioactive compounds such as carotenoids (1.93 mg/ 100 g) and phenols (7.29 mg GAE/ 100 g) having an antioxidant activity of 6.22 per cent. On the other hand, dried carrot pomace flour (CPF) exhibited 6.71 per cent moisture, 5.28 per cent ash, 15.87 per cent crude fibre, 20 per cent total soluble solids, 11.13 per cent reducing sugars, 17.34 per cent total sugars and 0.87 per cent titratable acidity. CPF also recorded 17.81 mg/ 100 g carotenoids, 63.79 mg GAE/ 100 g total phenols reflecting 52.28 per cent antioxidant activity.

2. Gluten-free bakery products (biscuit and cake)

2.1 Biscuit

Different treatment combinations were prepared for each type of biscuit and the combination which indicated highest overall acceptability was selected for evaluation during storage. In buckwheat-based biscuit, the treatment using 78 per cent buckwheat flour and 22 per cent carrot pomace flour was adjudged as the best in terms of qualitative analysis. Meanwhile in quinoa flour biscuit, the treatment with 72 per cent quinoa flour and 28 per cent carrot pomace flour showed highest sensory scores. Similarly, the amaranth biscuit containing 66 per cent amaranth flour and 34 carrot pomace flour was most acceptable by the sensory panel members.

2.2 Cake

Optimization of level of carrot pomace flour in pseudocereal-based cake was conducted by subjecting the treatments to sensory evaluation by panel members on a 9-point Hedonic scale. In buckwheat and quinoa-based cake, the treatment containing 72 per cent pseudocereal flour and 28 per cent carrot pomace flour was awarded maximum scores for overall acceptability and was chosen for further studies. However, in amaranth-based cake, the treatment prepared using 66 per cent amaranth flour and 34 per cent carrot pomace flour was favored most by the panel members and was selected for evaluating the stability during storage.

3 Proximate composition of pseudocereal based carrot pomace enriched bakery products (biscuit and cake)

3.1 Biscuit

3.1.1 Buckwheat-based biscuit

In carrot pomace enriched buckwheat-based biscuit, moisture (4.82%), ash (2.05%), crude fibre (5.76%), reducing sugars (2.65%), total sugars (10.23%) and total carotenoids (4.02 mg/ 100 g) were higher than the control containing only buckwheat flour. However, fat (18.79%), protein (7.91%), total phenols (90.53 mg GAE/ 100 g) and antioxidant activity (71.23%) of carrot pomace enriched biscuit were relatively lower than the control.

3.1.2 Quinoa-based biscuit

Quinoa biscuits enriched with carrot pomace flour contained higher moisture (4.98%), ash (2.63%), crude fibre (6.55%), reducing sugars (3.33%), total sugars (10.73%) and total carotenoids (5.06 mg/ 100 g) than control (quinoa flour biscuits). However, the protein (8.62%), fat (18.32), total phenols (34.40 mg GAE/ 100 g) and antioxidant activity (53.49%) of the dried carrot pomace flour enriched biscuits was comparatively lower.

3.1.3 Amaranth-based biscuit

Amaranth-based biscuit enriched with carrot pomace recorded moisture (5.11%), ash (3.09%), crude fibre (8.04%), reducing sugars (3.85%), total sugars (11.09%), total carotenoids (5.97 mg/ 100 g), total phenols (25.24 mg GAE/ 100 g) and antioxidant activity (21.49%) higher than the amaranth flour biscuit (control) whereas, protein (9.00%) and fat (17.23%) contents were comparatively lower than those of control.

3.2 Cake

3.2.1 Buckwheat-based cake

Buckwheat-based cake enriched with carrot pomace flour recorded higher moisture (23.19%), ash (2.53%), crude fibre (6.68%), reducing sugars (3.03%), total sugars (14.05%) and carotenoids (5.29 mg/ 100 g) than cake prepared from 100 per cent buckwheat flour. However, protein (12.26%), fat (17.83%), total phenols (89.19 mg GAE/ 100 g) and antioxidant activity (70.65%) of carrot pomace enriched cake was relatively lower than the control.

3.2.2 Quinoa-based cake

In quinoa-based carrot pomace enriched cake, moisture (23.95%), ash (3.06%), crude fibre (6.83%), reducing sugars (3.08%), total sugars (14.12%) and total carotenoid (5.21 mg/100 g) content were observed higher than the cake prepared from 100 per cent quinoa flour, whereas protein (12.61%), fat (17.13%), total phenols (34.57 mg GAE/ 100 g) and antioxidant activity (54.55%) of carrot pomace enriched cake were found relatively lower.

3.2.3 Amaranth-based cake

Amaranth-based cake enriched with carrot pomace flour recorded higher moisture (21.16%), ash (3.58%), crude fibre (8.40%), reducing sugars (3.58%), total sugars (14.23%) carotenoids (6.08 mg/ 100 g), total phenols (27.41 mg GAE/ 100 g) and antioxidant activity (21.57%) than the cake prepared from 100 per cent amaranth flour. However, comparatively lower values were obtained for protein (13.89%) and fat (15.61%) contents.

4 Storage Study

4.1 Effect of storage on quality of pseudocereal-based biscuit enriched with carrot pomace flour

With the advancement of storage period of 90 days, there was a slight increase in the moisture, reducing sugars and total sugars of biscuit whereas, ash, protein, fat, crude fibre,

total carotenoids, total phenols and antioxidant activity of the biscuit showed a decreasing trend. Sensory evaluation scores indicated a considerable effect of storage on the texture, taste and overall acceptability of the product, however, the sensory scores were still within the satisfactory range (above 7 on 9-point Hedonic scale) and product was found acceptable by the panelists at the end of 90 days storage period. Microbiological analysis of biscuit indicated that biscuits were safe for consumption at the end of 90 days storage period under refrigerated as well as room temperatures. Therefore, the carrot pomace flour and pseudocereal flours in different proportions were adjudged to be capable of utilization in development of gluten-free biscuit.

4.2 Effect of storage on quality of pseudocereal-based cake enriched with carrot pomace flour

As the storage period progressed, there was a slight increase in reducing sugars and total sugars whereas, all other parameters *viz*., moisture, ash, fat, protein, crude fibre, total carotenoids, total phenols and antioxidant activity exhibited a decreasing trend. Microbial analysis of the product at the end of 30 days showed that the cake stored under ambient condition had total plate count more than the prescribed limits and thus was discarded. However, cake stored under refrigerated condition was found shelf-stable and safe for consumption up to 30 days of storage. Sensory evaluation indicated a gradual decrease in overall acceptability of cake during storage but, the product under refrigerated condition was palatable at the end of storage period with sensory scores above 7 on a 9-point Hedonic scale. Therefore, pseudocereal flours and carrot pomace in different proportions could be successfully utilized for the preparation of nutritionally enriched gluten-free cake.

5 COST OF PRODUCTION

5.1 Cost of production of pseudocereal-based biscuit

The cost of production of buckwheat-based biscuit with and without carrot pomace flour was Rs.13.86/ 100 g and Rs.15.31/ 100 g, respectively. Likewise, cost of production of quinoa-based biscuit with carrot pomace flour and without carrot pomace flour was Rs.21.39/100 g and Rs.25.99/ 100 g, respectively. Similarly, preparation of amaranth biscuit enriched with carrot pomace flour costs Rs.11.40/ 100 g and amaranth flour biscuit costs Rs.13.12/ 100 g.

5.2 Cost of production of pseudocereal-based cake

The cost of production of buckwheat-based cake with and without carrot pomace flour worked out to be Rs.14.14/ 100 g and Rs.15.14/ 100 g, respectively. Similarly, cost of production of quinoa-based cake enriched with carrot pomace flour was Rs.18.52/ 100 g and without carrot pomace flour was Rs.21.00/ 100 g. Preparation of amaranth cake enriched with carrot pomace flour costs Rs.13.43/ 100 g, while cake without enrichment costs Rs.14.40/100 g.

Conclusion and Recommendation

1. Pseudocereals are gluten-free grains which can be processed into flour to be utilized as a component of bakery products in order to improve their functional properties, antioxidant potential and basic nutritive value.

2. Carrot pomace contains adequate amount of fibre and bioactive compounds such as carotenoids and polyphenolics and therefore, after drying the carrot pomace, flour could be used for the enrichment of biscuits, cakes and other bakery products.

3. The partial replacement of pseudocereal flour with carrot pomace flour positively support the improvement of functional and quality attributes of the bakery products and serves as another alternative for the utilization of bio-waste (pomace) generated by the carrot juice-processing industry.

4. The enrichment of biscuit and cake with 22 to 34 per cent carrot pomace flour substantially improved their nutritional and sensory qualities.

5. Utilization of pseudocereals such as buckwheat and quinoa considerably improved the protein content, total phenol content and antioxidant activity of the bakery products. Further, addition of carrot pomace flour to the pseudocereal-based biscuit and cake demonstrated positive impact on their fibre, mineral and carotenoid contents.

Annexure–8

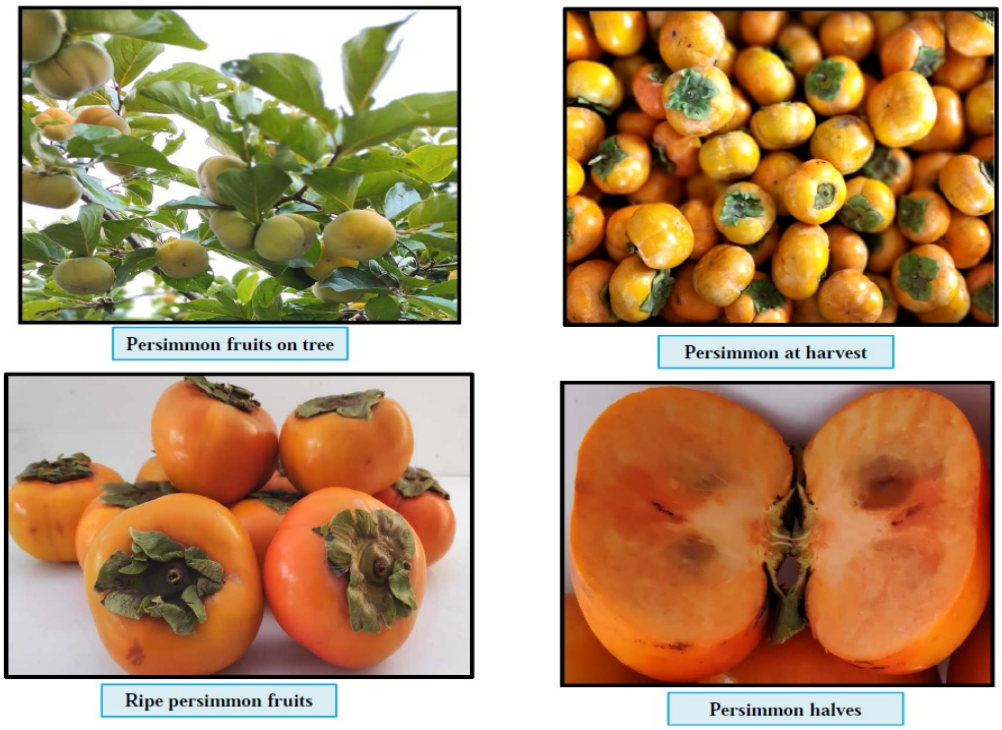
Sub-Project: Dehydration of persimmon (*Diospyros kaki* L.) for product development

The study was aimed at the development of products from Fuyu persimmon fruits which contained 80.39 per cent moisture, 17.06 ºBrix TSS and 5.66 pH, 0.12 per cent, titratable acidity, 12.60 per cent total sugars, 5.83 per cent reducing sugars and are good source of functional components such as ascorbic acid (12.40 mg/100 g), β-carotene (1.54 mg/100 g) and total phenols (2.70 mg/100 g). Among different pre-treatments, the steam blanching for 3 min + 300 ppm KMS + 0.3 per cent citric acid dip in water for 20 minutes was found to be the best on the basis of highest sensory scores for colour (8.53), texture (7.50), flavour (8.50) and overall acceptability (8.58) for dehydration of persimmon slices, development of persimmon chips and osmo-dried persimmon slices. The pre-treated persimmon slices possessed ascorbic acid (8.96 mg/100 g) and β-carotene (17.92 mg/100 g). Mechanical cabinet dehydrator (D_1) was found to be a better mode of drying for persimmon slices in comparison to solar tunnel (D_2) and solar glass (D_3) dryer. During storage of six months, the decrease in constituents like ascorbic acid (8.96 to 8.66 mg/100 g), β-carotene (17.92 to 13.47 mg/100 g), fibre content (1.25 to 1.04 %), antioxidant activity (63.19 to 59.59 %) and total phenols (14.05 to 10.30 mg/100 g) was minimum in slices dried in mechanical cabinet dehydrator as compared to solar tunnel and solar glass dryer. The dehydrated slices can be utilized for the development of persimmon chips, containing 2.51 mg/100 g ascorbic acid, 9.16 mg/100 g β-carotene. Osmo-dried persimmon were developed by soaking of slices in 50 °B hypertonic solution + 4 h dipping time at 45 °C prior to drying. The concentration of 20 per cent ginger extract and 15 per cent mint extract was found to be the best for production of flavoured osmo-dried persimmon. During storage of six months, the slices of treatment T_1 (osmo-dried persimmon slices) were considered as the best on the basis of higher retention of chemical and sensory quality. The decrease in ascorbic acid is (7.36 to 3.36 mg/100 g), β-carotene (17.92 to 12.34 mg/100 g) and total phenols (13.52 to 9.90 mg/100 g) was less in T_1 as compared to T_2 (ginger flavoured osmo-dried persimmon slices) and T_3 (mint flavoured osmo-dried persimmon slices) during storage. Persimmon dehydrated slices and osmo-dried slices can be safely stored for a period of 6 months while chips for a period of 90 days with minimal changes in chemical and sensory attributes when packed in Aluminium Laminated Pouches (ALP). Henceforth, it is concluded that non astringent variety Fuyu persimmon, can be successfully utilized for the production of dried products at remunerative cost.

Details of Experiments conducted:

Objective1: Procurement of raw materials

The persimmon fruits of variety Fuyu were procured from the Regional Horticultural Research and Training Station, Seobagh, Kullu. The firm ripe fruits of persimmon were stored under cold storage where temperature was maintained at 0±5 ºC. The firm ripe persimmons were utilized for the development of slices, chips and osmo-dried persimmon slices.

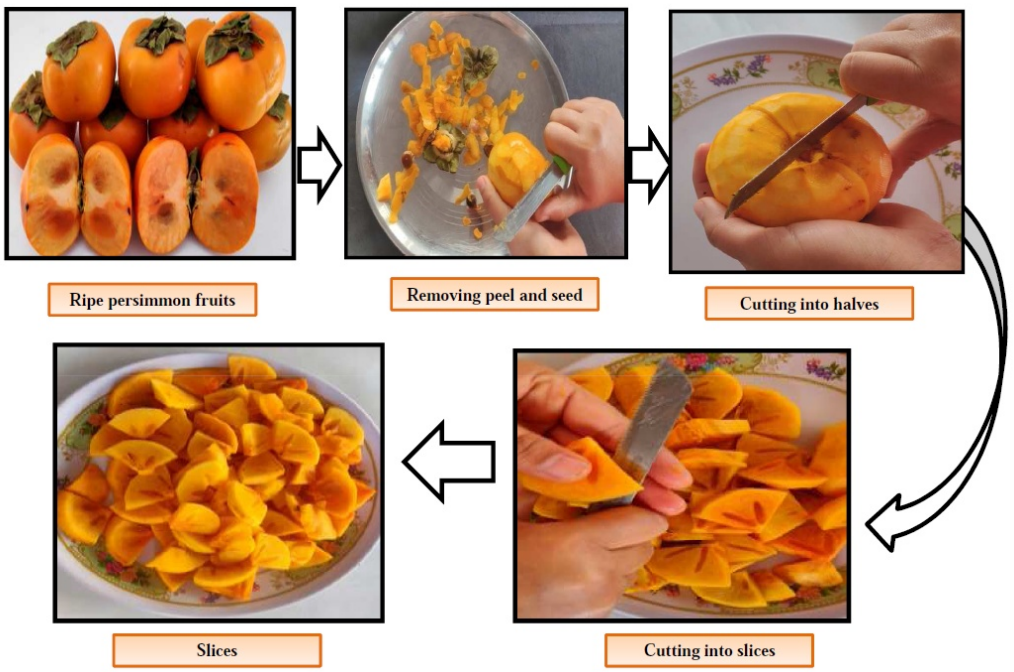


Ripe persimmon fruits

Objective 2: Standardization of technology for dehydrated persimmon products

2.1 Development and evaluation of persimmon slices

A) Preparation of persimmon slices: The persimmon fruits were washed under running water. The fruits were peeled, cut into slices of uniform size i.e. approximately 2 cm thickness using stainless steel knife and pre-treated as detailed below:



Unit operations for the preparation of persimmon slices

B) **Standardization of pre-treatments:** The persimmon slices were subjected to various pre-treatments in order to retain better chemical and sensory quality attributes. The detail of pre-treatments is given below:

i) **Without blanching:** The fresh slices without any treatment were dried in a mechanical cabinet dehydrator (50 ± 2 °C) till constant weight and referred as T_1 (Table 9) for further studies.

ii) **Blanching:** The prepared slices were subjected to water and steam blanching for different time periods (Table 1). In order to select the best treatment, the slices were analyzed for peroxidase test. The slices were then dried in a mechanical cabinet dehydrator at 50 ± 5 °C up to a constant weight was reached. The results were compiled and the best treatment was selected on the basis of maximum inactivation of enzyme and referred as T_2 (Table 9) for further studies.

Table: 1. Standardization of blanching type and time

Type of blanching	Time in minutes (min)
Steam blanching	1, 1.5, 2, 2.5, 3, 3.5, 4, 4.5, 5
Water blanching	1, 1.5, 2, 2.5, 3, 3.5, 4, 4.5, 5

i) **Potassium metabisulphite (KMS):** The slices of best treatment selected for blanching (Section 2.1 B) ii) were treated by dipping in KMS solution using different combinations of concentration and immersion time as indicated in Table 2. The slices were dried in a mechanical cabinet dehydrator (50 ± 2 °C) up to a constant weight. The samples were then subjected to sensory evaluation by a panel of ten judges. The treatment which got the highest sensory scores for all the sensory parameters was selected and referred as T_3 (Table 9) for further studies.

Table: 2. Standardization of potassium metabisulphite (KMS) concentration and dipping time

Pre-treatment	Potassium metabisulphite (KMS)	
	Concentration (ppm)	Dipping time (min)
K_1	500	10
K_2	1000	10
K_3	1500	10
K_4	2000	10
K_5	500	20
K_6	1000	20
K_7	1500	20
K_8	2000	20
K_9	500	30
K_{10}	1000	30
K_{11}	1500	30
K_{12}	2000	30
K_{13}	500	40
K_{14}	1000	40
K_{15}	1500	40
K_{16}	2000	40

ii) **Citric acid:** The slices of best treatment selected for blanching under Section 2.1 B) ii) were immersed in different combinations of citric acid concentration and dipping time. The different treatment combinations are shown in Table 3. After treating with citric acid, the slices were dried in a mechanical cabinet dehydrator at 50 ± 2 ºC till the constant weight was obtained. The samples were then subjected to sensory evaluation by a panel of ten judges. The slices of treatment which were awarded the maximum sensory scores for different parameters was referred as T_4 (Table 3.9) for subsequent studies.

Table: 3. Standardization of citric acid concentration and dipping time

Pre-treatment	Citric acid	
	Concentration (%)	Dipping time (min)
C_1	0.50	10
C_2	1.00	10
C_3	1.50	10
C_4	2.00	10
C_5	0.50	20
C_6	1.00	20
C_7	1.50	20
C_8	2.00	20
C_9	0.50	30
C_{10}	1.00	30
C_{11}	1.50	30
C_{12}	2.00	30
C_{13}	0.50	40
C_{14}	1.00	40
C_{15}	1.50	40
C_{16}	2.00	40

iii) **Ascorbic acid:** The blanched slices (Section 2.1 B) ii) were dipped in different concentrations of ascorbic acid for various time periods. The different combinations applied are presented in Table 4. The treated slices were dried in a mechanical cabinet drier (50 ± 5 ºC) till the constant weight was achieved. The results were compiled and the best treatment was selected keeping in view the highest sensory scores and referred as T_5 (Table 9) for further investigation.

Table: 4. Standardization of ascorbic acid concentration and dipping time

Pre-treatment	Ascorbic acid	
	Concentration (%)	Dipping time (min)
A_1	0.50	10
A_2	1.00	10
A_3	1.50	10
A_4	2.00	10
A_5	0.50	20
A_6	1.00	20
A_7	1.50	20
A_8	2.00	20
A_9	0.50	30
A_{10}	1.00	30
A_{11}	1.50	30
A_{12}	2.00	30
A_{13}	0.50	40
A_{14}	1.00	40
A_{15}	1.50	40
A_{16}	2.00	40

iv) Potassium metabisulphite (KMS) + citric acid:

The blanched slices selected under Section 2.1 B) ii) were treated with different combination of concentration of KMS + citric acid and dipping time. The treatment combinations were divided into three sections based on KMS concentration i.e. 100 ppm, 300 ppm and 500 ppm. In each sub-experiments KMS concentration was kept constant while various combinations of citric acid concentration (0.10 to 0.50 %) and dipping time (10 to 30 min) were used (Table 5, 6 and 7). The slices were dried in a mechanical cabinet dryer (50 ± 2 ºC) upto a constant weight and subjected to sensory evaluation by a panel of ten judges. The best treatment was selected under each sub-experiment and referred as T_1, T_2 and T_3 (Table 8). The treatments selected under each sub experiment were compared using sensory evaluation and treatment with highest sensory scores was selected for studies and referred as T_6 (Table 9).

Table: 5. Standardization of citric acid concentration and dipping time with 100 ppm KMS

Pre-treatment	Citric acid	
	Concentration (%)	Dipping time (min)
B_1	0.1	10
B_2	0.3	10
B_3	0.5	10
B_4	0.1	20
B_5	0.3	20
B_6	0.5	20
B_7	0.1	30
B_8	0.3	30
B_9	0.5	30

Table: 6. Standardization of citric acid concentration and dipping time with 300 ppm KMS

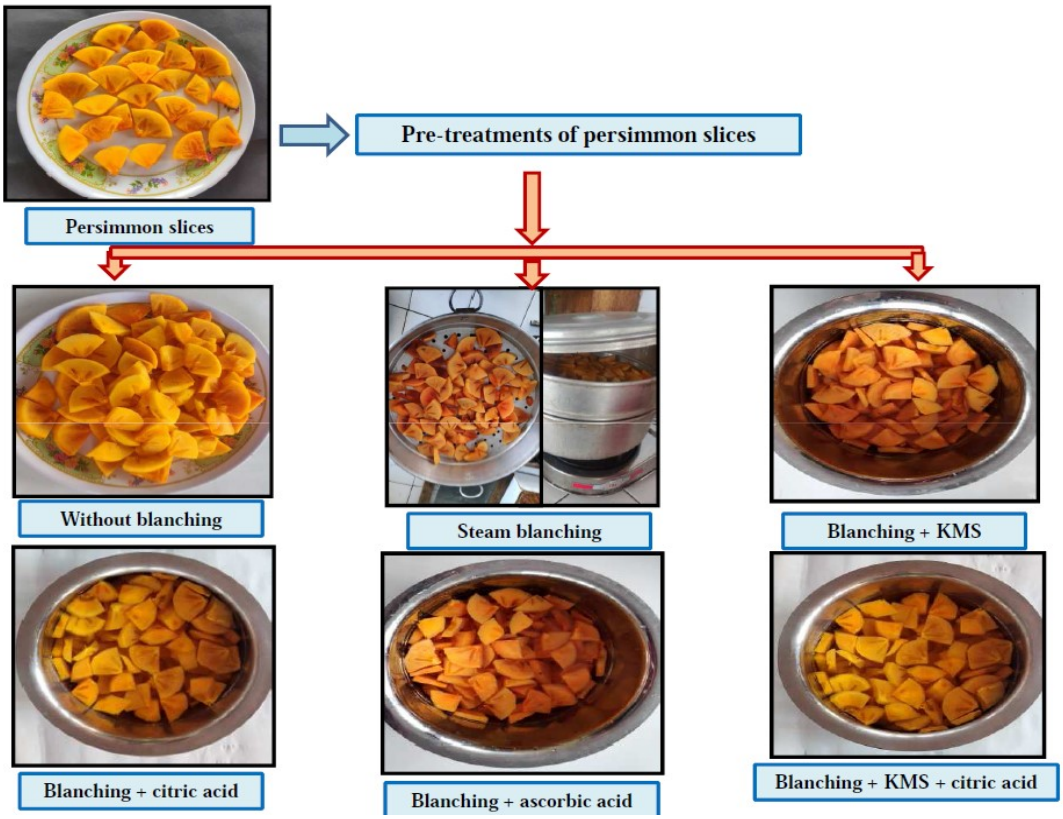
Pre-treatment	Citric acid	
	Concentration (%)	Dipping time (min)
B_1	0.1	10
B_2	0.3	10
B_3	0.5	10
B_4	0.1	20
B_5	0.3	20
B_6	0.5	20
B_7	0.1	30
B_8	0.3	30
B_9	0.5	30

Table: 7. Standardization of citric acid concentration and dipping time with 500 ppm KMS

Pre-treatment	Citric acid	
	Concentration (%)	Dipping time (min)
B_1	0.1	10
B_2	0.3	10
B_3	0.5	10
B_4	0.1	20
B_5	0.3	20
B_6	0.5	20
B_7	0.1	30
B_8	0.3	30
B_9	0.5	30

Table: 8. Detail of selected treatments for dehydration of persimmon slices

Treatment	Treatment detail
T_1	Best treatment selected from 100 ppm KMS + citric acid
T_2	Blanching treatment selected from 300 ppm KMS + citric acid
T_3	Blanching treatment selected from 500 ppm KMS + citric acid



Standardization of pre-treatments of persimmon slices for drying and dehydration

C) Selection of best treatment for further studies

The best pre-treatments of persimmon slices selected under different sub heads (i, ii,iii, iv, v and vi) of Section 2.1 B) has been presented in Table 8. The slices of these treatments after drying were analyzed for different chemical attributes. The samples were also subjected to sensory evaluation. The best treatment was selected for further storage studies keeping in view the combination of results in respect of chemical and sensory attributes.

Table: 9. Detail of treatments selected for drying of slices

Treatment	Description
T_1	Without blanching (control)
T_2	Blanching
T_3	Blanching + KMS
T_4	Blanching + citric acid
T_5	Blanching + ascorbic acid
T_6	Blanching + KMS + citric acid

D) **Standardization of different modes of drying for persimmon slices:** The pretreated persimmon slices as selected under Section 2.1 (C) were used to standardize the method of drying. The slices were dried under three different modes i.e. mechanical cabinet dehydrator, solar tunnel dryer and solar glass dryer (Table 11).

(i) **Mechanical cabinet dehydrator:** The pre-treated slices of known weight were spread on the perforated aluminium trays of mechanical cabinet dehydrator having dimension 76 × 56 cm and internal dimensions 78 × 58 × 128 cm. The temperature for drying of persimmon slices was standardized. The slices were dried by employing three different levels of temperature *viz.* 55, 60 and 65 °C (Table 10). The temperature and time of drying at which the slices got constant weight were recorded. The best temperature for drying of slices was selected on the basis of higher sensory scores awarded to the samples.

ii) **Solar tunnel dryer:** The pre-treated slices of known weight were spread on the perforated aluminium trays of dimension 76 × 56 inches covered with muslin cloth. Then the trays were put on a stand inside the solar tunnel having dimensions of 297 × 204 × 207 cm for drying. The slices were allowed to dry to a constant weight.

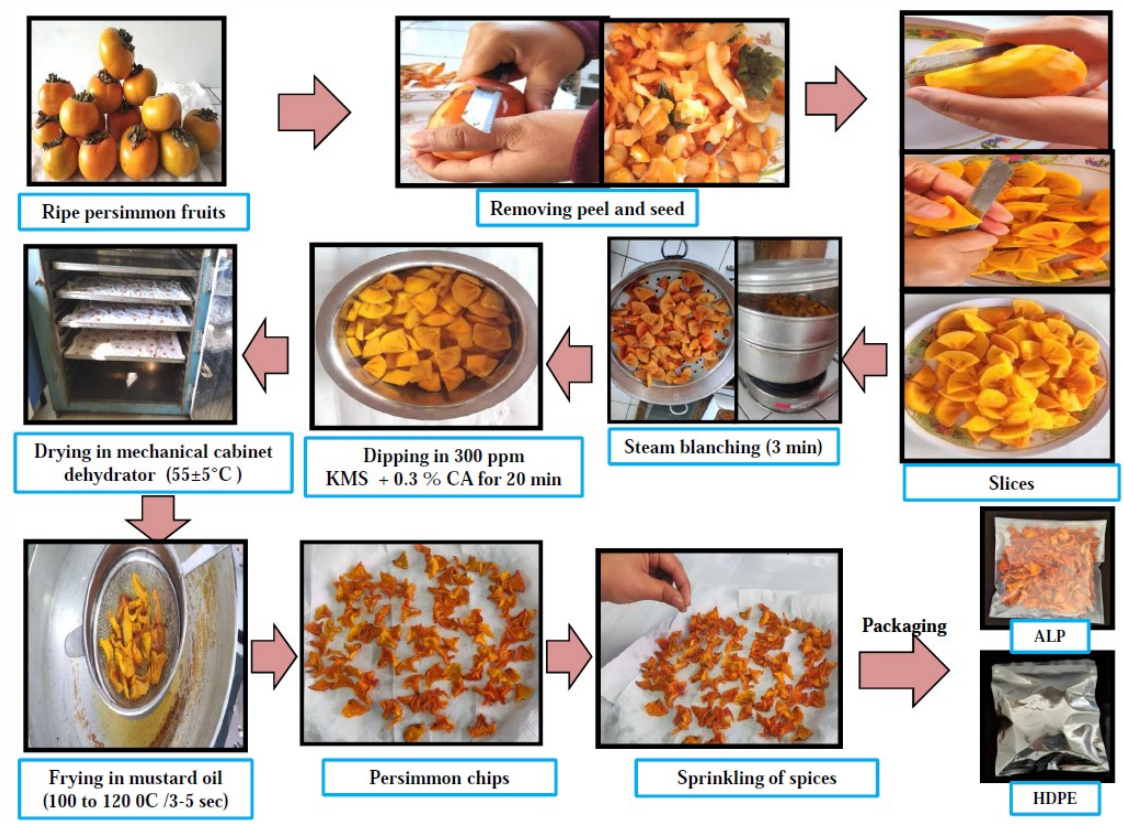
Table: 10. Standardization of drying temperature for persimmon slices in mechanical cabinet dehydrator

Treatment	Temperature (°C)
T_1	55
T_2	60
T_3	65

Table: 11. Treatment detail for drying of persimmon slices using different modes

Drying mode	Treatment code
Mechanical cabinet	D_1
Solar tunnel	D_2
Solar glass	D_3

E) **Storage studies of developed persimmon slices:** The persimmon slices of selected pre-treatment (Section 2.1 (D) dried by using different modes of drying were prepared, packed in Aluminium Laminated Pouches (ALP) and High Density Polyethylene (HDPE) pouches and labeled accordingly. The packed products were kept under ambient condition and evaluated for quality at 0, 3 and 6 months of storage.



Unit operations for the preparation of persimmon chips

Objective: 2.2 Development and evaluation of persimmon chips

A) **Preparation of persimmon rings:** The ripe but still firm persimmons were washed under running water. The fruits were peeled and divided into three lots in order to obtain the rings (Plate 5) of three different thickness (3, 5 and 8 mm). The rings were then pre-treated.

B) **Standardization of pre-treatments:** The pre-treatments as standardized under Section 2.1 (B) were followed for preparation of rings. The pre-treated rings were dried in a mechanical cabinet dehydrator by following the method standardized under Section 2.1 (D).

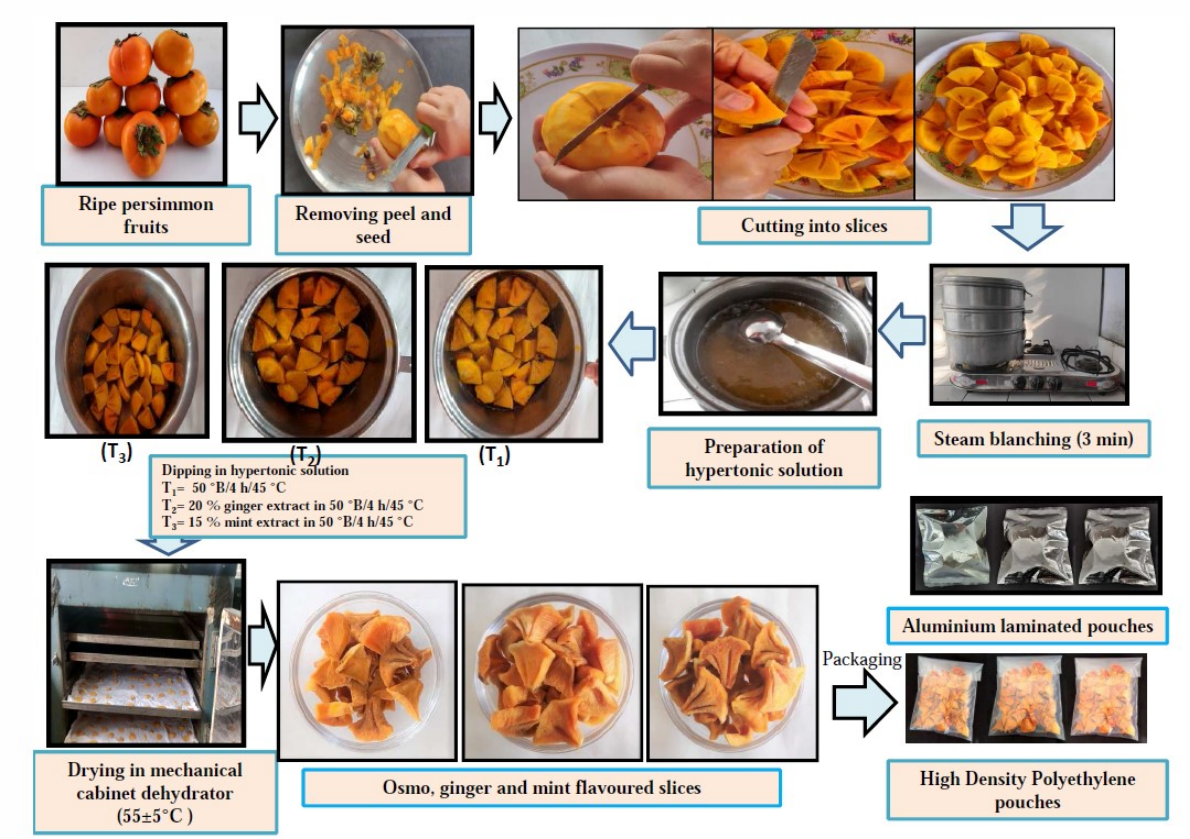
C) **Preparation of persimmon chips:** The pre-treated and dried persimmon rings were utilized for preparation of chips. The mustard oil was heated in a frying pan. The rings were fried in oil until golden brown (3 to 5 sec). The temperature of oil was maintained in the range from 100-120 °C. The chips were drained and allowed to cool down. The mixture of black salt (1.5 g) and spices like red chilli powder (3 g), coriander powder (3.5 g) and cumin powder (3 g) was sprinkled per 100 g of chips. The sensory evaluation of chips of different thickness was conducted by serving the samples to a panel of judges. The data was collected and the best treatment was selected on the basis of highest sensory scores. The unit operations for the preparation of persimmon chips are depicted below.

D) **Storage studies of developed persimmon chips:** The prepared chips of best treatment as above (2.2 C) were packed in Aluminium Laminated Pouches (ALP) and High Density Polyethylene (HDPE) pouches and labeled accordingly. The product was stored under ambient condition for evaluation at 0, 1 and 2 months to study the shelf life.

Objective: 2.3 Development and evaluation of osmo-dried persimmon slices

A) **Preparation and pre-treatment of slices:** The persimmon slices were prepared as per the method discussed under Section 2.1 A) and was treated with the best combination of pre-treatment selected under Section 2.1 C).

B) **Standardization of method for osmo-drying:** The prepared slices were used for the development of osmo-dried persimmon. The hypertonic solution of three different concentrations 30, 40 and 50 °B were prepared using sugar and water. The solution was maintained at different temperatures. The pre-treated slices were immersed in these solutions for various time period. The different combinations of temperature and immersion time for hypertonic solution of different concentration are highlighted in Table 12 (30 °B), 3.13 (40 °B) and 3.14 (50 °B). After treatments, the slices were drained and dried in a mechanical cabinet dehydrator at a temperature of 50 ± 5 °C up to a constant weight. The flow sheet of unit operations followed for preparation of osmo-dried persimmon is presented below.



Unit operations for the preparation of osmo, ginger and mint flavoured slices

Table: 12. Standardization of temperature and immersion time of slices in 30 °B hypertonic solution

Treatment	Temperature of hypertonic solution (°C)	Immersion time (h)
T_1	35	2
T_2	45	2
T_3	55	2
T_4	35	4
T_5	45	4
T_6	55	4
T_7	35	6
T_8	45	6
T_9	55	6

Table: 13. Standardization of temperature and immersion time of slices in 40 °B hypertonic solution

Treatment	Temperature of hypertonic solution (°C)	Immersion time (h)
T_1	35	2
T_2	45	2
T_3	55	2
T_4	35	4
T_5	45	4
T_6	55	4
T_7	35	6
T_8	45	6
T_9	55	6

Table: 14. Standardization of temperature and immersion time of slices in 50 °B hypertonic solution

Treatment	Temperature of hypertonic solution (°C)	Immersion time (h)
T_1	35	2
T_2	45	2
T_3	55	2
T_4	35	4
T_5	45	4
T_6	55	4
T_7	35	6
T_8	45	6
T_9	55	6

The best combination of temperature and immersion time for slices selected under each hypertonic solution *viz.* 30, 40 and 50 °B and referred respectively as T_1, T_2 and T_3

(Table 15) was taken to prepare the slices for the selection of best one. The osmo-dried slices thus prepared were subjected to sensory evaluation by a panel of judges. The best combination for treatment of slices was selected on the basis of highest sensory scores and for further studies was referred as T_1 (Table 19).

Table: 15. Treatment detail of selected treatment of 30, 40 and 50 °B hypertonic solution immersion time and temperature of osmotic solution

Treatment (T)	Treatment detail
T_1	Best treatment selected from 30 °B
T_2	Blanching treatment selected from 40 °B
T_3	Blanching treatment selected from 50 °B

C) Development and evaluation of flavoured osmo-dried persimmon slices: The best combination of hypertonic solution selected under Section 2.3 B) was used for the preparation of flavoured osmo-dried product. Under this, salt, spices (red chilli and cumin powder), ginger extract and mint extract were used as a flavouring agent. The method was standardized for the preparation and addition of spices, ginger and mint extracts in the hypertonic solution prior to development of ginger and mint flaovoured osmo-dried persimmon slices.

i) Development of ginger flavoured osmo-dried persimmon

a) Standardization of concentration of spices: The spices used for preparation of flavoured osmo-dried persimmon were red chili powder, cumin powder, common salt and black salt. The ratio of red chili and cumin powder was standardized using different combinations (Table 16) while the quantity of common (1 g) and black (2 g) salt was kept constant. The osmo-dried slices were prepared by using these combinations. The product of each combination was subjected to sensory evaluation by a panel of judges. The combination which got the highest sensory scores was followed to prepare ginger as well as mint flavoured osmo-dried slices.

Table: 16. Standardization of concentration of red chili powder and cumin powder

Treatment (S)	Concentration/ combination	
	Red chili powder (g)	Cumin Powder (g)
S_1	1	1
S_2	1	2
S_3	1	3
S_4	2	1
S_5	2	2
S_6	2	3

b) Preparation of ginger extract: The fresh ginger rhizomes were washed and peeled followed by further washing. The ginger was grated manually and the obtained shreds were ground in a mixer cum grinder (Model MX-1155) by adding water in the

ratio of 1:2. The juice was obtained by squeezing the mixture through double layer muslin cloth.

c) Standardization of ginger extract concentration for flavoured osmo-dried slices: Ginger flavoured osmo-dried persimmon slices were prepared by addition of ginger extract in different proportions (Table 17). The ginger extract was added to the hypertonic solution containing spices. The procedure followed was as discussed above in Section 2.3 C) i) a). Throughout the process, the TSS of the hypertonic solution was maintained by addition of sugar. Further, the osmotic solution was drained and slices were dried in a mechanical cabinet dehydrator up to a constant weight. The prepared slices were then subjected to sensory evaluation by a panel of ten judges. The slices awarded with maximum scores for different parameters was selected and referred as T_2 (Table 19).

Table: 17 Standardization of ginger extract concentration for flavoured osmo-dried slices

Treatment (G)	Ginger extract (%)
G_1	5
G_2	10
G_3	15
G_4	20
G_5	25

ii) Development of mint flavoured osmo-dried persimmon

a) Standardization of concentration of spices: The concentration of spices treatment standardized as above in Section 2.3 C) i) a) was taken for the preparation of mint flavoured osmo-dried slices.

b) Preparation of mint extract: The mint extract was prepared by using fresh mint leaves. The leaves were washed and ground in a mixer cum grinder with little amount of water (10 ml/ 100 g of mint). The juice was extracted by squeezing the material using double layered muslin cloth.

c) Standardization of mint extract concentration for flavoured osmo-dried slices:

Mint flavoured osmo-dried persimmon slices were prepared by addition of mint extract in different proportions (Table 18). The mint extract was added to the hypertonic solution containing spices where TSS was maintained by addition of sugar. The slices after treatment in spiced hypertonic solution keeping the temperature and time as per Section 2.3 B) were drained and dried in a mechanical cabinet dehydrator (Plate 7) till constant weight. The samples were subjected to a panel of ten judges for sensory evaluation. The treatment with highest sensory score was selected and referred as T_3 (Table 19).

Table: 18. Standardization of mint extract concentration for flavoured osmo-dried slices

Treatment (M)	Mint extract (%)
M_1	5
M_2	10
M_3	15
M_4	20
M_5	25

D) Storage studies of osmo-dried persimmon slices

The osmo-dried persimmon slices were prepared using best treatment selected under different Sections of 2.3 B), C ii) b) and C iii) b) and referred as T_1, T_2 and T_3 respectively. The products were packed in Aluminium Laminated Pouches (ALP) and High Density Polyethylene (HDPE) pouches. The packed products were stored under ambient conditions up to a period of 6 months for storage studies. The observations for different quality parameters were recorded at 0, 3 and 6 months of storage interval. The detail of different treatments selected for storage studies is presented in Table 19.

Table: 19. Detail of selected treatments for osmo-dried persimmon slices

Treatment	Description	Selected from Experiment No.
T_1	Osmo-dried persimmon slices	Best treatment from under Section 3.3 B)
T_2	Ginger flavoured osmo-dried persimmon slices	Best treatment from under Section .2.3. C) i) c)
T_3	Mint flavoured osmo-dried persimmon slices	Best treatment from under Section 2.3. C) ii) c)

Experimental results

1. Composition of raw material

The Fuyu fruits of persimmon (*Diospyros kaki* L.) possessed an average weight of 193.50 ± 10.93 g with mean length and diameter of 48.46 ± 2.12 and 71.08 ± 3.18 mm, respectively. The firmness in ripe fruits was 7.20 kg/cm2. Based on Royal Horticulture Society Colour Chart, the colour of peel and flesh matched with orange group colour (28 A) and yellow-orange group (22 A), respectively. The number of fruits per kg and seeds per fruit ranged from 5 to 6 and 2 to 4, respectively. The portion of flesh, peel and seed was recorded as 90.23, 7.85 and 2.22 per cent, respectively. The fruit contained 80.39 per cent moisture, 17.06 ºBrix TSS and 5.66 pH. While titratable acidity, total sugars, reducing sugars, fibre and ash content was recorded to be 0.12, 12.60, 5.83, 1.02 and 0.34 per cent, respectively. The value for functional components like ascorbic acid, total carotenoids and total phenols was 12.40, 1.54 and 2.70 mg/100 g, respectively while antioxidant activity was 70.33 per cent.

2. Standardization of technology for dehydrated persimmon products

2.1 Development and evaluation of persimmon slices

Fresh persimmon slices were subjected to six different pre-treatments *viz*. T_1 (without blanching i.e. control), T_2 (steam blanching for 3 min), T_3 (steam blanching for 3 minutes + 500 ppm KMS dip in water for 20 minutes), T_4 (steam blanching for 3 minutes + 0.50 % citric acid dip for 20 minutes) T_5 (steam blanching for 3 minutes + 1.00 % ascorbic acid dip for 20 minutes) T_6 **(**Steam blanching for 3 minutes + 300 ppm KMS + 0.30 % citric acid dip for 20 minutes**)**. Among these T_6 was found to be the best on the basis of maximum retention of nutrients and sensory quality after dehydration. The slices of treatment T_6 **(**Steam blanching for 3 minutes + 300 ppm KMS + 0.30 % citric acid dip for 20 minutes**)** revealed minimum moisture content (10.53 %), maximum retention of TSS (37.60 °B), ascorbic acid (8.96 mg/100 g) total carotenoids (17.92 mg/100 g) along with maximum scores for colour (8.53), texture (7.50), flavour (8.50) and overall acceptability (8.58) therefore, was selected for drying of slices in different modes. The comparison of different drying modes *viz*. mechanical cabinet dehydrator (D_1), solar glass dryer (D_2) and solar tunnel dryer (D_3) showed that minimum moisture (10.53 %), maximum TSS (37.60 ºB), total sugars (30.09 %), reducing sugars (23.19 %), titratable acidity (0.98 %), ash content (1.07 %) ascorbic acid (8.96 mg/100 g), ß carotene (17.92 mg/100 g), fibre content (1.25 %) antioxidant activity (63.19 %) and total phenols (14.05 mg/100 g) in mechanical cabinet dried slices. Time taken to dry 5 Kg of slices was 16.67 h in mechanical cabinet dehydrator, 56.00 h in solar tunnel dryer and 65.67 h in solar glass dryer. During storage of six months, the mechanical cabinet dried slices had maximum retention of chemical characteristics like TSS, total sugars, reducing sugars, total carotenoids, ascorbic acid and antioxidant activity followed by solar tunnel dried slices and solar glass dried slices. Further, minimum increase in moisture was observed in slices dried in this mode.

2.2 Development and evaluation of persimmon chips

The pre-treated persimmon slices **(**Steam blanching for 3 minutes + 300 ppm KMS + 0.30 % citric acid dip for 20 minutes**)** dried in a mechanical dehydrator at 60 °C for 16.67 h were used for preparation of chips. The chips contained 2.51 mg/100 g of ascorbic acid, 9.16 mg/100 g of β-carotene, 2.47 mg/100 g of total phenols, 1.52 per cent of fibre, 0.95 meq/ kg of peroxide value and 25.70 per cent of oil uptake. Sensory evaluation of chips exhibited the score of 8.46 for colour, 8.04 for texture, 8.53 for flavour, 8.24 for overall acceptability. During storage for 90 days, the chips packed in ALP recorded lesser decrease from 9.16 to 8.67 mg/100 g in β-carotene, 2.51 to 2.14 mg/100 g in ascorbic acid, 2.47 to 2.27 mg/100 g in total phenols, 1.52 to 1.44 per cent in fibre content and minimum rise in the value from 0.95 to 1.17 meq/ kg peroxide and oil uptake 25.70 to 26.52 per cent as compared High Density Polyethylene (HDPE) pouches. Further, the chips packed in ALP showed less decrease in sensory scores as compared to HDPE. Therefore, Aluminium Laminated Pouches (ALP) was found better packaging material for persimmon chips. Cost of production of 100 g of persimmon chips packed in HDPE pouches and ALP was calculated to be Rs. 83.80 and 84.16, respectively.

2.3 Development and evaluation of osmo-dried persimmon slices

Among different combinations of hypertonic solution, immersion time and temperature, the treatment T_8 comprising of 50 °B hypertonic solution + 4 h dipping time at 45 °C received the highest sensory scores for colour (8.52), texture (8.72) flavour (8.74), and overall acceptability (8.23) was selected and referred as T_1 (osmo-dried persimmon slices) for storage studies. Out of five different treatment combination for ginger flavoured osmo-dried slices, G_4 (20 per cent ginger extract in 50 ºB hypertonic solution + spices salt (2 g), black salt (1 g), red chilli powder (3 g) and cumin powder (1 g), dip for 4 h maintained at 45^0 C) was awarded the maximum score for overall acceptability (8.17) and therefore, was selected and referred as T_2 (ginger flavoured osmo-dried persimmon slices) for further storage studies. Among five different combinations for mint flavoured osmo-dried persimmon slices, M_3 (15 per cent mint extract in 50 °B hypertonic solution + spices salt (2 g), black salt (1 g), red chilli powder (3 g) and cumin powder (1 g), dip for 4 h maintained at 45 °C) got the highest overall acceptability therefore, was selected and referred as T_3 (mint flavoured osmo-dried persimmon slices) for further storage studies. The comparison of treatments T_1 (osmo-dried persimmon slices), T_2 (ginger flavoured osmo-dried persimmon slices) and T_3 (mint flavoured osmo-dried persimmon slices), indicated maximum mean value for moisture (13.83 %), TSS (68.27 °B), total sugars (61.42 %), reducing sugars (47.75 %), titratable acidity (0.53 %), β-carotene (17.92 mg/100 g), total phenols (13.52 mg/100 g), ash content (0.93 %) and antioxidant activity (63.48 %) at 0 day of storage in T_1.

Conclusion and Recommendation

1. Fuyu persimmon fruits contained 80.39 per cent moisture, 17.06 ºBrix TSS and 5.66 pH, 0.12 per cent titratable acidity, 12.60 per cent total sugars, 5.83 per cent reducing sugars and are good source of functional components such as ascorbic acid (12.40 mg/100 g), β-carotene (1.54 mg/100 g) and total phenols (2.70 mg/100 g).

2. Among different pre-treatments, the steam blanching of slices for 3 min + 300 ppm KMS + 0.3 % citric acid dip in water for 20 minutes was found to be the best on the basis of highest sensory scores for colour (8.53), texture (7.50), flavour (8.50) and overall acceptability (8.58) for dehydration of persimmon slices, development of persimmon chips and osmo-dried persimmon slices. The pre-treated persimmon slices possessed ascorbic acid (8.96 mg/100 g) and β-carotene (17.92 mg/100 g).

3. Mechanical cabinet dehydrator (T_1) was found to be a better mode for drying of persimmon slices in comparison with solar tunnel (T_2) and solar glass (T_3) dryer on the basis of better chemical attributes and higher sensory score. During storage the maximum retention of chemical and sensory quality was observed in slices dried in mechanical cabinet dehydrator.

4. The mechanical cabinet dehydrated slices contained ascorbic acid (8.96 mg/100 g), ß-carotene (17.92 mg/100 g), fibre content (1.25 %) antioxidant activity (63.19 %) and total phenols (14.05 mg/100 g). The dehydrated slices can be utilized for the development of persimmon chips. The chips contained 2.51 mg/100 g of ascorbic acid, 9.16 mg/100 g of β-carotene, 2.47 mg/100 g of total phenols, 1.52 per cent of fibre, 0.95 meq/ kg of peroxide value and 25.70 per cent of oil uptake.

5. Osmo-dried persimmon slices can be developed by soaking in 50 °B hypertonic solution + 4 h dipping time at 45 °C prior to drying. The concentration of 20 per cent

ginger extract and 15 per cent mint extract was found to be the best for production of ginger flavoured and mint flavoured osmo-dried persimmon, respectively.

6. Osmo-dried slices of T_1 (50 °B hypertonic solution + dipping time 4 hour maintained at a temperature 45 °C) retained better chemical quality and received higher sensory scores in comparison to T_2 (ginger flavoured osmo-dried slices) and T_3 (mint flavoured osmo-dried slices).

7. Therefore, it can be concluded that non- astringent Fuyu persimmon (*Diospyros kaki* L.) fruit which is highly nutritious but under-utilized for processing can be pre-treated and dehydrated for the development of different products such as chips, osmo-dried, ginger and mint flavoured osmo-dried products which can be stored safely when packed in appropriate packaging material.

Sub-Project: Development of muffins from ripe pumpkin (*Cucurbita moschata*) and their shelf life studies

The study was conducted to develop muffins by using pumpkin pulp and seeds (with or without coat) flour. The pumpkin fruits were found to be a good source of functional components such as ascorbic acid (14.02 mg/100 g), β-carotene (14.96 mg/100 g) and total phenols (3.94 mg GAE/g) while seeds were concentrated source of fat (34.21 %) and protein (33.13 %). The extracted pulp contained 88.91per cent moisture, 5.56 °B TSS while 3.39, 2.13, 0.04, 1.37 and 0.78 per cent of total sugars, reducing sugars, titratable acidity, protein and ash, respectively. Pumpkin pulp possessed 9.20 mg/100 g ascorbic acid, 8.86 mg/100 g β-carotene, 3.65 mg GAE/g total phenols and 25.57±0.24 per cent antioxidant activity. Substitution of pumpkin pulp @ of 70 per cent was found desirable to develop pumpkin muffins with whole wheat (T_1), rice (T_3) and barley (T_4) flours whereas, up to 80 per cent with semolina (T_2). The amount of ascorbic acid, β-carotene, total phenols and antioxidant activity was observed to increase with the enhancement of level of pulp. Among pumpkin muffins of different treatments with cereal flours, T_3 (pumpkin muffins with using rice flour) was selected on the basis of sensory evaluation for development of pumpkin muffins supplemented with whole seed and seed kernels. Substitution of rice flour with whole seed flour @ 20 per cent and seed kernel flour @ 25 per cent was selected and supplemented contained muffins contained 9.76 and 11.73 per cent protein, fat 21.92 and 25.51 per cent along with obtaining overall acceptability score, 8.76 and 8.36 respectively. The developed pumpkin muffins can be stored safely under ambient (6 days) and refrigerated (20 days) conditions when packed in Transparent Aluminium Laminated Pouches (ALP). During storage the moisture content recorded an increase, where (fat, fiber, ash, ascorbic acid, total phenols and antioxidant activity) showed a decreasing trend. Though sensory scores for all the treatments during storage decreased but were found to be well above acceptable limits in muffins of all the treatments. Henceforth, it can be concluded that the ripe pumpkin which otherwise is processed to a limited extent, can be successfully and conveniently utilized for the development of functional and good quality muffins at a remunerative cost.

Details of Experiments conducted:

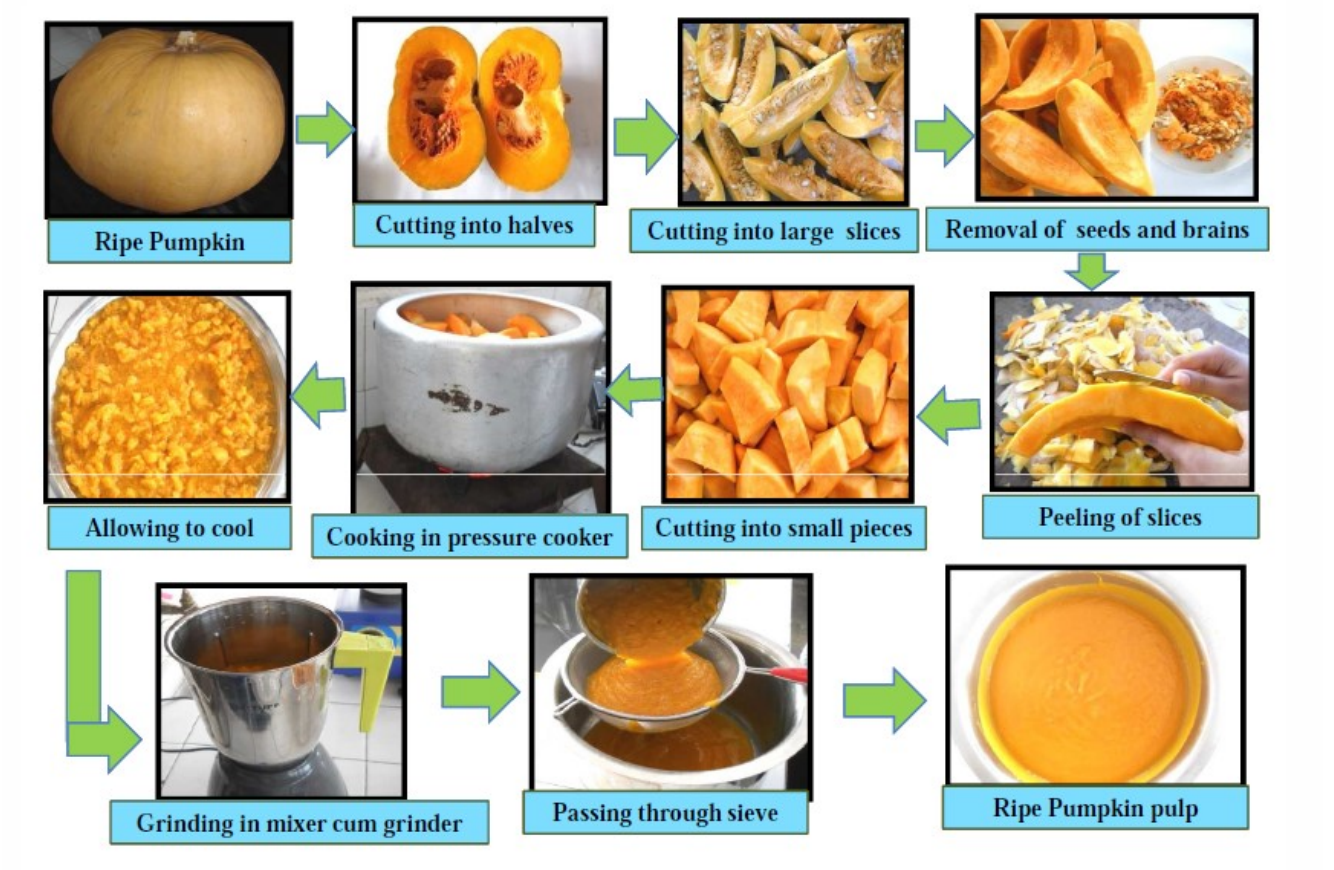
Objective 1: Procurement of raw materials

Fully ripe pumpkins were purchased from the vegetable market, Solan. To conduct the study, the raw ingredients such as whole wheat flour, semolina, rice flour, barley flour, sugar, milk powder, refined oil, baking powder and baking soda were procured from local market, Solan. For the preparation of whole seed and seed kernel flour, pumpkin seeds were procured from the Department of Seed Science and Technology, Dr YS Parmar University Horticulture and Forestry, Nauni, Solan. The present study is based on the preparation of pumpkin pulp, utilization of pulp for development of muffins in combination with different cereal (whole wheat, semolina, rice and barley) and pumpkin seed (with and without seed coat) flours and quality evaluation of fresh and stored products. The ripe pumpkin fruit, pumpkin seeds and seed kernels were evaluated for different physical and chemical quality characteristics.

Objective2: Development of muffins using ripe pumpkin pulp

2.1 Pumpkin muffins with whole wheat flour

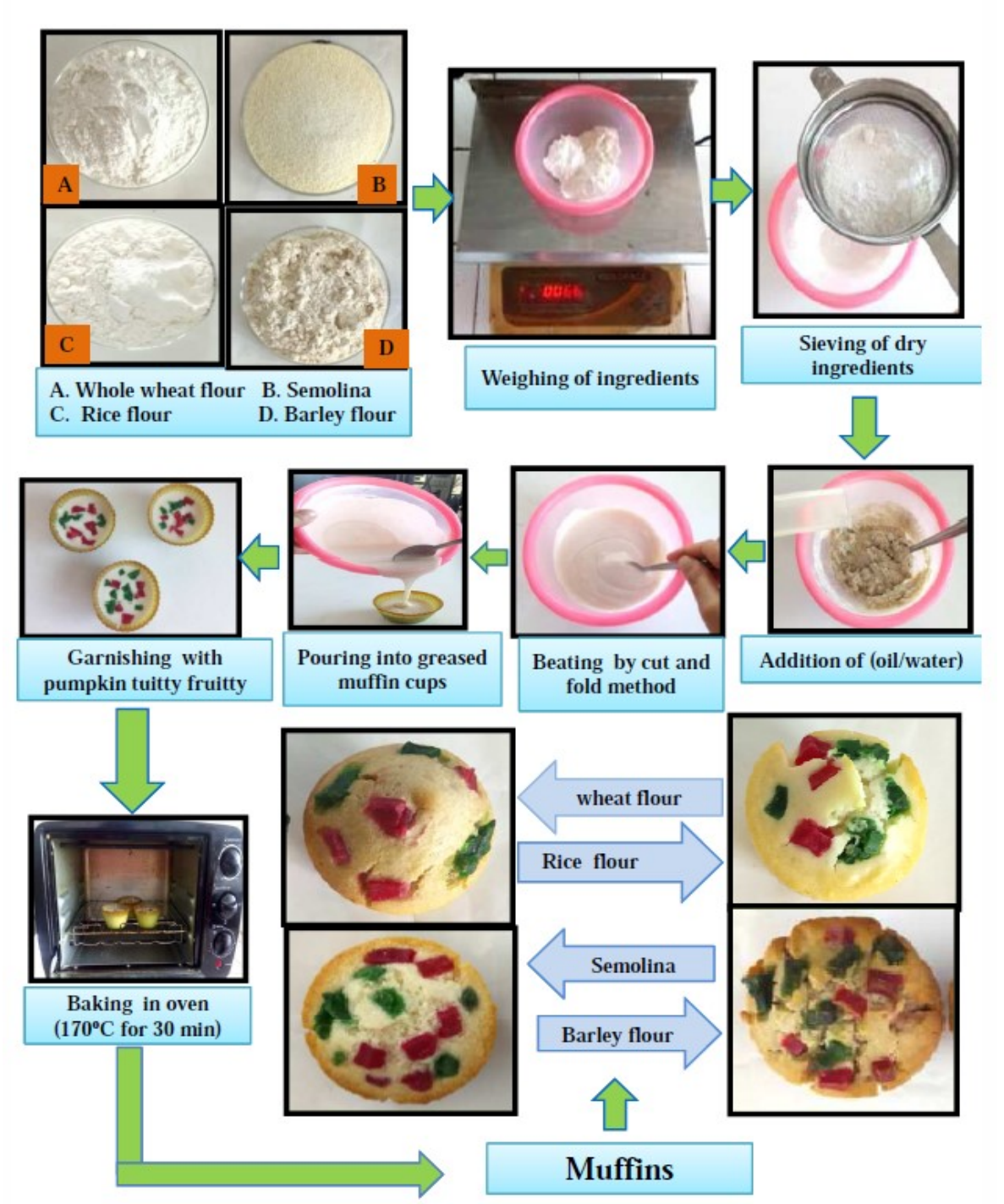
A) Preparation of pumpkin pulp: Ripe pumpkins were thoroughly washed and cut into halves. After removing the seeds and fluffy portion (fibrous strains/brains), pumpkins were cut into slices. The slices were peeled, washed and cut into small pieces. The pumpkin pieces (1 Kg) were heated in a pressure cooker of five kg capacity using domestic gas stove with 5 per cent water followed by cooking for 5 min. The whole mass was allowed to cool down and then converted into pulp by grinding in mixer cum grinder (Model MX-1155). The developed pulp was filled in pre-sterilized glass jars and kept under refrigerated conditions for fresh use.



Unit operations for preparation of ripe pumpkin pulp

B) Standardization of base recipe for preparation of whole wheat flour muffins: The recipe for the preparation of muffins using whole wheat flour was standardized after conducting preliminary trials. Four different recipes comprising of varied combinations of refined oil and sugar were used for standardization while the amount of other ingredients (whole wheat flour, milk powder, baking powder, baking soda and water) was kept constant. The detail of different combinations is shown in Table 1. All the ingredients were weighed accurately. The whole wheat flour, sugar, baking powder, baking soda and milk powder were sieved in a bowl using 36 mesh size sieves. To this, oil was added with continuous mixing followed by addition of water. Then the mixture was beaten well by cut and fold method until smooth batter was attained (approximately for 3 min). The cups of muffin were greased well with oil and

batter was poured into cups followed by garnishing with pumpkin tutti-fruiti. The baking oven was preheated at 170 °C and then muffin cups were placed in an oven and baked at a temperature of 170°C for 25-30 min. To see whether the muffins are baked properly or not stainless-steel knife was inserted into the muffins softly and taken out, when no mass stacked on the surface of knife, then the baking was assumed to be complete. Then, muffins were allowed to cool at room temperature. The muffins of all the combination were prepared by following similar procedure and subjected to sensory evaluation by a panel of judges. The recipe which received the maximum sensory scores was selected and referred as base recipe (T_0) for the preparation of pumpkin muffins.



Unit operations for preparation of muffins with cereal flours

C) **Standardization of recipe for pumpkin muffins with whole wheat flour:** The recipe standardized under Section 2.1 (B) was taken as base recipe for the preparation of pumpkin muffins. The muffins were prepared by replacing wheat flour with pumpkin pulp in different ratios (Table 2). Also, the amount of water used for preparation of batter was decreased with increase in addition of pulp. The concentration of pulp was sufficient to form the batter of desired consistency after 40 per cent replacement. The prepared muffins were analyzed for chemical characteristics and subjected to sensory evaluation by a panel of 10 judges. On the basis of chemical characteristics and higher sensory scores, the best treatment selected in this experiment was referred as T_1 for further storage studies.

Table: 1 Standardization of recipe for whole wheat flour muffins

Recipe	Whole Wheat flour (g)	Refined oil (mL)	Sugar (g)	Milk Powder (g)	Baking soda (g)	Baking Powder (g)	Water (mL)
R1	100	13	22	20	0.5	1.5	85
R2	100	15	25	20	0.5	1.5	85
R3	100	17	28	20	0.5	1.5	85
R4	100	19	31	20	0.5	1.5	85

Table: 2 Standardization of recipe for pumpkin muffins with whole wheat flour

Treatment	Pumpkin pulp (g)	Whole wheat flour (g)	Water (mL)
T0	0	100	85
T1	10	90	80
T2	20	80	75
T3	30	70	70
T4	40	60	65
T5	50	50	-
T6	60	40	-
T7	70	30	-
T8	80	20	-

2.2 Pumpkin muffins with semolina

A) **Preparation of pumpkin pulp:** Similar procedure was followed for the preparation of pumpkin pulp as discussed under Section 2.1 (A).

B) **Standardization of base recipe for preparation of semolina muffins:** For the preparation of muffins using semolina, the recipe was standardized after conducting preliminary trials. The recipe comprised of various ingredients such as semolina, refined oil, sugar, baking powder, baking soda, milk powder and water. For standardization, four different recipes were used by varying the concentration of refined oil and sugar while the amount of other ingredients was kept constant. The detail of quantity of different ingredients used is shown in Table 3. Similar procedure as discussed under Section 2.1 (B) was used for the preparation of muffins except that the whole wheat flour was completely replaced with semolina. The developed

semolina muffins were presented to a panel of judges for sensory evaluation and the recipe having highest scores for all sensory parameters was selected and referred as base recipe (T_0) for the preparation of pumpkin muffins.

Table: 3 Standardization of recipe for semolina muffins

Recipe	Semolina (g)	Refined oil (mL)	Sugar (g)	Milk powder (g)	Baking soda (g)	Baking powder (g)	Water (mL)
R1	100	11	17	20	0.5	1.5	60
R2	100	13	21	20	0.5	1.5	60
R3	100	15	25	20	0.5	1.5	60
R4	100	17	29	20	0.5	1.5	60

C) Standardization of recipe for pumpkin muffins with semolina: The recipe for preparation of pumpkin muffins with semolina was standardized by using base recipe [Section 2.2 (B)]. The muffins were prepared by substituting semolina with pumpkin pulp in different proportions (Table 4). The addition of water was decreased with increase in addition of pulp. After 50 per cent replacement, no more water was required as consistency of the batter was achieved at this concentration. The prepared muffins were analyzed for chemical characteristics and subjected to sensory evaluation by a panel of ten judges. On the basis of chemical characteristics and sensory scores, the best treatment was selected and referred as T_2 for further storage studies.

Table: 4 Standardization of recipe for pumpkin muffins with semolina

Treatment	Pumpkin pulp (g)	Whole wheat flour (g)	Water (mL)
T0	0	100	60
T1	10	90	55
T2	20	80	50
T3	30	70	45
T4	40	60	40
T5	50	50	35
T6	60	40	-
T7	70	30	-
T8	80	20	-
T9	90	10	-

2.3 Pumpkin muffins with rice flour

A) Preparation of pumpkin pulp: The pumpkin pulp was prepared as described in Section 2.1 (A).

B) Standardization of recipe for preparation of rice flour muffins: The recipe for the preparation of muffins using rice flour was standardized after performing preliminary trials. Four recipes were prepared by using different combinations of refined oil and

sugar (Table 5). The rest of the materials like rice flour, milk powder, baking soda, baking powder and water were kept constant. The procedure followed for preparation of rice muffins was same as given under Section 2.1 (B) except that whole wheat flour was completely replaced with rice flour. The developed muffins were subjected to sensory evaluation by a panel of judges. The recipe with maximum mean scores for all sensory parameters was selected and referred as base recipe (T_0) for the preparation of pumpkin muffins with rice flour.

Table: 5 Standardization of recipe for rice flour muffins

Recipe	Rice flour (g)	Refined oil (mL)	Sugar (g)	Milk Powder (g)	Baking soda (g)	Baking Powder (g)	Water (mL)
R1	100	13	20	20	0.5	1.5	100
R2	100	15	25	20	0.5	1.5	100
R3	100	17	30	20	0.5	1.5	100
R4	100	19	35	20	0.5	1.5	100

C) Standardization of recipe for pumpkin muffins with rice flour: The standardized recipe selected under Section 2.3 (B) was used for the preparation of pumpkin muffins. The different proportions of rice flour and pumpkin pulp (Table 6) were used for development of muffins. The amount of water used for preparation of batter was decreased with addition of pulp and at 50 per cent replacement, the concentration of pulp was found to be sufficient to form a batter of desired consistency. The analysis of muffins was conducted to evaluate chemical characteristics. The sensory evaluation was also conducted to see the acceptability of product by the panelists. On the basis of chemical and sensory parameters, the best treatment was selected and referred as T_3 for further storage studies.

Table: 6 Standardization of recipe for pumpkin muffins with rice flour

Treatment	Pumpkin pulp (g)	Whole wheat flour (g)	Water (mL)
T0	0	100	100
T1	10	90	95
T2	20	80	90
T3	30	70	85
T4	40	60	80
T5	50	50	75
T6	60	40	-
T7	70	30	-
T8	80	20	-

2.4 Pumpkin muffins with barley flour

A) Preparation of pumpkin pulp: The procedure followed for the preparation of pumpkin pulp was same as discussed under Section 2.1 (A).

B) **Standardization of recipe for preparation of barley muffins:** Preliminary trials were conducted to standardize the final recipe for preparation of muffins using barley flour. The various ingredients incorporated for preparation of barley muffins were barley flour, refined oil, sugar, baking powder, baking soda, milk powder and water. The recipes were standardized by employing different concentration of ingredients (Table 7). The similar process was used as illustrated under Section 2.1 (B) for the preparation of muffins except that barley flour was used in place of whole wheat flour. The muffins thus prepared were evaluated for sensory attributes by a panel of judges and recipe awarded with maximum score for all sensory parameter was selected and referred as base recipe (T_0) for the preparation of pumpkin muffins.

Table: 7 Standardization of recipe for barley flour muffins

Recipe	Barley flour (g)	Refined oil (mL)	Sugar (g)	Milk Powder (g)	Baking soda (g)	Baking Powder (g)	Water (mL)
R1	100	11	17	20	0.5	1.5	100
R2	100	13	21	20	0.5	1.5	100
R3	100	15	25	20	0.5	1.5	100
R4	100	17	29	20	0.5	1.5	100

C) **Standardization of recipe for pumpkin muffins with barley flour muffins:** The recipe standardized under Section 2.4 (B) was used as control recipe for the preparation of pumpkin muffins with barley flour. The proportion used for development of pumpkin muffins is reflected in Table 8. The water incorporated was reduced with the increased addition of pumpkin pulp. The prepared muffins were evaluated for chemical characteristics and sensory attributes and the best treatment was selected on the basis of combination of results. The treatment was referred as T_4 for further storage studies.

Table: 8 Standardization of recipe for pumpkin muffins with barley flour

Treatment	Pumpkin pulp (g)	Barley flour (g)	Water (mL)
T0	0	100	100
T1	10	90	95
T2	20	80	90
T3	30	70	85
T4	40	60	80
T5	50	50	75
T6	60	40	-
T7	70	30	-
T8	80	20	-

2.5 Quality evaluation of pumpkin muffins during storage

The best recipe of pumpkin muffins selected in Section (C) of each experiment No. 2.1, 2.2, 2.3 and 2.4 and referred as T_1, T_2, T_3 and T_4, respectively (Table 9) were used to

conduct the storage studies. The muffins of each treatment were prepared and packed in Transparent Aluminium Laminated Pouches (ALP). The muffins were kept for storage under ambient and refrigerated conditions. The products were evaluated for quality at storage interval of 0, 3, 6 days and 0, 10 and 20 days, respectively.

Table: 9 Treatments detail of pumpkin muffins selected for storage studies

Treatments	Description	Selected from Experiment No.
T1	Pumpkin muffins with whole wheat flour	Best treatment from Section 2.1 C)
T2	Pumpkin muffins with semolina	Best treatment from Section 2.2 C)
T3	Pumpkin muffins with rice flour	Best treatment from Section 2.3 C)
T4	Pumpkin muffins with barley flour	Best treatment from Section 2.4 C)

Objective 3: Development of pumpkin muffins supplemented with seed flour

3.1 Selection of recipe for pumpkin muffins supplementation with seed flour

The muffins of different treatments given in Table 9 were prepared and subjected to sensory evaluation to select the recipe for preparation of pumpkin muffins for supplementation with seed flour. The recipe with highest sensory scores was selected for the preparation of muffins supplemented with seed flour and referred as T_1 for further storage studies.

3.2 Pumpkin muffins supplemented with whole seed flour

A) Preparation of whole seed flour: Seed flour was prepared by roasting the seeds in a pan on gas stove for approximately 2 min with slow mixing and folding till light brown. The seeds were allowed to cool at room temperature and ground using mixer cum grinder (Model MX-1155). The powder thus obtained was sieved using 36 mesh metallic sieve and packed in transparent Aluminium Laminated Pouches (ALP) for further use in the study.

B) Standardization of recipe for pumpkin muffins supplemented with whole seed flour: For preparation of muffins supplemented with whole seed flour, the cereal flour of recipe selected under Section 3.1 was replaced at different level (Table 10) with whole seed flour. The muffins with these combinations were prepared by following procedure discussed under Section 2.1 (B). In order to obtain the best combination, the prepared muffins were analysed for chemical characteristics and subjected to sensory evaluation. Based upon the results, the best treatment was selected and referred as T_2 for further storage studies.

Table 3.10: Standardization of recipe for pumpkin muffins supplemented with whole seed flour

Treatment	Cereal Flour (g)	Pumpkin whole seed flour (g)
T1	30.00	0.00
T2	28.50	1.50
T3	27.00	3.00
T4	25.50	4.50
T5	24.00	6.00
T6	22.50	7.50
T7	21.00	9.00

3.3 Pumpkin muffins supplemented with seed kernel flour

A) Preparation of pumpkin seed kernel flour: Pumpkin seed kernels were manually separated from the seed coat. The kernels were roasted on a pan on gas stove for approximately 2 min with slow mixing and folding till light brown for development of flour. The seed kernels were kept at room temperature for cooling and ground using mixer cum grinder (Model MX-1155). The powder thus obtained was sieved using 36 mesh metallic sieve and packed in Transparent Aluminium Laminated Pouches (ALP) for further uses.

B) Standardization of recipe for pumpkin muffins supplemented with seed kernel flour: The best treatment for pumpkin muffin selected under Section 2.3.1 was taken into consideration for the preparation of muffins supplemented with seed kernel flour. Table 11 reflects the different concentration of seed kernel flour used for replacement of flour of selected recipe. The procedure described under Section 2.1 (B) was used for the preparation of muffins. The prepared muffins were analysed for chemical characteristics and presented to a panel of ten judges for sensory evaluation. On the basis of combinations of results, the best treatment was selected and referred as T_3 for further storage studies.

Table 11: Standardization of recipe for pumpkin muffins supplemented with seed kernel flour

Treatment	Cereal Flour (g)	Pumpkin whole Kernel flour (g)
T1	30.00	0.00
T2	28.50	1.50
T3	27.00	3.00
T4	25.50	4.50
T5	24.00	6.00
T6	22.50	7.50
T7	21.00	9.00

3.4 Quality evaluation of pumpkin muffins supplemented with seed flour during storage

The pumpkin muffins of best recipes selected under sections 3.1, 3.2 (B) and 3.3 (B) and referred as T_1 (Pumpkin muffins with rice flour), T_2 (Pumpkins muffins with pumpkin seed flour) and T_3 (Pumpkin muffins with pumpkin kernel flour), respectively were prepared and packed in transparent ALP. The quality evaluation of muffins was done at storage interval of 0, 3, 6 days when stored under ambient conditions and at 0, 10 and 20 days when stored under refrigerated condition. The detail of treatments is given in Table 12.

Table 12: Treatment detail of pumpkin muffins selected for storage studies

Treatments	Description	Selected from Experiment No.
T1	Pumpkin muffins with rice flour	Best treatments from under section 2.3.1
T2	Pumpkins muffins with pumpkin seed flour	Best treatments from under section 2.3.2
T3	Pumpkin muffins with pumpkin kernel flour	Best treatments from under section 2.3.3

Experimental results

1. Composition of raw material

The ripe pumpkin fruit had an average weight of 4380±185.26 g. The mean length and diameter were found to be 36.78± 0.69 and 63.21± 0.08 cm, respectively. The pumpkin seeds and seed kernels had average weight of 0.20±0.002 and 0.14±0.001 g, respectively. Further, the length, width and thickness of 1.68±0.04, 0.74± 0.07 and 0.27±0.03 cm for pumpkin seeds and 1.16±0.05, 0.54±0.05 and 0.25 ± 0.02 cm was recorded in seed kernels, respectively. Based on Royal Horticulture Society Colour Chart, the colour of pumpkin peel was observed to match with yellow orange group (19A), flesh with yellow orange group (15A), pumpkin seed with yellow group 8D and seed kernel with yellow green group (148 C). Pumpkin fruit showed firmness of 21.38±0.18lbs/inch^2. The flesh, seed and peel in pumpkin fruit was 72.89±0.06, 4.35±0.12 and 13.7±0.02 per cent, respectively and the ratio was found to be 77:4:19. Pumpkin fruit possessed 87.29±0.26 per cent moisture, 8.05±0.07 °B TSS and 4.67±0.14 pH. The total and reducing sugars, titratable acidity, fat, protein, fiber, ash, was recorded as 3.44±0.14, 2.69±0.07, 0.06±0.00, 0.43±0.01, 1.52±0.01, 0.56±0.03 and 0.77±0.03 per cent, respectively. Pumpkin pulp contained 88.91±0.07 per cent moisture, 5.56±0.04 °B TSS, 3.39±0.18 per cent total sugars, 2.13±0.02 per cent reducing sugars, 0.04 ± 0.00 per cent titratable acidity, 5.25±0.04 pH, 0.28±0.01 per cent fat, 1.37±0.01 per cent protein, 0.51±0.02 per cent fiber, 0.78±0.02 per cent ash, 9.20 ± 0.04 mg/100 g ascorbic acid, 8.86±0.05 mg/100 g β-carotene, 3.65±0.13 mg GAE/g total phenols and 25.57±0.24 per cent antioxidant activity. The pumpkin seeds had average moisture, fat, protein, fiber and ash contents of 5.6±1.60, 34.21±0.89, 33.13±0.82, 13.59±0.01 and 4.91±0.02 per cent, respectively while the values for seed kernels were 4.49±0.06, 47.34±0.45, 45.54±0.68, 0.87 ± 0.03 and 4.37 ± 0.01 per cent, respectively.

2. Development of muffins using ripe persimmon pulp

2.1 Pumpkin muffins with whole wheat flour

Among different recipes tried for standardization of muffins using whole wheat flour, recipe R^2 (whole wheat flour 100 g, refined oil 15 mL, sugar 25 g, baking powder 1.5 g, baking soda 0.5 g, milk powder 20 g and water 80 mL) was selected as base recipe for further preparation of pumpkin muffins with whole wheat flour and referred as T_0. Out of nine different treatments, the pumpkin muffins prepared by incorporating 70 per cent of pumpkin pulp and 30 per cent whole wheat flour got maximum score for colour (8.13), flavor (8.16), texture (8.16) and overall acceptability (8.10). The prepared muffins contained 5.15 mg/100 g ascorbic acid, 23.67 mg/100 g β-carotene, 10.17 mg GAE/g total phenol and 64.51 per cent antioxidant activity. The treatment was selected and referred as T_1 for storage studies.

2.2 Pumpkin muffins with semolina

The muffins were prepared by completely replacing wheat flour with semolina using four different recipes (R_1, R_2, R_3 and R_4) by varying the concentration of refined oil and sugar while the amount of other ingredients was kept constant. Recipe R_3 with semolina 100 g, refined oil 15 mL, sugar 25 g, baking powder 1.5 g, baking soda 0.5 g, milk powder 20 g and water 80 mL was selected on the basis of highest sensory scores and considered as base

recipe (T_0) for further preparation of pumpkin muffins with semolina. Among different treatments of pumpkin muffins developed with semolina, T_8 (80 per cent pumpkin pulp and 20 per cent semolina) received the maximum score for colour (8.23), flavour (8.10), texture (8.26) and overall acceptability (8.16) and possessed 4.85mg/100 g ascorbic acid, 22.95 mg/100 g β-carotene, 9.38 mg GAE/g total phenol and 52.38 per cent antioxidant activity and was selected and referred as T_2. The pumpkin muffins prepared with semolina revealed values of 30.55 ± 0.14 g for weight and 5.05 ± 0.06, 3.45 ± 0.06and 2.02 ± 0.04 cm for upper diameter, lower diameter and height, respectively. The dough yield and baking loss was 87.14 ± 0.01 and 12.80 ± 0.02 per cent, respectively.

2.3 Pumpkin muffins with rice flour

Among four recipes of muffins prepared with rice flour as base ingredient, R_2 was awarded maximum overall acceptability score of 7.40 and was selected as base recipe (T_0) for the preparation of pumpkin muffins with rice flour. Out of nine treatments employed for development of pumpkin muffins with rice flour, T_7 (70 per cent pulp +30 per cent of rice flour) obtained maximum score of 8.06 for colour, 8.13 for flavour, 8.16 for texture and 8.10 for overall acceptability. The muffins of treatment T_7 recorded 4.34 mg/100 g ascorbic acid, 22.66 mg/100 g of β- carotene, 7.54 mg GAE/g total phenol and 43.49 per cent antioxidant activity. Based on highest sensory scores this treatment was selected for further storage studies and referred as T_3.

2.4 Pumpkin muffins with barley flour

Out of four different recipes tried for standardization of muffins by completely replacing whole wheat flour with barley flour, R_3 was selected as base recipe (T_0) for preparation of pumpkin muffins with barley flour. For the development of pumpkin muffins with barley flour, nine different treatments were used and treatment T_7 containing 70 per cent of pumpkin pulp and 30 per cent barley flour got the maximum score for overall acceptability (8.00) and was selected for further studies. The muffins possessed 4.27 mg/100 g ascorbic acid, 21.36 mg/100 g β-carotene, 9.27 mg GAE/g total phenol and 35.46 per cent antioxidant activity. The selected treatment was referred as T_4.

2.5 Storage studies and cost of production of pumpkin muffins

The muffins of different treatments packed in transparent ALP showed an increase in moisture content while the parameters like fat, fiber, ash, ascorbic acid, total phenols and antioxidant activity reflected a significant decrease during storage. The sensory scores for colour, flavor, texture and overall acceptability also recorded a decreasing trend. Though physical and chemical characteristics of muffins of all the treatments reflected a decrease in value but remained above the acceptable limits and can be stored safely for a period of 6 days under ambient and for 10 days under refrigerated conditions.

3. Development of pumpkin muffins supplemented with seed flour

3.1 Pumpkin muffins supplemented with seed flour

Out of treatments selected for development of pumpkin muffins with whole wheat flour (T_1), semolina (T_2), rice flour (T_3), and barley flour (T_4), treatment T_3 obtained highest

overall acceptability (8.16) score and was followed by T_2, T_1 and T_4 and thus was selected for further studies and referred as T_1.

3.2 Pumpkin muffins supplemented with whole seed flour

Out of seven treatments of pumpkin muffins supplemented with whole seed flour, muffins of treatment T_5 containing 20 per cent whole seed flour got the maximum score for overall acceptability (8.76) and possessed 9.76, 21.92, 1.57 and 3.49 per cent of protein, fat, fiber and ash contents respectively. The treatment was selected and referred as T_2 for further studies.

The muffins supplemented with whole seed flour had a weight of 32.21± 0.26 g, upper diameter of 5.15±0.06 cm, lower diameter of 3.55±0.06, height of 2.55± 0.06 cm, dough yield of 92.24±0.02 per cent and baking loss 7.76±0.01 per cent.

3.3 Pumpkin muffins supplemented with seed Kernel flour

Among seven different treatments of pumpkin muffins supplemented with seed kernel flour, muffins containing 25 per cent of seed kernel flour (T6) received maximum score for colour (8.46), flavour (8.33), texture (8.40) and overall acceptability (8.36). The muffins contained 11.73 per cent protein, 25.51 per cent fat, 7.57 mg/100 g ascorbic acid and 25.24 mg/100 g β-carotene. The treatment was selected and referred as T3 for storage studies. The mean value of 34.28±0.45 g for weight, upper diameter of 5.25±0.06 cm, lower diameter of 3.55±0.06, height of 2.35±0.06 cm, dough yield of 94.28±0.30 per cent and baking loss 5.73±0.01 per cent was observed in pumpkin muffins supplemented with seed kernel flour.

3.4 Storage studies and cost of production of pumpkin muffins

The muffins of different treatments packed in transparent ALP showed an increase in moisture content while the parameters like fat, fiber, ash, ascorbic acid, total phenols and antioxidant activity reflected a significant decrease during storage. The sensory scores for colour, flavor, texture and overall acceptability also recorded a decreasing trend. Though physical and chemical characteristics of muffins of all the treatments reflected a decrease in value but remained above the acceptable limits and can be stored safely for a period of 6 days under ambient and for 10 days under refrigerated conditions. The cost of pumpkin muffins supplemented with pumpkin whole seed and kernel flour worked out to be Rs 19.49 and 21.43 per 100 g of muffins, respectively.

Conclusion and Recommendation

1. The pumpkin pulp is a good source of ascorbic acid (9.20 mg/100 g), β-carotene (8.86 mg/100 g), fiber (0.51 %), total phenols (3.65 mg/100 g), antioxidant activity (25.57 %) while pumpkin whole seeds and seed kernels were concentrated source of fat (34.21 and 47.34 %) and protein (33.13 and 45.54 %), respectively.
2. Pumpkin muffins can be developed by using pulp at a level of 70 per cent in each case using whole wheat, rice and barley flour and up to 80 per cent with semolina. The incorporation of pulp was found to enhance the functional properties of muffins with respect to ascorbic acid, β-carotene, total phenols and antioxidant activity.

3. Pumpkin muffins can further be supplemented with pumpkin whole seed and seed kernels up to 20 and 25 per cent of replacement with rice flour, respectively, which was found to improve the protein and fat content.
4. The developed muffins can be stored safely under ambient (6 days) and refrigerated conditions (20 days) when packed in Transparent Aluminum Laminated Pouches (ALP) with minimal changes in chemical and sensory attributes.
5. Hence, it can be concluded that the ripe pumpkin which otherwise is processed to a limited extent, can be successfully and conveniently utilized for the development of functional and good quality muffins at a remunerative cost.

Annexure–11

Sub-Project: Development of *anardana* from unmarketable fruits of commercial pomegranate

The study was conducted for development of *anardana* from unmarketable fruits of commercial pomegranate. Pomegranate fruit is rich source of anthocyanins, phenols, crude fibre, sugars, vitamins, minerals and antioxidants. It has become one of the commercial fruits of Himachal Pradesh in recent years. However, sufficient amount of this crop goes waste because of fruit cracking. So, the present investigations were conducted to develop *anardana* from the cracked/unmarketable fruits of Kandhari Kabuli cultivar of this fruit. The arils after manual extraction were steam blanched (30 to 90 seconds) and best steam blanching time (60 seconds) was standardized to inactivate enzymes. Treated arils were then dipped in citric acid solution of varying concentrations for different time periods followed by sulphur fumigation (0.3% for 60 min) and one best treatment (dipping in 50 % citric acid for 5 min) was selected for drying under various drying modes (mechanical cabinet drier, solar tunnel drier and open sun). *Anardana* prepared in the best drying mode *i.e*, mechanical cabinet drier was packed in four different packaging material including jute bags, polyethylene pouch (PEP), aluminium laminated pouches (ALP) and ALP with vacuum and stored under ambient (18-27^{o}C) and refrigerated (4-7^{o}C) temperature conditions for 6 months. *Anardana* packed in ALP with vacuum and stored under refrigerated conditions retained better quality during storage. However, quality changes were observed faster in ambient as compared to refrigerated storage conditions. Treated arils can also be dried under solar tunnel drier for the development of *anardana* with slightly higher moisture content as compared to mechanical cabinet drier. The cost of *anardana* prepared in mechanical cabinet drier was comparable to the cost of similar product available in the market.

Details of Experiments conducted:

Objective 1: Procurement of raw materials

Ripe fruits of Kandhari Kabuli cultivar of pomegranate were procured from Bajaura district of Kullu (HP) and brought to Department of Food Science and Technology, UHF, Nauni Solan (HP). The fruits were used for the preparation of *anardana*.

Objective 2: Standardization of pre-treatments

i) **Blanching time:** Arils were steam blanched for varying period of time and activity of peroxidase enzyme was observed.

ii) **Impregnation of acid:** Blanched arils were dipped in different concentrations of citric acid for varying times (Table.1) and fumigated in sulphur fumigation chamber. Treated arils were dried under mechanical cabinet drier at 60 ± 2^{o}C till they attained constant weight.

Cracked fruits

Table: 1 Treatment details of different concentration of citric acid and varying time

Treatment Symbol	Concentration (%)	Time (min)
T_1	Control	-
T_2	20% citric acid	5
T_3	20% citric acid	10
T_4	20% citric acid	15
T_5	25 % citric acid	5
T_6	25 % citric acid	10
T_7	25 % citric acid	15
T_8	30 % citric acid	5
T_9	30 % citric acid	10
T_{10}	30 % citric acid	15
T_{11}	40 % citric acid	5
T_{12}	40 % citric acid	10
T_{13}	40 % citric acid	15
T_{14}	50 % citric acid	5
T_{15}	50 % citric acid	10
T_{16}	50 % citric acid	15

Objective 3: Drying of arils

Pre-treated arils were dried under different modes of drying as explained below:

1. **Sun Drying:** The pre-treated arils were spread on the perforated aluminium trays and kept in the open sun in an inclined position for drying. The material was kept till the sunset before shifting it back in the laboratory for night. Arils were dried in the sun till they attained the constant weight. The mean temperature during these studies were recorded in the range of 12 to 28^{o}C.

Mechanical cabinet drying

Solar tunnel drying

Sun drying

Drying of arils under different drying modes

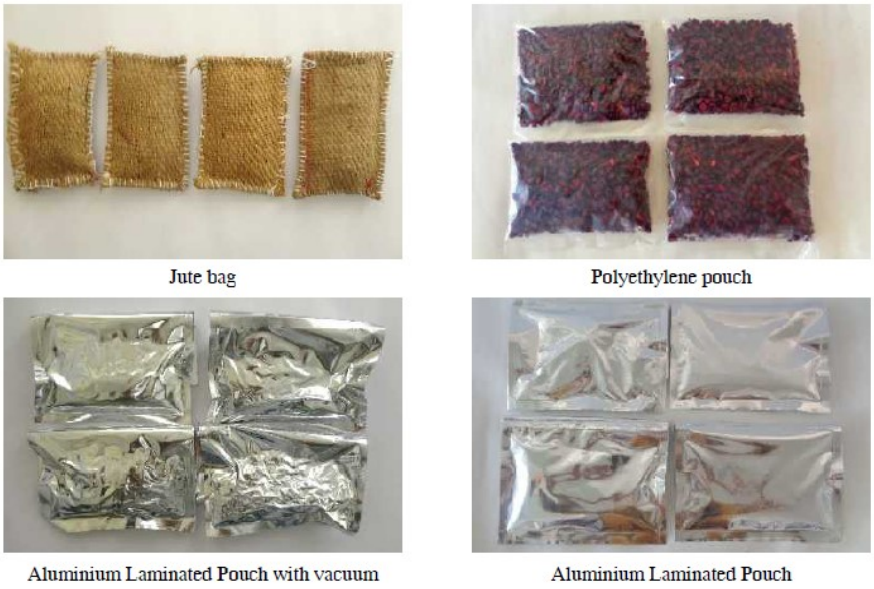
2. **Solar tunnel drying:** The pre-treated arils were kept in perforated aluminum trays inside solar tunnel drier having dimensions of 207 x 209 x 207 cm and covered with a thick polyethylene sheet (0.31 mm). The temperature recorded in this drier during these studies was in the range of 19 to 32°C. The pre-treated arils were dried in this mode of drying till they attained a constant weight.
3. **Mechanical cabinet drying:** The pre-treated arils were thoroughly spread in an even layer of 0.50 cm on perforated steel trays of dimension of (76× 56 cm) in mechanical cabinet drier having internal dimensions 78 x 58 x 128 cm. The temperature for drying was set at 60 ± 2°C and product was dried until it attained the constant weight. To ensure uniform drying each tray was rotated periodically inside the drier.

Objective 4: Packaging and Storage

The *anardana* from best selected drying mode was packed in different packaging materials as per the detail given in Table.2 The *anardana* in different packaging material was stored under ambient temperature (18-27^{o}C) and refrigerated temperature (4-7^{o}C) conditions for a period of 6 months storage.

Table: 2 Detail of Treatments

Treatment	Thickness (µm)	Treatment Symbol
Jute Bags	-	T_1
Polyethylene pouch	(PEP) 65 µm	T_2
Aluminium laminated pouch	(ALP) 89 µm	T_3
Aluminium laminated pouch with vacuum	125 µm	T_4



***Anardana* packed in different packaging material**

Experimental results

1. Composition of raw material

Among various physico-chemical characteristics of pomegranate fruits, the average length, diameter and weight were recorded as 8.39 cm, 7.52 cm and 227.02 g, respectively. The colour of fruit and arils was observed to be pinkish red (Red 48 A) and blood red (Red 53 A), respectively and arils comprised moisture and total solids to be 79.32 per cent and 20.68 per cent, respectively. The titratable acidity of the arils was 0.54 per cent, whereas, the pH was 4.01. Arils also contained 9.30 per cent, 12.10 per cent, 14.47 mg/100g and 18.80 mg/100g of reducing sugars, total sugars, ascorbic acid and anthocyanins, respectively. The crude fibre and pectin contents were 1.4 per cent and 1.3 per cent, respectively. The total phenols content of arils was 48.29 mg/100g and antioxidant activity was observed to be 32.30 per cent.

2. Standardization of pre-treatments

Pre-treatment of arils with steam blanching for 60 sec was standardized based on the estimation of optimum enzyme activity of 0.624 units/min/g FW and slight loss of visual colour of arils as well as total soluble solids. Steam blanched arils were then further dipped in various concentrations of citric acid solution for different time period, out of which dipping in 50 per cent citric acid solution for 5 min was found most favourable on the basis of sensory attributes like colour (7.28), texture (7.30), flavour (8.70) and overall acceptability (8.75) scores.

3. Drying of Arils

While comparing different drying modes, mechanical cabinet dried arils possessed maximum TSS (41.30 ºB), titratable acidity (12.20%), ascorbic acid (10.71 mg/100g), reducing sugars (24.34 %), total sugars (28.20%), anthocyanins (41.81 mg/100g), phenols (92.38 mg/100g), crude fibre (33.70%) and antioxidant activity (59.30 %). It took minimum time (20.50 h) to dry a given tray load (1 Kg), had minimum NEB (0.05 OD), furfural (14.66 ppb), HMF (0.95 ppm) and residual SO_2 (246.38 ppm). Mechanical cabinet dried arils were rated best among all drying modes on the basis of highest sensory scores of colour (8.20), texture (8.00), flavour (8.56) and overall acceptability (8.55).

4. Packing and Storage

Mechanical cabinet dried arils (*anardana*) packed in all the packaging material and stored under refrigerated and ambient temperature conditions exhibited some changes in all physico-chemical characteristics of *anardana* during storage. However, minimum changes were observed in ALP with vacuum (T_4) and ALP (T_3) with respect to visual colour, besides slight increase in moisture from 9.20 to 9.21 per cent, water activity from 0.241 to 0.242, reducing sugars from 24.34 to 24.39 per cent, NEB from 0.050 to 0.052 (OD), HMF from 0.95 to 1.28 ppm and furfural from 14.66 to 18.72 ppb, during storage. Whereas, minimum decrease was observed in total solids from 90.80 to 90.78 per cent, titratable acidity from 12.20 to 12.18 per cent, total sugars from 28.20 to 28.15 per cent, TSS from 41.30 to 41.29 ºB, ascorbic acid 10.71 to 10.31 mg/100g, anthocyanins from 41.81 to 41.78 mg/100g, total phenols from 92.38 to 91.21 mg/100g, antioxidant activity from 59.30 to 58.68 per cent and residual SO_2 from 246.38 to 242.10 ppm in the same packaging material (T_4) during six months of storage. Sensory characteristics scores of *anardana* decreased with respect to colour from 8.50 to 8.42, texture from 8.30 to 8.21, flavour from 8.40 to 8.30 and overall acceptability from 8.65 to 8.56 during storage. So, *anardana* packed in ALP with vacuum (T_4) manifested higher-ranking quality in terms of physico-chemical and sensory properties in compared to other packaging material. The cost of production of per kg *anardana* in best packaging material that is ALP with vacuum (T_4) was recorded as Rs. 477.12, whereas it was observed as Rs. 476.61 in next best treatment ALP (T_3).

Conclusion and Recommendation

1. *Anardana* is a commercial product which is mainly prepared from wild pomegranate but it can also be prepared from healthy or cracked fruits of commercial pomegranate cultivar (Kandhari Kabuli) by increasing its acid content in suitable amount.

2. For developing the best quality *anardana* its arils can first be steam blanched for 60 sec, then dipped in 50 per cent citric acid solution for 5 min, followed by sulphuring @ 0.3 per cent for 60 min before drying.

3. Best pre-treated arils can be dried in mechanical cabinet drier successfully at 60±2 ºC for the development of *anardana*. Mechanical cabinet dried arils (*anardana*) packed in aluminium laminated pouch (ALP) with vacuum stored under refrigerated conditions retained better quality during 6 months of storage.

4. However, quality changes were observed faster in ambient storage conditions as compared to refrigerated. Treated arils can also be dried under solar tunnel drier for the development of *anardana* with slightly higher moisture content as compared to mechanical cabinet drier.

5. The cost of production of *anardana* packed in ALP with vacuum was slightly higher but comparable to the cost of the similar product available in the market. Conclusively, these results can provide a supplementary benefit to the pomegranate growers if this technology is followed efficiently.

Annexure–12

Sub-Project: Carrot juice concentrate production and utilization

The present investigations were conducted involving evaluation of four types of carrot for juice concentrate production and its further utilization in food products. Carrot is a widely consumed vegetable throughout the world and is known for its high antioxidant properties due to the presence of bioactive compounds like total carotenoids, anthocyanins and total phenolics. Out of various pre-treatments tried for enhancement of juice yield, acidified water blanching in black and purple carrot for 4 min and 3 min, respectively was optimized. Whereas, ultrasound assisted blanching for 5 min before extraction of juice in orange and red carrot was found to be the best. Further, carrot juice concentrates were developed by Response Surface Methodology (RSM) with different temperature-concentration combinations in rotary vacuum evaporator. The prepared black carrot juice concentrates (53.2ºC and 65.68ºB) had maximum anthocyanins, total phenolics and antioxidant activity of 1378.16 mg/ 100 g, 2490.17 mg GAE/ 100 g and 75.34 per cent free radical scavenging activity, respectively. The optimized concentrates were packed in transparent and amber colour glass vials and analyzed for various chemical and sensory attributes during storage. Though concentrates experienced marginal changes in quality attributes, yet remained shelf-stable during the storage period of 6 months at ambient and refrigerated temperature. The concentrate was further utilized for the nutritional enrichment of bakery food products. On the basis of sensory evaluation, 15 per cent incorporation of orange carrot juice concentrate in cookies and muffin and 20 per cent in cereal bar was found to be the best combination. Further, the developed bakery products had better taste, palatability, medicinal and nutritive value. Moreover, cookies and cereal bar retaining acceptable quality could be stored for 60 days and muffin for 30 days in polyethylene pouches at both ambient and refrigerated temperatures. The cost of production of all products was comparable to the cost of similar products in the market. The carrot available in winter months at reasonable price could successfully be utilized for the development of juice concentrate at commercial scale and further making the concentrate available to the ancillary food industry for its use in bakery products for nutritional, natural colour and antioxidants enrichment.

Details of Experiments conducted:

Objective 1: Procurement of raw materials

Four types of carrot *viz.*, black, orange, purple and red were procured from the Department of Vegetable Science, Dr Yashwant Singh Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh.

Objective 2: Standardization of methodology for carrot juice extraction

The carrot roots were washed under running tap water, trimmed using stainless steel knife, dirty skin and undesirable hair were removed. Further, the roots were subjected to different pre-treatments for standardization of methodology for juice extraction.

2.1 Effect of blanching method and time on juice extraction

The carrot roots were either shredded with stainless steel vegetable grater or whole carrots (10 cm) were subjected to different blanching treatments i.e. as hot water blanching, steam blanching, acidified water blanching (citric acid @ 4.50%), ultrasound assisted blanching and microwave assisted blanching for variable time intervals i.e. 1, 2, 3, 4 and 5 minutes, as per details given in Table 1.

Table 1 Treatment detail of juice extraction using different blanching methods and time

Treatments		Time of blanching (min)				
Control (without blanching)	Whole carrot	-	-	-	-	-
	Grated carrot	-	-	-	-	-
Hot water blanching	Whole carrot	1	2	3	4	5
Steam blanching	Whole carrot	1	2	3	4	5
	Grated carrot	1	2	3	4	5
Acidified water blanching	Whole carrot	1	2	3	4	5
Ultrasound assisted blanching	Whole carrot	1	2	3	4	5
	Grated carrot	1	2	3	4	5
Microwave assisted blanching	Whole carrot	1	2	3	4	5
	Grated carrot	1	2	3	4	5

2.2 Effect of enzymatic treatment on juice extraction

The carrot roots were shredded using a stainless-steel vegetable grater and subjected to the treatment of different enzymes. Different concentrations of enzymes (0.1, 0.2 and 0.3%) were used to treat carrot shreds for different time interval (60, 90 and 120 minutes) at a constant temperature of 50ºC. Details of the experiment are given in Table 2.

Table 2: Treatment detail of juice extraction using enzyme treatment

Pectinase Concentration (%)	Time (min)	Cellulase Concentration (%)	Time (min)	Pectinase + Cellulase (1:1) Concentration (%)	Time (min)
0.1	60	0.1	60	0.1	60
0.1	90	0.1	90	0.1	90
0.1	120	0.1	120	0.1	120
0.2	60	0.2	60	0.2	60
0.2	90	0.2	90	0.2	90
0.2	120	0.2	120	0.2	120
0.3	60	0.3	60	0.3	60
0.3	90	0.3	90	0.3	90
0.3	120	0.3	120	0.3	120

Juice extracted by these methods was compared on the basis of juice yield and quality. The best selected treatment was further recommended for juice extraction.

Objective 3: Standardization of technology for the concentration of carrot juice and its stability during storage

3.1 Optimization of process parameters for the concentration of carrot juice

Extracted juice was stored in glass bottles after pasteurization and heat processing. The juice was further used for concentration by removal of water in vacuum rotatory evaporator (Igene labserver) at different temperatures. Different combinations of temperature and concentration were obtained according to the Central Composite Design (CCD). The range of temperature and concentration was 30-60ºC and 40-70 per cent, respectively. The treatment detail is given in Table 3 and 4.

Table 3 Treatment detail for range of coded and actual values of independent variable by RSM for carrot juice concentration

Independent variables	Coded values				
	-α (-1.41)	-1	0	+1	+α (1.41)
Temperature (ºC)	23.79	30	45	60	66.21
Concentration (%)	33.79	40	55	70	76.21

3.2 Storage stability of carrot juice concentrate

The best treatment from previous sub-experiment (3.1) was then packed in glass vials (transparent and amber coloured) and stored under different storage conditions [ambient (10.2-28.3ºC) and refrigerated (4-7ºC)]. The concentrates were further analysed for various physico-chemical and sensory characteristics at different intervals i.e. 0, 3- and 6-months during storage.

Objective 4: Utilization of carrot juice concentrate for the development of functional food products

The carrot juice concentrate (best) was incorporated into the food products (cookies, muffin and cereal bar) to supplement their nutritional and functional properties. The method of preparation and optimization of incorporation level in these products are discussed here under;

4.1 Optimization of level of carrot juice concentrate in cookies

The cookies were prepared according to the method described Vanlalliani (2019) with slight modifications. The ingredient such as wheat flour, oil, powdered sugar, skim milk powder, salt and sodium bicarbonate were for the preparation of cookies. The powdered sugar was mixed with oil and mixture was beaten until light and fluffy. The sieved refined wheat flour, salt along with sodium bicarbonate and skimmed milk powder were added to the fluffy mass for the formation of soft dough. In control sample, water was used for dough preparation, which was replaced with carrot juice concentrate (Table 6) in functionally enriched cookies. The mixture was kneaded properly for about 10 min and wrapped in an aluminium foil. The dough was allowed to stand at room temperature and after that it was converted into small balls. The balls were flattened into sheets and cut into circular shapes

with the help of cookie cutter. The cut shapes were placed on a baking tray lined with butter paper and baked in an oven at 180ºC for 35 min. The best combination was selected on the basis of sensory evaluation for further studies.

Table 5: Recipe for cookie preparation

Ingredients	Amount
Wheat flour (g)	100
Vegetable oil (mL)	40
Sugar powder (g)	35
Skim milk powder (g)	10
Salt (g)	0.75
Baking powder (g)	1
Water (mL)	25

Table 6: Treatment detail for the incorporation of different levels of carrot juice concentrate in cookie

Treatment	Carrot juice concentrate (%)
T_1	0
T_2	5
T_3	10
T_4	15
T_5	20
T_6	25

4.2 Optimization of level of carrot juice concentrate in muffins

The recipe suggested by Singh *et al.* (2017) with slight modifications was followed for the development of muffins. The fat and powdered sugar were mixed together and beaten until the mixture became light and fluffy. Pre-weighed dry ingredients i.e. wheat flour, baking powder and baking soda were sieved and the fluffy mixture. In control muffin sample milk was added however, it was replaced with carrot juice concentrate (0, 5, 10, 15, 20 and 25%) in functionally enriched muffins. Continuous mixing and whipping of the mixture were done until the desired consistency was achieved. The prepared batter was poured in pre-greased baking mould. Baking was done in pre-heated oven at 200ºC temperatures for 30 min. After baking, cake was allowed to cool at room temperature. Best treatment was selected on the basis of sensory evaluation.

Table 7: Recipe for muffin preparation

Ingredients	Amount
Wheat flour (g)	100
Vegetable oil (mL)	8
Sugar powder (g)	54
Milk (mL)	80
Baking soda (g)	0.75
Baking powder (g)	5

Table 8: Treatment detail for the incorporation of different levels of carrot juice concentrate in muffin

Treatment	Carrot juice concentrate (%)
T_1	0
T_2	5
T_3	10
T_4	15
T_5	20
T_6	25

4.3 Optimization of level of carrot juice concentrate in cereal bar

Cereal bar was prepared by using oats, peanut powder and honey. Base recipe of Padmashree *et al.* (2012) was used with slight modifications. Roasted oats and peanut powder (1:1) were weighed and mixed thoroughly. Mixture is than added to honey on a low flame. Honey was used as binding agent in control samples. However, for the formation of functionally enriched cereal bar, honey was replaced with carrot juice concentrate. The mixture was put in to pre-greased moulds after through mixing. The mixture was pressed to remove air gaps and kept in refrigerator for setting (15 min). Best treatment was selected on the basis of highest sensory score and was packed and stored for further studies.

Table 9: Treatment detail for the incorporation of different levels of carrot juice concentrate in cookie

Treatment	Carrot juice concentrate (%)
T_1	0
T_2	5
T_3	10
T_4	15
T_5	20
T_6	25

Experimental results

1. Composition of raw material

Among the physico-chemical characteristics of different types of carrot (black, orange, purple and red) indicates that maximum root weight and length was reported in red carrot whereas, maximum diameter was noted in orange carrot. Further, red carrot had maximum value for total soluble solids, reducing sugars and total sugars followed by black carrot, purple carrot and orange carrot. Maximum titratable acidity and minimum pH was found in black carrot roots. The fibre and pectin content was highest in orange carrot and lowest in black carrot. Black carrot had maximum antioxidant activity (80.25%) which might be due to presence of high anthocyanins (249.32 mg/ 100 g) and total phenolics (290.63 mg GAE/ 100 g).

2. Standardization of methodology for carrot juice extraction

2.1 Effect of blanching method and time on juice extraction

In total, 42 treatment combinations were tried to standardize the blanching method and time in each type of carrot for the extraction of juice. In black carrot, juice extracted after 4 min of acidified water blanching of whole carrot was selected as best treatment on the basis of juice yield (65.30%), anthocyanin content (185.76 mg/ 100 g), total phenolics (93.50 mg GAE/ 100 g) and antioxidant activity (68.98%). However, in orange carrot, ultrasound assisted blanched whole carrot (5 min) had better juice quality (52.90%) as compared to rest of the treatments. Likewise, acidified water blanched whole carrot for 3 min (juice yield 66.60) and ultrasound assisted whole carrot for 4 min (juice yield 72.40%) were recorded as best treatments in purple carrot and red carrot, respectively.

2.2 Effect of enzymatic treatment on juice extraction

For comparing different enzymes, concentration and time of application, 21 treatments were applied to each type of carrot. The juice extracted was analyzed for various chemical parameters. Cellulase @ 0.1 per cent applied for 120 min had the maximum juice yield of 57.10 per cent in black carrot. Similarly, in orange carrot, 0.3 percent Cellulase for 90 min was found to be the best treatment. Further, Cellulase @ 0.1 and 0.3 per cent for 90 and 120 min was optimized for juice extraction in purple carrot and red carrot, respectively. The temperature was kept constant at 50ºC.

3. Standardization of technology for the concentration of carrot juice and its stability during storage

3.1 Optimization of process parameters for the concentration of carrot juice

Further, carrot juice concentrates (black, orange, purple and red) were prepared according to treatments/ run designed by Response Surface Methodology (RSM). The responses measured were yield, total sugars, reducing sugars, titratable acidity, ascorbic acid, total carotenoids, anthocyanins, total phenolics, antioxidant activity, non-enzymatic browning and sensory parameters i.e. colour, body, flavor and overall acceptability. On the basis of these responses, the process parameters were optimized. The best carrot juice concentrates (black, orange, purple and red) were packed in transparent and amber coloured glass vials which were than stored in ambient (10.2 - 28.3ºC) and refrigerated conditions (4 - 7ºC) for quality evaluation at an interval of 0, 3 and 6 months.

3.2 Storage stability of carrot juice concentrate

During storage, the carrot juice concentrates experienced slight decrease in total soluble solids, total sugars, titratable acidity, ascorbic acid, total carotenoids, anthocyanins, total phenolics and antioxidant activity whereas, increase in reducing sugars and non-enzymatic browning up to 6 months of storage period was recorded. Although, the sensory quality of juice concentrate decreased during storage, yet the concentrate had sensory score within acceptable range. The changes in various quality attributes of carrot juice concentrate stored at ambient temperature were observed to be slightly higher as compared to refrigerated storage condition.

4. Utilization of carrot juice concentrate for the development of functional food products

4.1 Optimization of level of carrot juice concentrate in cookies

The best rated orange carrot juice concentrate was further utilized for the preparation of functionally enriched food products. In carrot juice concentrate enriched cookies, 15 per cent carrot juice concentrate was optimized on the basis of sensory evaluation. Further, these carrot juice concentrate enriched cookies had higher amount of total carotenoids (8.37 mg/ 100 g), total phenols (15.85 mg GAE/ 100 g) and antioxidant activity (35.69%) as compare to control cookies.

4.2 Optimization of level of carrot juice concentrate in muffins

In the case of functionally enriched muffins, 15 per cent carrot juice concentrate was declared as best on the basis of colour, texture, flavor and overall acceptability score. The best rated treatment was further reported to contain 5.76 mg/ 100 g ascorbic acid, 28.12 mg GAE/ 100 g total phenolics and 39.24 per cent antioxidant activity as compared to control muffins which had 1.42 mg/ 100 g, 6.54 mg GAE/ 100 g and 7.12 per cent ascorbic acid, total phenolics and antioxidant activity, respectively.

4.2 Optimization of level of carrot juice concentrate in cereal bar

In cereal bar, treatment with 20 per cent carrot juice concentrate was adjudged the best by panelists in term of sensory score and hence was optimized for the preparation of functionally enriched cereal bar. Organoleptically best rated cereal bar contained 7.58 mg/ 100 g total carotenoids, 24.76 mg GAE/ 100 g and 47.26 per cent antioxidant activity.

The concentrate enriched food products i.e. cookies, muffin and cereal bar could be stored safely in polyethylene pouches under ambient (27.1 - 29.1ºC) and refrigerated condition (4 - 7ºC) for a period of 60, 30 and 60 days, respectively with minimum changes in chemical and sensory attributes. However, comparatively fewer changes in products stored under refrigerated conditions were observed as compared to the products stored under ambient temperature. The cost of production of various products was calculated on the basis of current market price of all the ingredients. The cost of production was 290.55, 373.46, 260.85 and 277.52 (Rs/ L) for black, orange, purple and red carrot juice concentrate, respectively. Further, price of functionally enriched cookies, muffin and cereal bar was 10.22, 8.46 and 29.24 rupees per 100 g, respectively. However, a lower cost of production for control (without addition of carrot juice concentrate) samples i.e. 6.93 and 5.90 Rupees per 100 g was calculated for cookies and muffin, respectively.

Conclusion and Recommendation

1. The carrots of 4 different types (black, orange, purple and red) were evaluated for the preparation of carrot juice concentrate and its further utilization in formulation of functionally enriched food products. Among these carrot roots, black carrot was found to have the highest anthocyanins, total phenolics and antioxidant activity.

2. The prepared carrot juice concentrates were subjected to storage and it was found that these could be stored safely up to 6 months under both ambient and refrigerated

conditions in both packaging materials (transparent and amber coloured glass vials) with minimum changes in quality attributes.

3. To ascertain the utilization of concentrates in bakery products enriched with functional food products, cookies and muffin prepared with 15 per cent orange carrot juice concentrate were adjudged the best on the basis of sensory characteristics. Similarly, cereal bar with 20 per cent carrot juice concentrate was optimized as the best.

4. The functionally enriched bakery products contained higher amount of ascorbic acid, total carotenoids, total phenolics as well as antioxidant activity. These food products could be stored successfully in polyethylene pouches at ambient and refrigerated temperature for a period of 30 days (muffin) and 60 days (cookies and cereal bar).

5. Carrot is available in plenty in winter season at a reasonable cost, the juice can successfully be converted to carrot juice concentrates and substantially be incorporated for the enrichment of bakery food products. The cost of production of concentrates and functionally enriched food products was comparable to the cost of similar products in the market.

Annexure–13

Sub-Project: Extraction of isoflavone and development of functional food products from soybean (*Glycine max* L. Merrill)

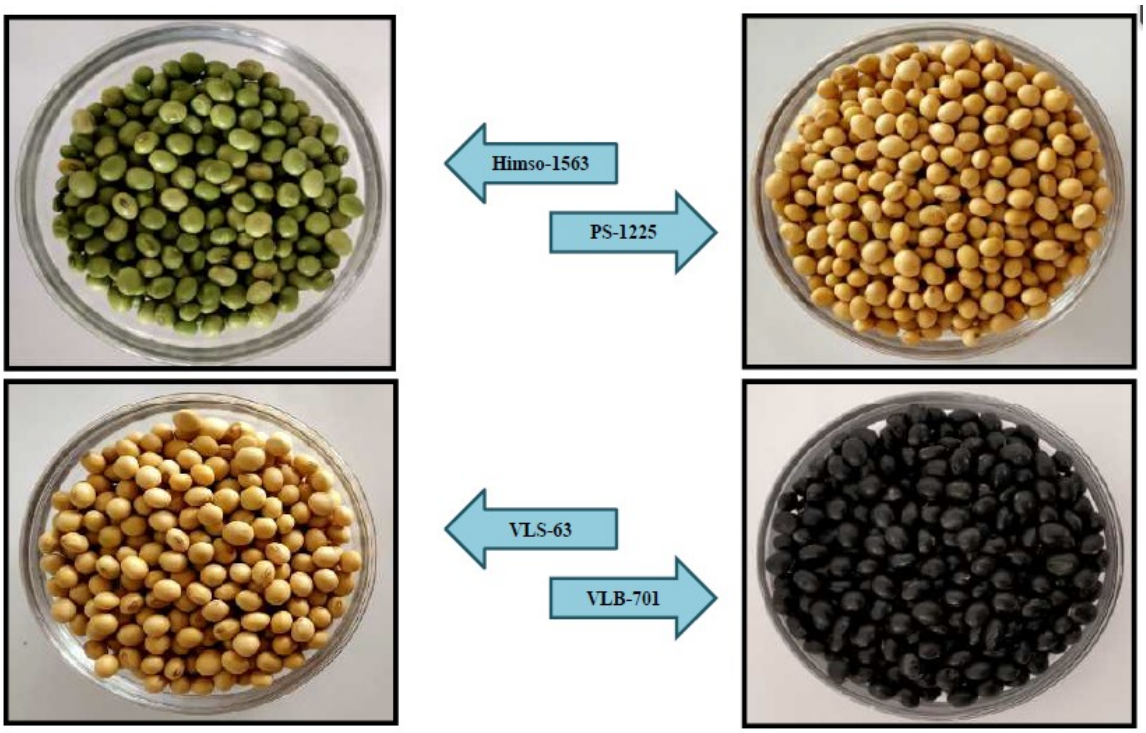
The study was aimed at the development of *Harit* soya (Himso-1563) an evergreen variety of soybean was used to conduct the study on the extraction of isoflavone and development of functional food products. The study revealed that raw seeds possessed various components such as protein (37.96 %), total chlorophyll (17.45 mg/100 g), phenolics (4.53 mg GAE/g), isoflavones (5.32 mg/g), iron (142.41 ppm) etc which increased significantly when seeds were germinated for three days. Among water based, solvent based and ultrasonic-assisted extraction methods, isoflavone extracted using 60 per cent ethanol mixed with powder in the ratio 25:1 at 50 °C for 3 h exhibited the highest total isoflavones (21.02 mg/g) when dried using freeze dryer. The encapsulation of extracted isoflavone with 6 per cent maltodextrin possessed higher encapsulation efficiency (77.59 %) with isoflavone content of 7.14 mg/g. The encapsulated isoflavone extract can be stored safely for a period of six months in transparent as well as ambered glass vials under refrigerated and ambient conditions however, higher retention of quality was achieved under refrigerated conditions when packed in ambered glass vials. *Harit* soya was also utilized for the development of value-added products. The seeds pre-treated by soaking in 0.5 % $NaHCO_3$ solution + hot water grinding indicated maximum removal of beany flavour from soymilk with overall acceptability score of 8.76. Out of ten different treatments, soymilk developed from dehulled seeds in 1:9 seed to water received higher sensory scores. Further the soya and dairy milk enriched with isoflavone and encapsulated isoflavone extracts @ 50 mg/250 mL revealed significant increase in functional characteristics with maximum phenolics (75.32 mg/100 mL) and isoflavone (19.90 mg/100 mL) content in soymilk with encapsulated isoflavone extract. The milk of different treatments packed in glass bottles can be stored safely for six months under refrigerated conditions with minimal changes in quality attributes. The yoghurt developed from *Harit* soya milk was not liked by the panelist and was rejected. The dairy yoghurt enriched with isoflavone extracts @ 50 mg per 100 g packed in polystyrene cups recorded higher value for functional characteristics and received maximum sensory scores. The product can be stored up to ten days under refrigerated conditions. Tofu (soya *paneer*) prepared from 1.50 per cent calcium chloride as coagulant obtained highest overall acceptability (8.52) and contained sufficient amount of nutritional and functional components like phenolic (110.05 mg GAE/100 g) and isoflavone (20.69 mg/100 g) content. Tofu (soya *paneer*) as well as dairy *paneer* can be enriched with isoflavone extracts @ 50 mg/100 g with higher acceptability and stored safely in LDPE pouches under refrigerated conditions for ten days. Henceforth, it can be concluded that *Harit* soya which otherwise has not been exploited for processing can successfully be utilized for extraction of isoflavones, production of value-added products such as milk, tofu, etc. as well as extracted isoflavone can be incorporated in these products to enhance their functional properties.

<u>Details of Experiments conducted</u>:

Objective1: Procurement of raw materials

Four varieties of soybean *viz*. Himso-1563 (green), PS-1225 (yellow), VLS-63 (yellow) and VLB-701 (black) were used to conduct the study. The seeds were procured

from the Sale Centre of the Directorate of Extension Education, Dr YS Parmar University of Horticulture and Forestry, Nauni, Solan, GB Pant University of Agriculture and Technology, Pantnagar and Vivekananda *Parvatiya Krishi Anusandhan Sansthan*, Dugalkhola, Almora, Uttarakhand. Yoghurt mixed culture (*Lactobacillus delbrueckii* subsp. *bulgaricus* and *Streptococcus thermophiles*) was acquired from National Dairy Research Institute, Karnal, Haryana.



Soybean seeds of different varieties

Objective 2: Quality evaluation of *Harit* soya seeds of different treatments

The raw seeds of *Harit* soya were subjected to different treatments such as soaking, dehulling, germination, roasting and soaking+roasting prior to analysis for various quality characteristics. After each treatment, the dried seeds were ground in a mixer cum grinder (Havells, Model MX-1155) and passed through 36 mesh sieves in order to get fine and uniform powder. The powder was packed in PET jars for further quality evaluation. The treatments with detail are discussed below:

i) **Raw (without any treatment):** The raw soybean seeds without any treatment were ground to form $_{\text{fine powder}}$ and referred as T_1.

ii) **Soaking:** The raw soybean seeds were soaked in lukewarm water in the ratio of 1:10 for 16 h. After soaking, seeds were spread on trays and dried in shade till constant weight was attained. The dried seeds were converted into fine powder by following the same procedure as discussed above. The seed powder thus obtained was referred as T_2.

iii) **Dehulling:** The raw soybean seeds of known weight were soaked in lukewarm water in the ratio of 1:10 for 16 h. The soaked seeds were rubbed between hands under running tap water to separate hull from seeds. The dehulled seeds were then dried under shade by spreading on trays till constant weight was achieved. The seeds

were converted into fine powder. The dehulled seed powder was referred as T_3 for further studies.

iv) **Hull :** The seed coat recovered during dehulling of seeds was shade dried till constant weight was accomplished and ground to form fine and uniform powder as elaborated in first para of this section. The developed powder was referred as T_4.

v) **Germination:** The known amount of raw soybean seeds was soaked in lukewarm water in the ratio of 1:10. After soaking (16 h), the seeds were kept in sprout box for sprouting. The sprouted seeds were evaluated for different functional components at an interval on 0 (G1), 1 (G2), 2 (G3) and 3 (G4) days during germination. The plumule size at different stages was recorded. The germinated seeds were dried (till constant weight) and ground to obtain a fine and uniform powder. The best treatment that gave maximum value for all functional characteristics was selected and referred as T_5.

Table 1: Treatments for germination of *Harit* soya seeds

Treatment (G)	Germination (Days)
G_0	0 (after soaking)
G_1	1
G_2	2
G_3	3

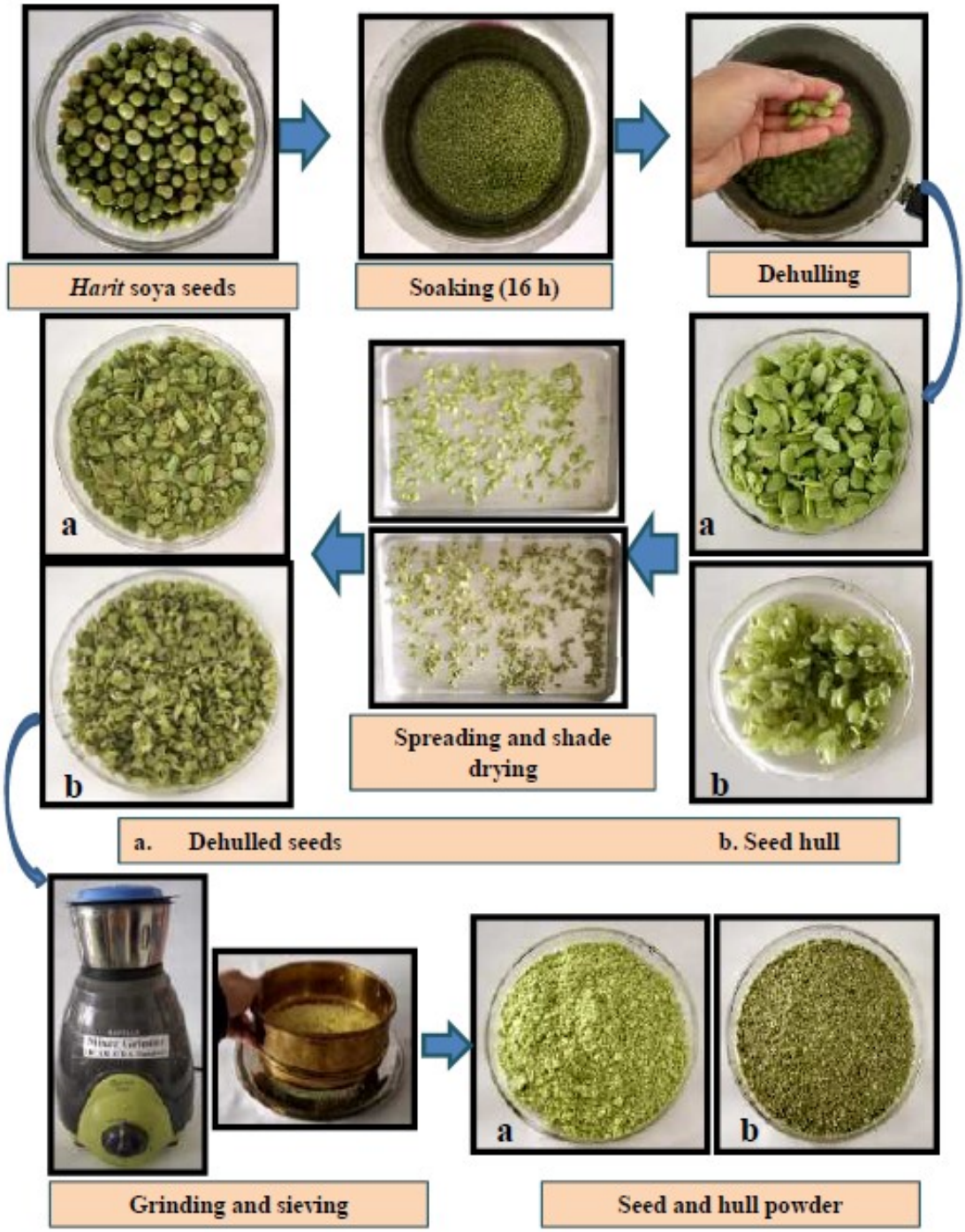
vi) **Roasting:** The raw soybean seeds of known weight were placed in pre heated baking oven at 150°C for 20 min. The seeds were gradually turned upside down using spatula for uniform heating and allowed to cool down at room temperature. The roasted seeds were ground to get fine powder. The powder was packed and referred as T_6 for further studies.

vii) **Soaking+roasting:** The raw soybean seeds of known amount were soaked in lukewarm water in the ratio of 1:10 for 16 h. The soaked seeds were spread on muslin cloth to remove surface moisture and then roasted in pre-heated baking oven at 150°C for 60 min. For uniform heating, the seeds were turned upside down with the help of spatula after 10min interval. After roasting, the seeds were allowed to cool down at room temperature and ground to form fine powder. The seed powder of this treatment was referred as T_7. The seed powder of each treatment (Table 2) was analysed for quality in respect of chemical and functional characteristics. The powder of treatment which reflected the maximum value for isoflavone was selected to conduct the experiments on extraction of isoflavone by different methods as detailed under section 2.2.

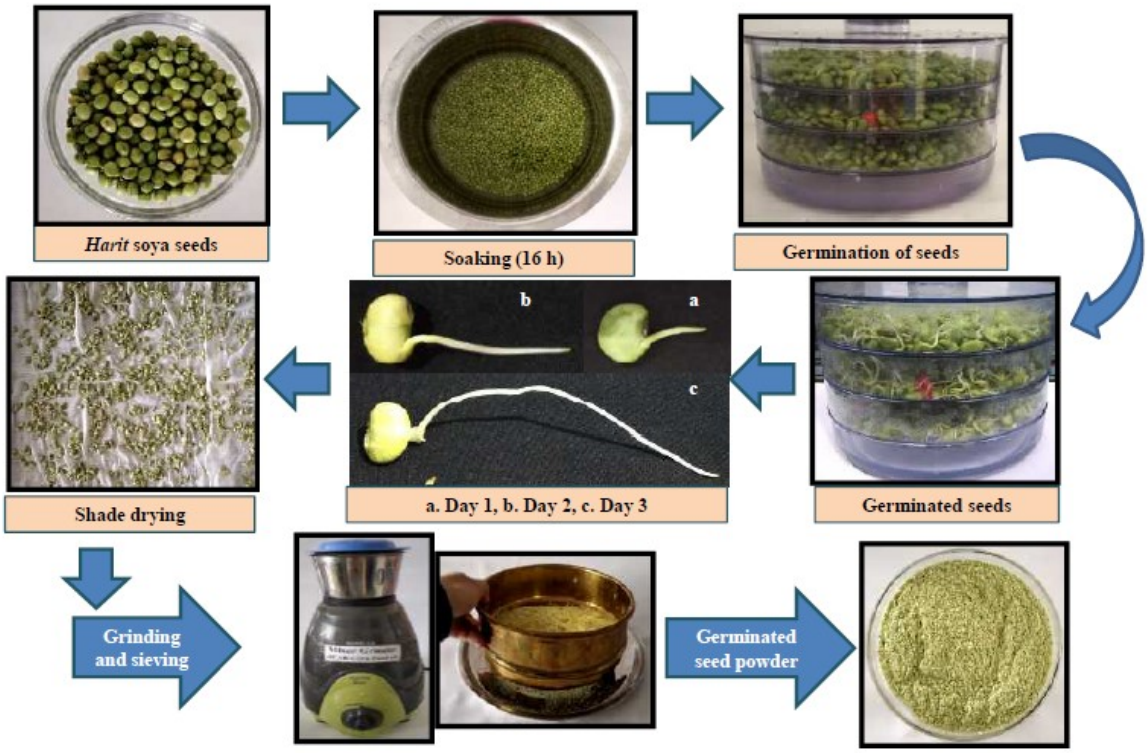
Table 2: Treatments for quality evaluation of *Harit* soya seeds

Treatment (T)	Description
T_1	Raw (without any treatment)
T_2	Soaking
T_3	Dehulling
T_4	Hull
T_5	Germination
T_6	Roasting
T_7	Soaking+ Roasting

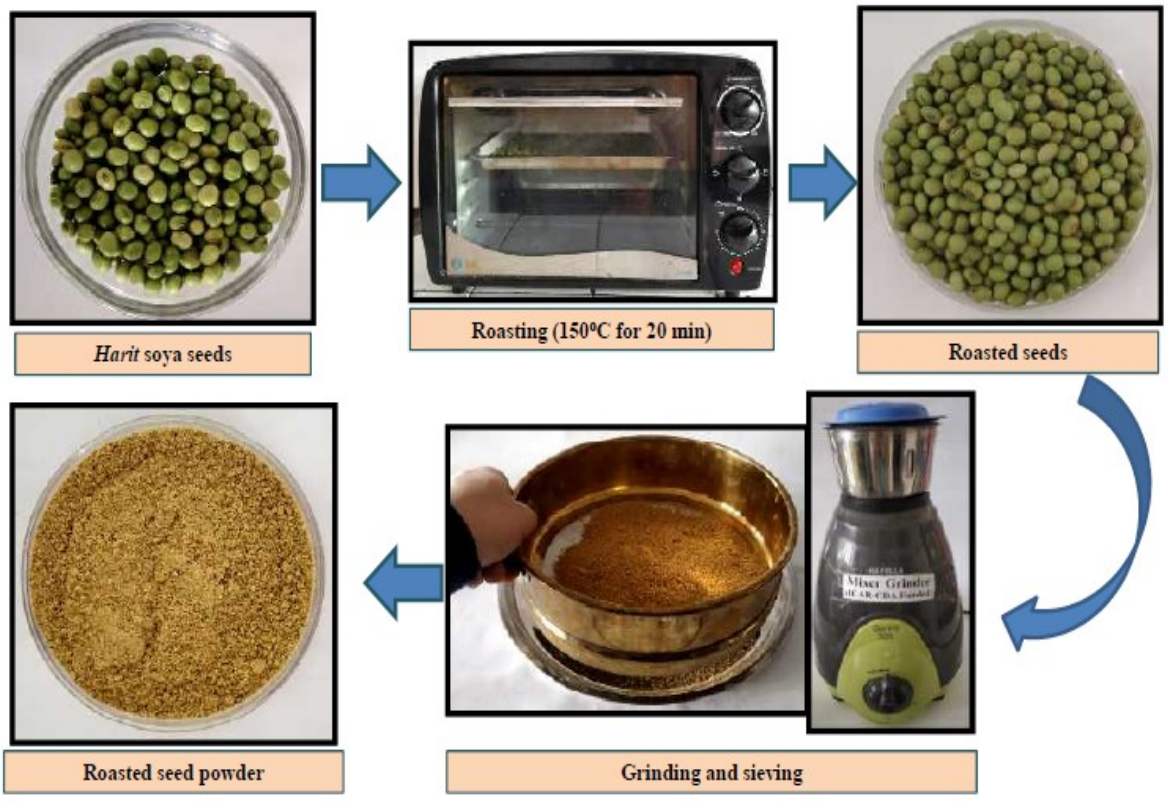
Process for preparation of soaked *Harit* soya seed powder



Process for preparation of dehulled *Harit* soya seed powder and hull powder



Process for preparation of germinated *Harit* soya seed powder



Process for preparation of roasted *Harit* soya seed powder

Objective 3: Standardization of technique for extraction of isoflavone from *Harit* soya seeds and drying of isoflavone extract

In order to standardize the technique for extraction of isoflavone from *Harit* soya, three different methods *viz*. the water based, solvent based and ultrasonic-assisted extraction were followed.

3.1.1 Water based extraction method

A) Standardization of solid to water ratio: The varied ratios of seed powder to water (Table 3) were used to extract isoflavone. The standard procedure as given by Cesar *et al*. (2008) with little modifications was followed for extraction. The soybean powder was mixed with distilled water in a beaker. The temperature of ultrasonic bath was maintained at 35±2 °C and the mixture was sonicated for 5 min. The ultrasonic bath was operated at frequency of 40 kHz with maximum input power of 100 W. The mixture was then filtered through Whatman No. 1 filter paper to separate the liquid fraction from insoluble fractions. The liquid fraction was concentrated in rotary vacuum evaporator till 1/4th of the extract volume was left. The concentrated extract was dried in freeze dryer at -30±2 °C and 0.04 mbar vacuum pressure. The extract was analysed for functional components and the treatment containing maximum value for total isoflavone content was selected. This treatment was used for optimization of extraction conditions in subsequent experiment.

Table 3: Treatments for selection of solid to water ratio for isoflavone extraction

Treatment (T)	Solid to water ratio
T_1	1:20
T_2	1:40
T_3	1:60
T_4	1:80
T_5	1:100
T_6	1:120

B) Optimization of pH, temperature and time conditions for isoflavone extraction: The isoflavone from soybean seed powder was extracted by varying the conditions like pH of water, temperature and time of extraction. The solid to water ratio as optimized in above experiment was taken to conduct the study. The soybean seed powder was mixed with distilled water and stirred continuously using magnetic stirrer. The various combinations of pH of water, time and temperature used to extract isoflavone are highlighted in Table 4. The data were obtained for yield of isoflavone extract. The treatment which showed the maximum total isoflavone content was selected and referred as T1 for further studies.

Table 4: Optimization of parameters for water based isoflavone extraction

pH	Extraction temperature (°C)	Extraction time (h)
7, 9, 11	30, 50, 70	1,2,3,4
7, 9, 11	30, 50, 70	1,2,3,4
7, 9, 11	30, 50, 70	1,2,3,4
7, 9, 11	30, 50, 70	1,2,3,4

3.1.2 Solvent based extraction method

A) Selection of solvent and solid to solvent ratio for isoflavone extraction: The type of solvent and solid to solvent ratio as depicted in Table.5 were used to extract isoflavone before optimization of extraction condition of solvent based extraction method. The soybean seed powder was mixed with solvent in a beaker. The conditions in relation to type of solvent and solid: solvent ratio which gave the maximum isoflavone content was selected for optimization of other conditions like solvent concentration, extraction time and temperature in subsequent experiment.

Table 5: Treatments for selection of solvent and solid to solvent ratio for isoflavone extraction

Solvent	Solid to solvent ratio
Ethanol	1:10, 1:15, 1:20, 1:25, 1:30
Methanol	1:10, 1:15, 1:20, 1:25, 1:30
Acetone	1:10, 1:15, 1:20, 1:25, 1:30
Acetonitrile	1:10, 1:15, 1:20, 1:25, 1:30

B) Optimization of solvent concentration, temperature and time for isoflavone extraction: The various combinations of solvent concentration, extraction temperature and time were employed (Table. 6) for optimizing the conditions for isoflavone extraction from soybean seed powder. The type of solvent and solid to solvent ratio as selected in Section 3.2 (A) was taken to conduct this experiment. The soybean seed powder was mixed with solvent and stirred continuously using magnetic stirrer. The isoflavone extract was obtained by applying different conditions. The condition under which maximum recovery of isoflavone extract was obtained from soybean seed powder was selected and referred as T2 for further studies.

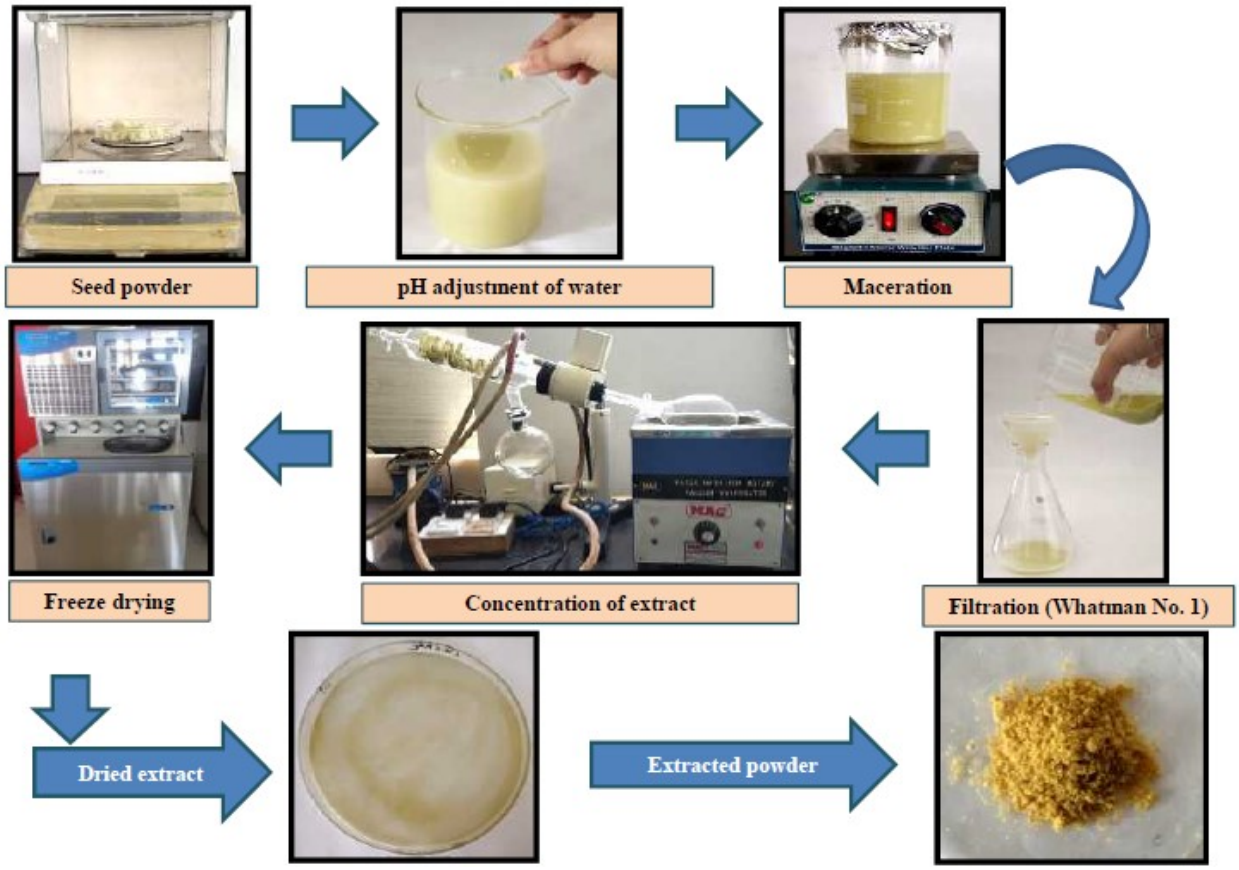
Table 6: Optimization of parameters for solvent based isoflavone extraction

Concentration of solvent (%)	Extraction temperature (°C)	Extraction time (h)
50, 60, 70, 80	30, 50, 70	1, 2, 3, 4
50, 60, 70, 80	30, 50, 70	1, 2, 3, 4
50, 60, 70, 80	30, 50, 70	1, 2, 3, 4
50, 60, 70, 80	30, 50, 70	1, 2, 3, 4

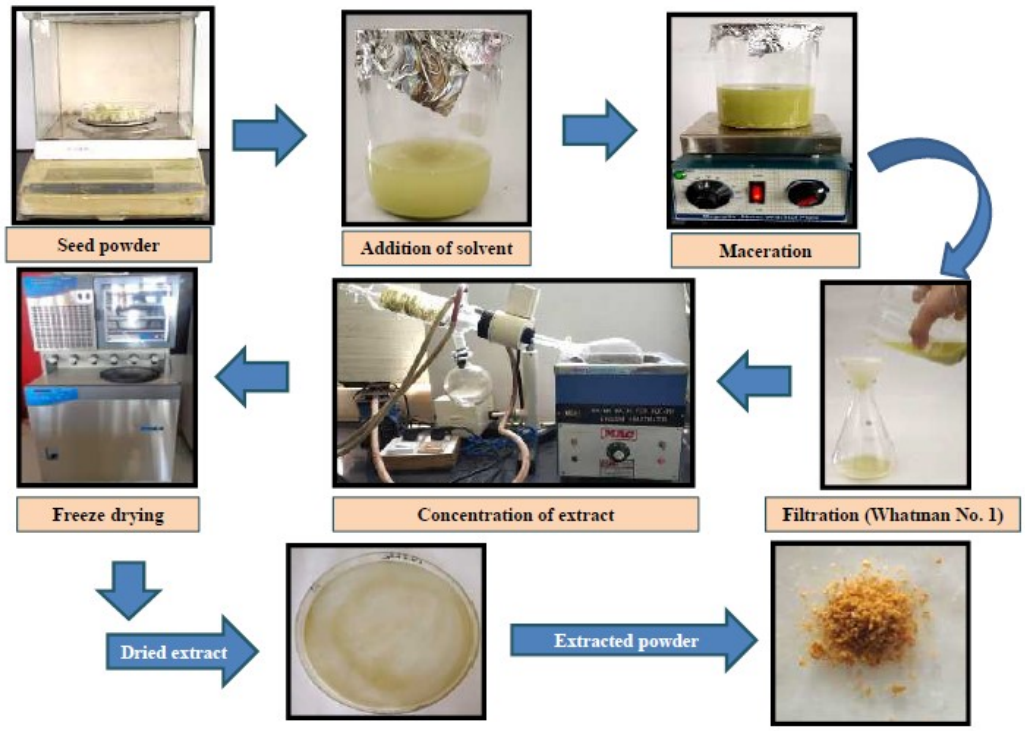
3.1.3 Ultrasonic-assisted extraction method: The type of solvent and solid to solvent ratio as selected under Section 3.2 (A) was used to conduct the experiment on ultrasonic-assisted extraction method. The various combinations of solvent concentration, extraction temperature and time (Table. 7) were employed for extraction of isoflavone. The extract of each treatment were analysed for different quality parameters. The treatment with maximum amount of total isoflavone content was selected and referred as T_3 for further studies.

Table 7: Optimization of parameters for ultrasonic-assisted isoflavone extraction

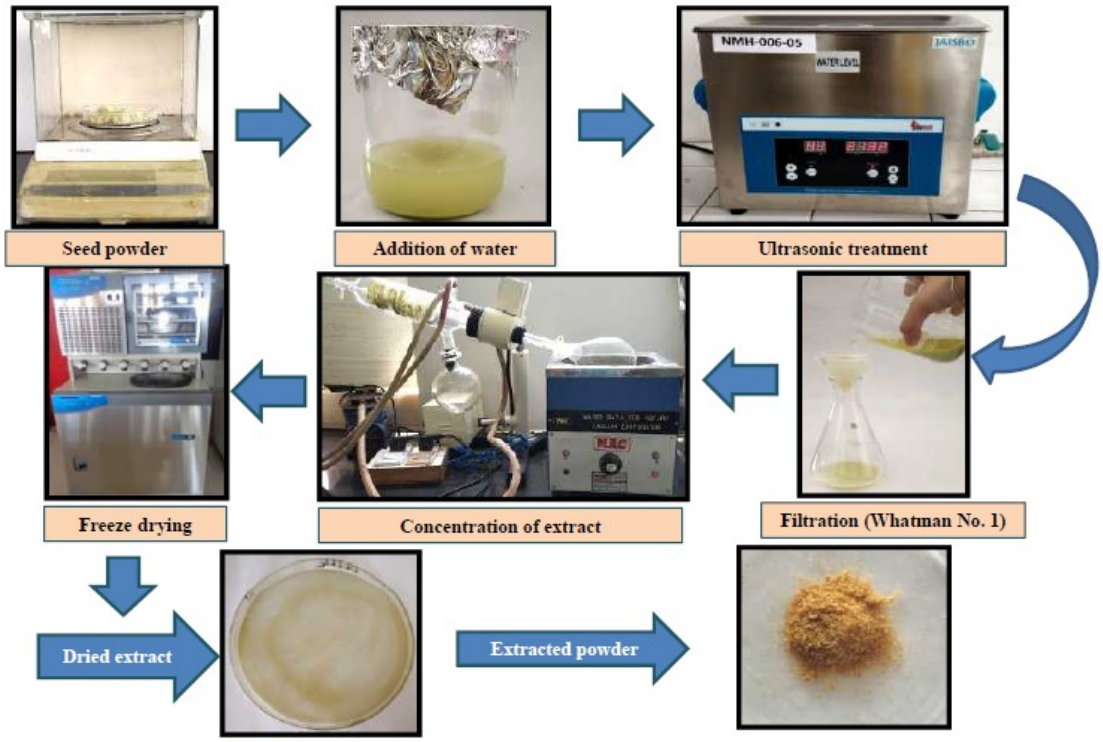
Solvent concentration (%)	Extraction temperature (°C)	Extraction time (min)
0, 25, 50, 75	30, 50, 70	15, 30, 45
0, 25, 50, 75	30, 50, 70	15, 30, 45
0, 25, 50, 75	30, 50, 70	15, 30, 45
0, 25, 50, 75	30, 50, 70	15, 30, 45



Process for extraction of isoflavone with water-based extraction method



Process for extraction of isoflavone with solvent based extraction method



Process for isoflavone extraction with ultrasonic-assisted extraction method

Detail of treatments selected for isoflavone extraction by different methods

The different treatments selected from water based, solvent based and ultrasonic-assisted extraction method under Sub-Section 3.1 (B), 3.2 (B) and 3.3, respectively of

Section 3 are presented in Table 8. The isoflavone extracts of these treatments were used for encapsulation with different carrier material under Sub-Section 4.1 of Section 4.

Table 8: Treatment details for isoflavone extraction by different methods

Treatment (T)	Description	
	Isoflavone extract	**Experiment No.**
T_1	Water based isoflavone extract	3.1 (B)
T_2	Solvent based isoflavone extract	3.2 (B)
T_3	Ultrasonic-assisted isoflavone extract	3.3

3.2 Drying of isoflavone extract by different modes

The isoflavone extract in above experiments was dried by using freeze drier as standard procedure. Freeze drying is highly appreciated for the retention of quality of the dried extract but it is an expensive method. Therefore, different methods *viz*. freeze, vacuum oven and hot air oven drying were used to dry isoflavone extract extracted by employing different techniques (Table.9). The comparative studies of drying were conducted to observe the recovery and efficacy of extracted isoflavone as well as economic feasibility and product quality. For drying, the concentrated extract (25 mL) of each treatment was poured into a petri plate of 150 mm diameter. The same procedure as discussed in Section 3.1(A) was followed for freeze drying. In case of hot air oven drying, the petri plate containing extract was placed in oven having internal dimensions of 60 × 60 × 60 cm and dried at a temperature of 50 ± 2 °C. Similarly, for vacuum oven drying, the extract was kept in a cabinet of 30 × 30 × 30 cm internal dimensions and dried at 50 ± 2 °C under 650 mm Hg pressure. The extract dried using different modes was evaluated for quality and the results were complied.

Table 9: Treatment details for drying of isoflavone extract

Treatment (D)	Description	
	Type of extract	**Drying mode**
D_1	Water based isoflavone extract	Freeze drying
D_2	Water based isoflavone extract	Hot air oven
D_3	Water based isoflavone extract	Vacuum oven
D_4	Solvent based isoflavone extract	Freeze drying
D_5	Solvent based isoflavone extract	Hot air oven
D_6	Solvent based isoflavone extract	Vacuum oven
D_7	Ultrasonic-assisted isoflavone extract	Freeze drying
D_8	Ultrasonic-assisted isoflavone extract	Hot air oven
D_9	Ultrasonic-assisted isoflavone extract	Vacuum oven

Objective 4: Standardization of technique for encapsulation of soy isoflavone extract

4.1 Encapsulation of isoflavone extract with different carrier material

The isoflavone extract obtained from different extraction methods (Table. 8) was utilized for encapsulation. The liquid extract was concentrated up to 1/4th of the initial volume and mixed with carrier material *viz*. β-cyclodextrin, maltodextrin, tapioca starch, sodium alginate and carboxyl methyl cellulose at different concentration (Table. 10). The

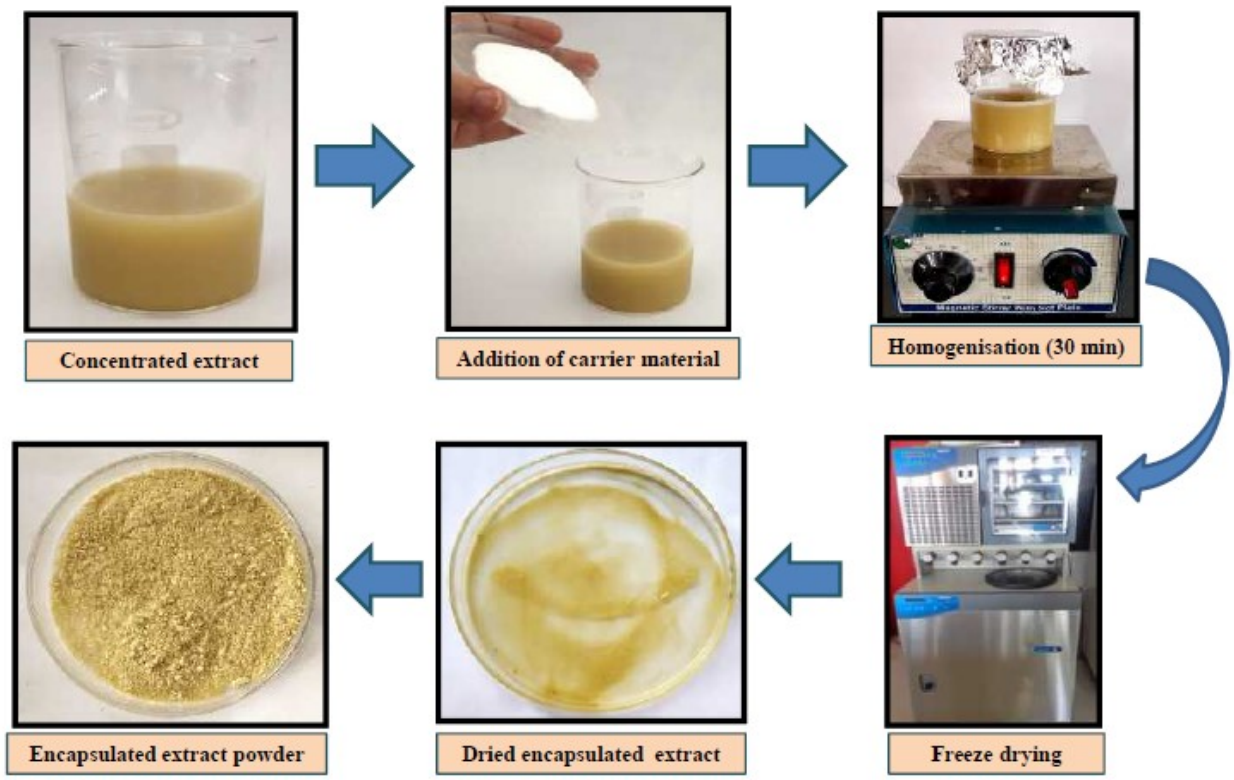
mixture was homogenized well for 30 min followed by freeze drying at -30±2°C. The encapsulated isoflavone extract was analysed of different physical and chemical parameters. The best treatment with high encapsulation efficiency and total isoflavones out of encapsulated isoflavone extract of each method was selected. The treatment was referred as T_1 for water based, T_2 for solvent based and T_3 for ultrasonic assisted encapsulated isoflavone extract for conducting storage studies.

4.2 Quality evaluation of encapsulated isoflavone extract during storage

The treatments of encapsulated isoflavone extract taken to conduct the storage studies are presented in Table 11. The encapsulated extract was packed in Transparent Glass Vials (TGV) and Amber Glass Vials (AGV) and stored under ambient (Appendix I) and refrigerated conditions. The samples were analysed for quality and storage stability at an interval of 0, 3 and 6 months.

Table 11: Treatments for quality evaluation of encapsulated isoflavone extract during storage

Treatment (T)	Description
T_1	Water based encapsulated isoflavone extract
T_2	Solvent based encapsulated isoflavone extract
T_3	Ultrasonic-assisted encapsulated isoflavone extract



Process for encapsulation of isoflavone extract

Objective 5: Development of functional food products from *Harit* soya and storage studies

The *Harit* soya seeds were processed into different value added products such as soymilk, yoghurt and tofu (soya *paneer*). The developed products were enriched with isoflavone and encapsulated isoflavone extracts in order to enhance their functional characteristics. For conducting comparative studies, the products were also prepared from dairy milk and enriched with isoflavone and encapsulated isoflavones extracts.

5.1 Soymilk

However, soybean is extensively utilized for the production of milk but it contains beany flavour which is not accepted by the consumers. Several methods such as soaking, blanching, hot grinding, etc. are generally employed to remove the beany flavour. Since, no such studies have been conducted and documented for *Harit* soya therefore, different treatments were tried to standardize the best method for removal of beany flavour to the acceptable level.

A) Standardization of pre-treatment for removal of beany flavour from *Harit* soya soymilk

i) **Soaking in sodium bicarbonate ($NaHCO_3$) solution:** The soybean seeds were soaked in $NaHCO_3$ solution of different concentration (Table 12) in the ratio of 1:8 for 16 h (as per preliminary trials). The soaked seeds were rubbed between hands under running tap water to separate the seed and hull. The dehulled soybean seeds were ground to form thin paste using potable water at normal temperature and hot water (90-100 °C). The domestic mixer cum grinder was used to grind the seeds. The soymilk was prepared with the use of seed to water ratio of 1:8. The slurry obtained was strained through double layered muslin cloth to separate milk from residue. The soymilk was heated at 100°C for 10 min with continuous stirring and then allowed to cool down. The milk of different treatments was stored under refrigerated conditions prior to sensory evaluation by a panel of ten judges. The treatment which received the highest sensory scores was selected and referred as T_1 for further studies.

Table 12: Pre-treatments for soaking *Harit* soya seeds in sodium bicarbonate ($NaHCO_3$) solution

Treatment (S)	Description
S_0 (Control)	Soaking seeds in water + normal water grinding
S_1	Soaking seeds in 0.25 % $NaHCO_3$ solution + normal water grinding
S_2	Soaking seeds in 0.50 % $NaHCO_3$ solution + normal water grinding
S_3	Soaking seeds in 0.75 % $NaHCO_3$ solution + normal water grinding
S_4	Soaking seeds in 0.25 % $NaHCO_3$ solution + hot water grinding
S_5	Soaking seeds in 0.50 % $NaHCO_3$ solution + hot water grinding
S_6	Soaking seeds in 0.75 % $NaHCO_3$ solution + hot water grinding

ii) **Blanching in sodium bicarbonate ($NaHCO_3$) solution:** The soybean seeds were heated in $NaHCO_3$ solution in the ratio 1:8 for 30 min at 85-95 °C (as per preliminary trials. The soymilk prepared using different treatments (Table 13) was subjected to sensory evaluation by a panel of ten judges. The treatment awarded with maximum sensory scores was selected and referred as T_2 for further studies.

Table 13: Pre-treatments for blanching *Harit* soya seeds in sodium bicarbonate ($NaHCO_3$) solution

Treatment (H)	Description
B_0 (Control)	Blanching seeds in water + normal water grinding
B_1	Blanching seeds in 0.25 % $NaHCO_3$ solution + normal water grinding
B_2	Blanching seeds in 0.50 % $NaHCO_3$ solution + normal water grinding
B_3	Blanching seeds in 0.75 % $NaHCO_3$ solution + normal water grinding
B_4	Blanching seeds in 0.25 % $NaHCO_3$ solution + hot water grinding
B_5	Blanching seeds in 0.50 % $NaHCO_3$ solution + hot water grinding
B_6	Blanching seeds in 0.75 % $NaHCO_3$ solution + hot water grinding

iii) **Addition of β-cyclodextrin in soymilk:** The soybean seeds were soaked in tap water in the ratio 1:8 for 16 h (as per preliminary trials). The β-cyclodextrin was mixed with the milk at different concentrations before and after heating at 100 °C for 10 min (Table 14). The soymilk was allowed to cool down at room temperature and then stored in refrigerator. The milk of different treatments was subjected to sensory evaluation by a panel of ten judges. The milk of treatment which got the highest sensory scores was selected and referred as T_3 for further investigation.

Table 14: Pre-treatments with addition of β-cyclodextrin in soymilk

Treatment	Description
C_0 (Control)	Without addition of β-cyclodextrin
C_1	Addition of 0.25 % β-cyclodextrin in soymilk before heating
C_2	Addition of 0.50 % β-cyclodextrin in soymilk before heating
C_3	Addition of 0.75 % β-cyclodextrin in soymilk before heating
C_4	Addition of 0.25 % β-cyclodextrin in soymilk after heating
C_5	Addition of 0.50 % β-cyclodextrin in soymilk after heating
C_6	Addition of 0.75 % β-cyclodextrin in soymilk after heating

B) Selection of pre-treatment for removal of beany flavour from soymilk

The different pre-treatments selected under various sub-sections of Section 5.1 A) were taken to select the best pre-treatment for preparation of soymilk of highest acceptability. The milk was prepared from soybean seeds of different treatments (Table. 15) by following the method explained under Section 5.1 A). The soymilk prepared without any pretreatment was kept as control sample. The product was subjected to sensory evaluation as well as analysed for different chemical parameters. The data was recorded and compiled. The overall results were taken into consideration for selection of best treatment.

Table 15: Pre-treatments for removal of beany flavour from soymilk

Treatment (T)	Description
T_0	Control
T_1	Soaking soybean seeds in $NaHCO_3$ solution
T_2	Blanching soybean seeds in $NaHCO_3$ solution
T_3	Addition of β-cyclodextrin in soymilk

C) Standardization of method for preparation of soymilk from hulled and dehulled seeds

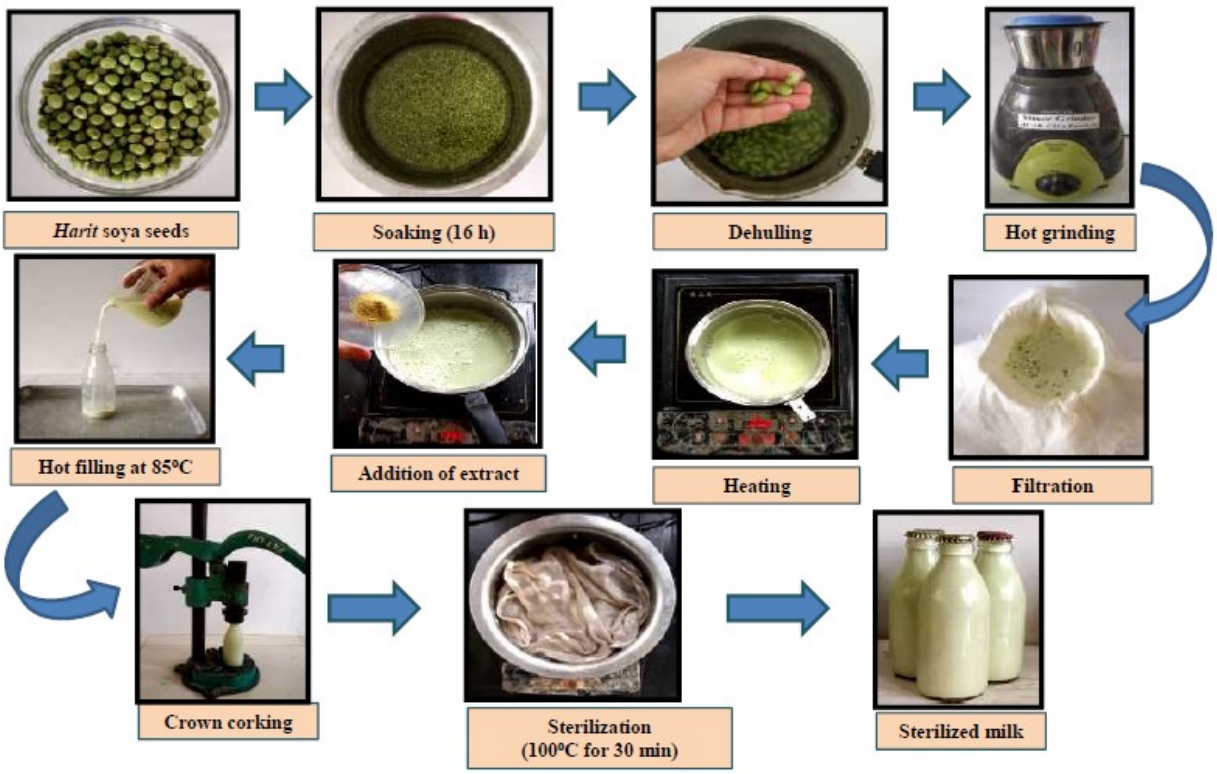
The hulled and dehulled soybean seeds were treated as per the pre-treatment selected under Section 5.1 B) to remove the beany flavour. Soymilk was prepared by using different proportions of water (Table 16) in order to achieve the highest consumer acceptability. The milk samples were subjected to sensory evaluation by a panel of ten judges. The milk of treatment which received the highest sensory scores was selected for conducting further studies.

Table16: Standardization of treatment for preparation of soymilk

Treatment (T)	Soybean seeds	Seeds to water ratio
T_1	Hulled	1:6
T_2	Hulled	1:7
T_3	Hulled	1:8
T_4	Hulled	1:9
T_5	Hulled	1:10
T_6	Dehulled	1:6
T_7	Dehulled	1:7
T_8	Dehulled	1:8
T_9	Dehulled	1:9
T_{10}	Dehulled	1:10

D) Incorporation of isoflavone in milk and storage studies

The soymilk was prepared as per the treatment selected under Section 5.1 C). The isoflavone and encapsulated isoflavone extracts were added at a level of 50 mg/250 mL of milk. In order to compare the quality, dairy milk (standardized milk) was also enriched with isoflavone and encapsulated isoflavone extracts. The different treatments as detailed in Table 17 was used to prepare milk. The milk was then heated up to 85-90 °C, filled in pre-sterilized glass bottles and crown corked. The filled bottles were sterilized at 100 °C for 30 min in boiling water. The bottles were allowed to cool down at room temperature and stored under ambient and refrigerated conditions. The milk was evaluated for different quality parameters at 0, 3 and 6 months of storage interval.



Process for preparation of isoflavone enriched soymilk

Table 17: Treatment details of isoflavone enriched soya and dairy milk for storage Studies

Treatment (T)	Description
T_1	Soymilk
T_2	Soymilk with isoflavone extract
T_3	Soymilk with encapsulated isoflavone extract
T_4	Dairy milk
T_5	Diary milk with isoflavone extract
T_6	Dairy milk with encapsulated isoflavone extract

5.2 Yoghurt

A) Preparation of soya yoghurt

The yoghurt from *Harit* soymilk was prepared by following standard procedure as described by Ihemeje *et al*. (2015). The soymilk was heated up to 85°C and allowed to cool down to a temperature of 42-45°C. The milk was inoculated with mixed yoghurt culture *Lactobacillus delbrueckii* subsp. *bulgaricus* and *Streptococcus thermophilus* @ 1 per cent. The milk was poured into polystyrene cups which were covered with caps and kept for incubation at 43°C for 6 to 8 h. After incubation, the cups were transferred to refrigerator for cooling.

B) Incorporation of isoflavone in yoghurt and storage studies

In soya yoghurt, the isoflavone and encapsulated isoflavone extracts were incorporated to enhance the functional value. These were added in milk prior to inoculation @ 50 mg/100 g. The dairy yoghurt was also prepared by using standardized milk. The method described above (Section 5.2 A) was followed for preparation of yoghurt. The dairy yoghurt was enriched with isoflavone in similar way as soya yoghurt. The different treatments used to carry out the storage studies are depicted in Table 18. The yoghurt in polystyrene cups was stored under ambient and refrigerated conditions. The quality evaluation studies of yoghurt of different treatments were conducted at 0, 5 and 10 days of storage.

Table 18: Treatment details of isoflavone enriched soya and dairy yoghurt for storage studies

Treatment (T)	Description
T_1	Soya yoghurt
T_2	Soya yoghurt with isoflavone extract
T_3	Soya yoghurt with encapsulated isoflavone extract
T_4	Dairy yoghurt
T_5	Dairy yoghurt with isoflavone extract
T_6	Dairy yoghurt with encapsulated isoflavone extract

5.3 Tofu (soya *paneer*)

A) Standardization of method for preparation of tofu (soya *paneer*)

The method for preparation of tofu from soymilk was standardized by using varying concentrations of different coagulating agents (Table 19). The soymilk was heated at 90°C for 5 min followed by cooling up to 70 °C. Simultaneously, the citric acid and calcium chloride ($CaCl_2$) solutions were prepared. The coagulant solutions were heated up to 70 °C and added to soymilk slowly with continuous stirring till coagulation gets completed and whey get separated. Then after 2 min, the material was filtered to separate the coagulum from whey. The coagulum was transferred in hoop and pressure was applied further for 15 min to remove extra whey. The tofu (soya *paneer*) having best quality was selected by conducting sensory evaluation of product of different coagulant by a panel of ten judges. The best treatment among citric acid concentrations as well as among $CaCl_2$ concentrations was selected and referred as T_1 and T_2, respectively for further studies.

Table 19: Standardization of treatment for preparation of tofu (soya *paneer*)

Treatment (T)	Coagulating agent	Concentration (%)
T_1	Citric acid	1.00
T_2	Citric acid	1.50
T_3	Citric acid	2.00
T_4	Citric acid	2.50
T_5	Calcium chloride	1.00
T_6	Calcium chloride	1.50
T_7	Calcium chloride	2.00
T_8	Calcium chloride	2.50

B) Selection of treatment for development of tofu (soya *paneer*)

The different treatments selected using each coagulant under Section 5.3 A) were taken to conduct this experiment. The tofu prepared using 2 per cent citric acid was kept as control sample. The tofu of different treatments (Table 20) was prepared by following the method discussed in Section 5.3 A). The product was subjected to sensory evaluation and analyzed for different physical and chemical attributes. The data was compiled and overall results were considered to select the best treatment.

Table 20: Detail of treatments of coagulating agent for preparation of tofu (soya *paneer*)

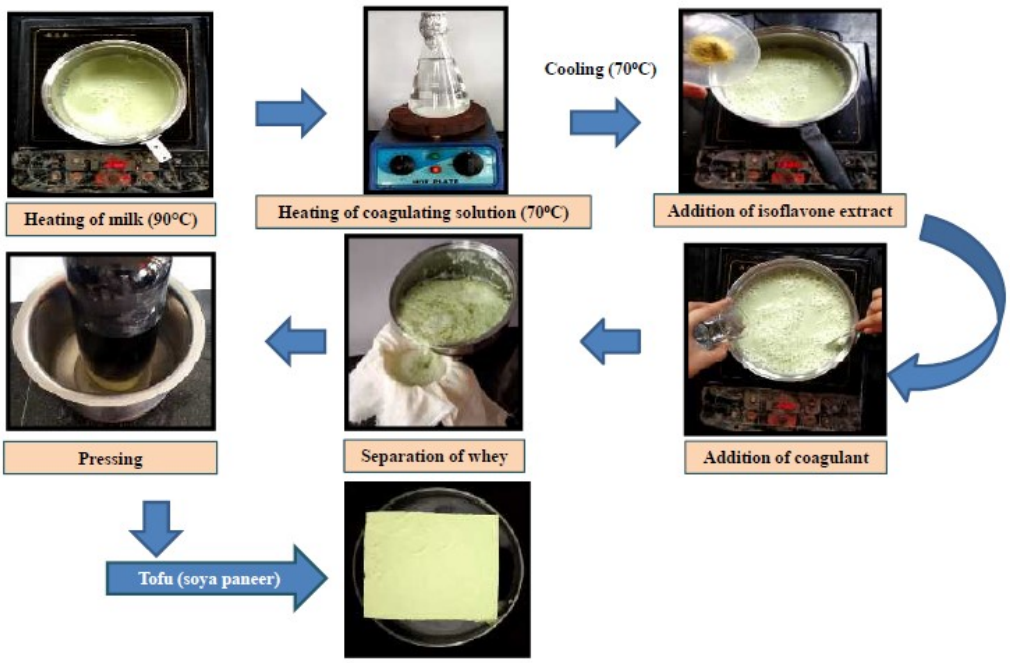
Treatment (T)	Description
T_0	Coagulation using 2 % citric acid solution
T_1	Coagulation using citric acid solution
T_2	Coagulation using calcium chloride solution

C) Incorporation of isoflavone in *paneer* and storage studies

The isoflavone and encapsulated isoflavone extracts were incorporated in tofu (soya *paneer*) to enhance the functional quality. The isoflavone @ 50 mg of isoflavone/100 g of *paneer* was added in milk prior to coagulation. The *paneer* developed using dairy milk (standardized milk) was also enriched with isoflavone and encapsulated isoflavone extracts. The procedure suggested by De (1980) was used to prepare *paneer* from dairy milk (standardized milk) with 2 per cent citric acid. The different treatments of soya and dairy *paneer* are detailed in Table 21. The *paneer* was packed in Low Density Polyethylene (LDPE) pouches and stored under ambient and refrigerated conditions. The developed *paneer* was analysed for different chemical and sensory attributes at 0, 5 and 10 days of storage interval.

Table 21: Treatment details of isoflavone enriched soya and dairy *paneer* for storage studies

Treatment (T)	Description
T_1	Tofu (soya *paneer*)
T_2	Tofu (soya *paneer*) with isoflavone extract
T_3	Tofu (soya *paneer*) with encapsulated isoflavone extract
T_4	Dairy *paneer*
T_5	Dairy *paneer* with isoflavone extract
T_6	Dairy *paneer* with encapsulated isoflavone extract



Process for preparation of isoflavone enriched tofu (soya *paneer*)

Experimental results

1. **Effect of treatments on quality of *Harit* soya seed powder:** *Harit* soya seed of treatments T_1 (raw seed powder), T_2 (soaked seed powder), T_3 (dehulled seed powder), T_4 (hull powder), T5 (germinated seed powder), T_6 (roasted seed powder) and T_7 (soaked+roasted seed powder) possessed a range from 44.64 ±0.78 to 64.55 ± 1.93, -8.20 ± 0.57 to 8.40 ± 0.58 and 24.18 ± 0.99 to 32.77 ± 1.00, respectively for L, a* and b* unit. Maximum value for protein and fat content was 40.11 ± 0.92 and 19.28 ± 0.21 per cent, respectively in T_3 (dehulled seed powder), ash content of 5.01 ± 0.03 per cent in T_5 (germinated seed powder) while crude fiber, pectin and carbohydrate content of 37.41 ± 0.16, 3.21 ± 0.05 and 40.91 ± 0.59 per cent, respectively in T_4 (hull powder). Highest value for total phenolics (5.30 ± 0.01 mg GAE/g), flavonoids (1.65 ± 0.02 mg GAE/g), antioxidant activity (53.80 ± 0.46 %), *in vitro* pepsin digestibility (72.63 ±0.11 %) and *in vitro* trypsin digestibility (25.80 ± 0.11 %) was recorded in T_5 (germinated seed powder). Treatment T_5 (germinated seed powder) showed the lowest value for trypsin inhibitor (13.91 ± 1.02 mg/g) and phytic acid (74.94 ± 1.42 mg/100 g) content. Calcium (762.89 ± 1.26 ppm), phosphorus (397.95 ± 4.99 ppm), potassium (237.94 ±1.12 ppm), copper (42.58 ± 0.42 ppm), iron (168.35 ± 0.79 ppm), manganese (59.39 ±0.83 ppm) and magnesium (152.59 ± 0.90 ppm) content was observed to be maximum in T_5 (germinated seed powder). T_5 (germinated seed powder) treatment also recorded maximum amount for daidzin (3.78 ± 0.02 mg/g), glycitin (1.59 ± 0.06 mg/g), glycitein (0.65 ± 0.03 mg/g) and genistein (0.40 ± 0.02 mg/g). Total isoflavones was highest in T_5 (6.61 ± 0.81 mg/g), followed by T_3 (5.47 ± 0.17 mg/g), T_1 (5.32 ± 0.15 mg/g), T_2 (5.27 ± 0.19 mg/g), T_6 (4.54 ± 0.14 mg/g), T_7 (4.31 ± 0.16 mg/g) and lowest in T_3 (2.45 ± 0.13 mg/g). Hence germinated seed powder was selected for extraction of isoflavone.
3. **Optimization of methods for extraction of isoflavone:** In case of water-based extraction method, among different solid to water ratio, 1:80 gave highest value for

total phenolics (14.72 mg GAE/g), flavonoids (1.37 mg QE/g), isoflavones (5.94 mg/g) and antioxidant activity (44.67 %) and was selected for optimization of extraction parameters. Out of various combinations of pH (7, 9 and 11), temperature (30, 50 and 70 °C) and time (1, 2, 3 and 4 h), the extraction at pH 9, 50°C for 3 h exhibited the maximum value for total isoflavones (12.16 mg/g), phenolics (39.00 mg GAE/g), flavonoids (3.65 mg QE/g) and antioxidant activity (55.71 %) in extract. Among four solvents, the extract isolated with ethanol at 1:25 solid to solvent ratio contained maximum total isoflavones (8.57 mg/g), phenolics (17.74 mg GAE/g) and flavonoids (2.82 mg QE/g) and was selected for solvent based extraction method. Optimization of different parameters *viz.* solvent concentration (50, 60, 70 and 80 %), extraction temperature (30, 50 and 70 °C) and time (1, 2, 3 and 4 h), the isolation of extract with 60 per cent of solvent concentration at 50 °C for 3 h noted the maximum total isoflavones (21.02 mg/g), phenolics (40.85 mg GAE/g), flavonoids (6.39 mg QE/g) and antioxidant activity (73.15 %). In ultrasonic-assisted method, isoflavone extracted at 50 °C for 30 min with 50 per cent solvent concentration mixed in 1:25 solid to solvent ratio gave highest total isoflavones (18.80 mg/g), phenolics (38.45 mg GAE/g), flavonoids (6.03 mg QE/g) and antioxidant activity (69.86 %). Among different drying modes, freeze drying of extract revealed higher value for total isoflavones followed by vacuum oven and hot air oven drying. The freeze-dried extract of water based, solvent based and ultrasonic-assisted method recorded total isoflavone content of 12.16, 20.85 and 18.80 mg/g, respectively. The production cost of water based, solvent based and ultrasonic-assisted isoflavone extract of 10 g was worked out to be Rs. 2.74, 113.95 and 91.00 without packaging while Rs. 10.74, 121.95 and 99.00 when packed in ambered glass vials.

4. **Optimization of technique for encapsulation of isoflavone extract:** Among various carrier material used at varied concentration, the maximum encapsulation efficiency was found to be 88.33, 82.27 and 84.48 per cent in 12 per cent maltodextrin (C8) while total isoflavones of 10.68, 19.75 and 16.71 mg/g in 0.30 per cent sodium alginate (C16) of water based (T_1), solvent based (T_2) and ultrasonic assisted (T_3) isoflavone extract, respectively. Based upon higher encapsulation efficiency, total isoflavone content and SEM analysis for extract, 6 per cent maltodextrin showed homogeneity in powder without agglomeration and represents a predominant size without using higher concentration of carrier material, hence was selected for storage studies. Encapsulated isoflavone extract can be stored safely in transparent and ambered glass vials for a period of six months with minimal changes in quality under ambient and refrigerated conditions. A significant decrease from 11.98 to 11.04 mg GAE/g, 1.78 to 1.64 mg QE/g and 5.43 to 4.89 mg/g, respectively for total phenolics, flavonoids and isoflavones was observed irrespective of the treatments. The retention of functional components was higher in extract packed in ambered glass vials stored under refrigerated conditions. Water based, solvent based and ultrasonic-assisted encapsulated isoflavone extract each weighing 10 g can be produced @ Rs. 12.37, 51.12 and 43.45 when packed in ambered glass vials while Rs. 8.37, 47.12 and 39.45 in transparent glass vials, respectively.

5. Development of functional food products from *Harit* soya seeds

5.1 Soymilk: Three different pre-treatment methods i.e. soaking in $NaHCO_3$ solution, blanching in $NaHCO_3$ solution and addition of β-cyclodextrin were used for the

removal of beany flavour for the preparation of soymilk. Out of seven treatment of *Harit* soya seeds soaked in sodium bicarbonate ($NaHCO_3$) solution, treatment S5 (soaking seeds in 0.50 % $NaHCO_3$ solution + hot water grinding) received the maximum score for colour (8.75), consistency (8.59), flavor (8.79) and overall acceptability (8.76) therefore, was selected and referred as T_1. Among seven treatments of *Harit* soya seeds blanched in $NaHCO_3$ solution, treatment B2 (blanching seeds in 0.50 % $NaHCO_3$ solution + cold water grinding) awarded the highest scores for sensory parameters with overall acceptability score of 8.26, hence was selected and referred as T2. Out of seven treatments of soymilk treated with β-cyclodextrin, C3 (addition of 0.75 % β-cyclodextrin in soymilk before heating) achieved the maximum score for overall acceptability (8.49) which was selected and referred as T_3. Soymilk of different pre-treatments T_0 (control), T_1 (soaking seeds in 0.50 % $NaHCO_3$ solution + hot water grinding), T_2 (blanching seeds in 0.50 % $NaHCO_3$ solution +cold water grinding) and T_3 (addition of 0.75 % β-cyclodextrin in soymilk before heating) revealed maximum value for protein (3.33 %) and fat (1.60 %) in T_1 while for total phenolics (53.65 mg GAE/100 mL), flavonoids (20.75 mg QE/100 mL) and isoflavones (6.54 mg/100 mL) in T_0. The differences in functional characteristics between treatment T_0 and T_1 were found to be non-significant. Pre-treatment T_1 (soaking seeds in 0.50 % $NaHCO_3$ solution + hot water grinding) was awarded highest overall acceptability score (8.76) followed by T_3 (8.49), T_2 (8.26) and T_0 (6.05) therefore was selected for further experiment for preparation of *Harit* soya milk. Out of ten different treatments of soymilk prepared using hulled and dehulled seeds at varying seed to water ratio, milk of treatment T_9 received the maximum scores for colour (8.55), consistency (8.72), flavour (8.56) and overall acceptability (8.52) hence was selected for further studies. The *Harit* soya and dairy milk as well as the milk enriched with isoflavone and encapsulated isoflavone extracts @ 50 mg/250 mL revealed highest value for protein (3.16 %) and fat (4.50 %) content in dairy milk while total phenolics (75.32 mg GAE/100 mL), flavonoids (25.50 mg QE/100 mL) and isoflavones (19.90 mg/100 mL) were found in soymilk with encapsulated isoflavone extract. Addition of extracts significantly increased the functional properties of milk. Among six different treatments, T_3 (soymilk with encapsulated isoflavone extract) received the highest scores for colour (8.62) and consistency (8.79) while the maximum scores for flavour (8.75) and overall acceptability (8.72) were obtained by T_6 (dairy milk with encapsulated isoflavone extract). A mean increase in titratable acidity (0.10 to 0.15 %) whereas, a decrease in total solids (11.56 to 10.22 %), protein (2.92 to 2.81 %), total phenolics (54.35 to 44.21 mg GAE/100 mL), flavonoids (15.98 to 13.31 mg QE/100 mL) and isoflavones (13.76 to11.74 mg/100 mL) was recorded in milk of different treatments packed in glass bottles during six months of storage under refrigerated conditions. The retention of total isoflavones was found to be higher in milk enriched with encapsulated isoflavone extract as compared to isoflavone extract. Maximum decrease in value was observed in T_1 (26.29 %), followed by T_5 (23.67 %), T_2 (20.87 %), T_6 (6.15 %) and minimum in T_3 (4.77 %). During six month of storage, however significant decrease in mean scores of colour (8.52 to 8.09), consistency (8.57 to 8.04), flavour (8.46 to 7.95) and overall acceptability (8.51 to 8.01) was reflected but still the milk was found to be within acceptable limit. The cost of production of soymilk, milk with isoflavone extract and milk with encapsulated isoflavone extract packed in glass bottles (250 mL capacity) was calculated to be Rs. 7.16, 28.01 and

30.64, respectively. Whereas, somewhat higher cost of Rs. 17.05, 123.83 and 137.84, respectively was recorded for 250 mL of dairy milk, milk with isoflavone extract, milk with encapsulated isoflavone extract in glass bottles.

5.2 **Soya yoghurt:** *Harit* soya yoghurt of different treatments was not liked by the panelist due to unacceptable changes like faded green with pink tinge and intense beany flavour, therefore the samples were rejected for conducting further studies. Out of T_1 (dairy yoghurt), T_2 (dairy yoghurt with isoflavone extract) and T_3 (dairy yoghurt with encapsulated isoflavone extract) treatments, the maximum protein and fat content of 3.08 and 4.16 per cent, respectively was noticed in T_1 while total phenolics (98.19 mg GAE/100 g), flavonoids (19.76 mg QE/100 g) and isoflavones (47.23 mg/100 g) in T_3. Yoghurt of treatment T_1 (dairy yoghurt), T_2 (dairy yoghurt with isoflavone extract) and T_3 (dairy yoghurt with encapsulated isoflavone extract) packed in polystyrene cups can be safely stored for a storage period of 10 days under refrigerated conditions with minimal changes in quality. Among different treatments, T_3 (dairy yoghurt with encapsulated isoflavone extract) showed minimum syneresis (13.49 mL/50 g) along with better retention of total phenolics (95.12 mg GAE/100 g), flavonoids (19.17 mg QE/100 g), isoflavones (48.69 mg/100 g) and antioxidant activity (76.34 per cent) in comparison to T_1 and T_2 during storage. Also, comparatively less decrease in sensory scores *viz*. colour (8.44), texture (8.53), flavour (8.50) and overall acceptability (8.46) was observed in T_3. The production cost of 100 g dairy yoghurt packed in polystyrene cups was calculated to be Rs. 18.52. The cost worked out for dairy yoghurt enriched with isoflavone extract and encapsulated isoflavone extract was Rs. 61.23 and 66.84, respectively.

5.3 **Tofu (soya *paneer*):** Out of two different coagulants i.e. citric acid and calcium chloride used at different concentrations for development of tofu, T_2 (1.50 % citric acid) and T_6 (1.50 % calcium chloride) achieved the highest overall acceptability scores of 8.02 and 8.52, respectively. The treatments were selected for further experimentation and referred as T_1 and T_2, respectively. Among tofu of treatment T_0 (2 % citric acid), T_1 (1.50 % citric acid) and T_2 (1.50 % calcium chloride), T_0 reflected the highest value of 15.92 per cent, 7.39 per cent, 129.18 mg GAE/100 g, 40.61 mg QE/100 g and 22.33 mg/100 g for protein, fat, total phenolics, flavonoids and isoflavones, respectively. Tofu of treatment T_2 in comparison to T_0 and T_1, was awarded highest sensory scores for colour (8.51), texture (8.26), flavour (8.48) and overall acceptability (8.52), hence was selected for further studies. Among tofu and *paneer* of different treatments, dairy *paneer* reflected highest value for protein (19.58 %) and fat (23.51 %) content while total phenolics (182.36 mg GAE/100 g), flavonoids (51.05 mg QE/100 g) and isoflavones (49.87 mg/100 g) were found to be maximum in soya *paneer* with encapsulated isoflavone extract. Addition of isoflavone extracts (@ 50 mg/100 g) significantly enhanced the value for all the functional characteristics in product. Sensory scores for tofu and p*aneer* of all six treatments were noticed to be well above the acceptable limits but T_6 (soymilk with encapsulated isoflavone extract) received the highest overall acceptability (8.72) scores. Tofu and *paneer* of different treatment when packed in LDPE pouches can be stored safely for a period of 10 days under refrigerated conditions with slight increase in total solids (36.12 to 38.69 %), titratable acidity (0.36 to 0.44 %) and a decrease in total phenolics (135.99 to 121.46 mg GAE/100 g), flavonoids (34.55 to 30.90 mg QE/100

g) and isoflavones (37.60 to 36.32 mg/100 g). The total isoflavones were observed to be more in tofu and *paneer* enriched with encapsulated isoflavone extract in comparison to isoflavone extract. The losses were higher in T_1 and T_5 (5.99 %), followed by T_2 (3.99 %), T_6 (1.62 %) and minimum in T_3 (1.61 %). During six month of storage, however significant decrease in the scores for colour (8.50 to 8.28), texture (8.49 to 8.07), flavour (8.47 to 7.22) and overall acceptability (8.50 to 7.84) was seen in tofu as well as *paneer* but all the samples were observed to be well above the acceptable limits. The cost of production of 100 g of soya *paneer*, soya *paneer* with isoflavone extract, soya *paneer* with encapsulated isoflavone extract each packed in LDPE pouches was found to be Rs. 23.92, 46.97 and 45.70, respectively. Comparatively higher cost of Rs. 28.17, 58.04 and 61.25, respectively was recorded for 100 g of dairy *paneer*, dairy *paneer* with isoflavone extract, dairy *paneer* with encapsulated isoflavone extract packed in LDPE pouches.

Conclusion and Recommendation

1. *Harit* soya seeds are a rich source of various components such as protein (37.96 %), total chlorophyll (17.45 mg/100 g), phenolics (4.53 mg GAE/g), isoflavones (5.32 mg/g), iron (142.41 ppm) etc. The values can further be enhanced by germination of seeds for 3 days.
2. The type of extraction methods and conditions had significant effect on total isoflavone content of the extract. Among water based, solvent based and ultrasonic-assisted extraction methods, 60 per cent ethanol in 1:25 solid to solvent ratio used for extraction at 50 °C for 3 h exhibited the highest total isoflavone content (21.02 mg/g).
3. The encapsulation of isoflavone extract with 6 per cent maltodextrin possessed better encapsulation efficiency (77.59 %) and total isoflavones (7.14 mg/g). The encapsulated isoflavone extract can be stored safely for a period of six months in transparent as well as ambered glass vials under refrigerated and ambient conditions reflecting higher retention of quality under refrigerated condition when packed in ambered glass vials.
4. The *Harit* soya seeds of pre-treatment with soaking in 0.5 % $NaHCO_3$ solution + hot water grinding indicated higher nutritional and functional characteristics. Out of ten different treatments, soymilk developed from dehulled seeds in 1:9 seed to water received higher sensory scores.
5. The soya and dairy milk enriched with isoflavone and encapsulated isoflavone extracts @ 50 mg/250 mL revealed maximum value for functional characteristics like total phenolics, flavonoids and isoflavones with good palatability. The milk of different treatments packed in glass bottles can be stored safely for six months under refrigerated conditions with minimal changes in quality attributes.
6. The yoghurt developed from *Harit* soya milk was not liked by the panellist and was rejected. The dairy yoghurt enriched with isoflavone extracts @ 50 mg per 100 g packed in polystyrene cups recorded higher value for functional characteristics and received maximum sensory scores. The product can be stored up to ten days under refrigerated conditions.
7. Tofu (soya *paneer*) prepared from 1.50 per cent calcium chloride as coagulant obtained higher rating for sensory quality and contained sufficient amount of nutritional and functional components. Tofu (soya *paneer*) as well as dairy *paneer*

can be enriched with isoflavones extracts @ 50 mg/100 g with higher acceptability and stored safely in LDPE pouches under refrigerated conditions for ten days.

8. Henceforth, it can be concluded that *Harit* soya which otherwise has not been exploited for processing can successfully be utilized for extraction of isoflavones, production of value-added products such as milk, tofu, etc. as well as extracted isoflavone can be incorporated in these products to enhance their functional properties.

New Strategy Developed

Annexure- 14

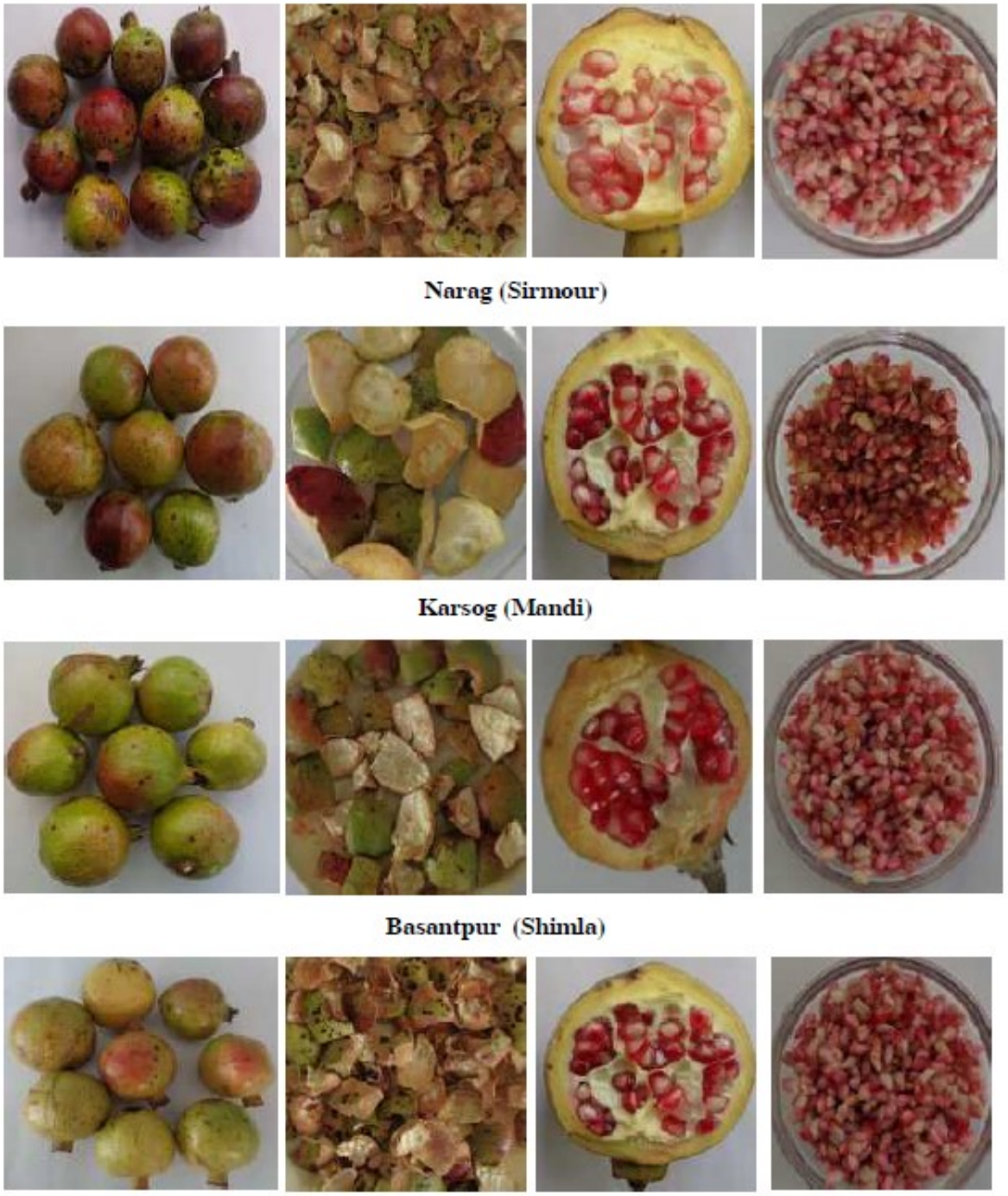
Sub-Project: Extraction and utilization of phenolic antioxidants from wild pomegranate (*Punica granatum* L.) fruits

In the present investigation, studies were carried out for the development of popular dried product known as anardana. In this study, different parts like arils, albedo, flavedo and pomace of wild pomegranate fruit from four different locations of HP were compared on the basis of various antioxidants and their properties. Fruits from best location (Karsog) on the basis of various antioxidants and their properties were selected further for carrying out drying of different parts under different drying modes. Highest amount of phenolic antioxidants were recorded in the mechanical cabinet dried flavedo part of the fruit of Karsog location, which was further converted into powder form of 425 microns particle size. The prepared flavedo powder did contain ascorbic acid (7.86 mg/100g), crude protein (3.91 %), crude fibre (20.53 %), total phenols (48.10 mg GAE/g), total flavonoids (5.90 mgQuE/g), DPPH anti-oxidant activity (82.05 %), metal chelating activity (58.46 %), FRAP (3.24 µM Fe2+/g) and reducing power (1.720). From this flavedo powder phenolic antioxidants were extracted successfully by the solvent (solid to solvent ratio 1:20) which was a combination of ethanol and distilled water (60:40) by maceration method after 6h of extraction at 30 ºC followed by concentration of extract in rotary vacuum evaporator and further lyophilized by freeze drier. The prepared lyophilized extract powder was further analyzed for its various physico-chemical characteristics, antioxidants, antioxidant properties, antimicrobial activity (against *Staphylococcus aureus* and *E. coli*) and functional groups by FT-IR analysis. Extracted phenolic antioxidant extract was encapsulated successfully with maltodextrin in the ratio of 1:2. Microencapsulated phenolic extract powder could be however stored safely for a period of four months under ambient (9-21°C) and refrigerated temperature (4-7 °C) conditions in amber coloured glass vials but minimum changes in antioxidant attributes of powder were recorded under refrigerated storage. The microencapsulated phenolic extract powder further could be utilized for the enrichment of food products like yoghurt and mango drink. Both the products could be enriched with 2 per cent micro-encapsulated phenolic extract powder successfully. Yoghurt could be stored safely for a period of fourteen days in polystyrene cups under refrigerated (4-7 °C) temperature conditions and drink for six months in PET bottles under both refrigerated (4-7 °C) and ambient (9.7-24 °C) temperature conditions. However minimum changes in the quality of both the products were observed under refrigerated storage conditions. Hence flavedo part of this fruit can be utilized for the extraction of phenolic antioxidants on commercial scale for the development of high antioxidant products like yoghurt and fruit drink besides the major use of its arils in anardana production.

Details of Experiments conducted:

Objective1: Standardization of drying modes for the preparation of samples

Wild pomegranate fruits were procured from four locations of Himachal Pradesh viz Narag, District-Sirmour located at height of 1130metre above mean sea level, Karsog, District-Mandi located at height of 1265 metre above mean sea level, Basantpur, District-Shimla located at height of 1325metre above mean sea level and Darlaghat, District Solan located at height of 1390metre above mean sea level. Yoghurt cultures (*Lactobacillus bulgaricus* subsp. *delbrueckii* and *Streptococcus thermophilus*) were procured from National Collection of Dairy Cultures (NCDC), Dairy Microbiology Division, National Dairy Research Institute, Karnal, Haryana, India. Canned mango pulp (Ratnagiri Alphonso) used in the preparation of drink was procured from Vimal Agro Products Pvt. Ltd. Bardoli, Surat-Gujarat.



Wild pomegranate fruit parts of 4 different locations of Himachal Pradesh

Different parts of wild pomegranate fruit viz. arils, flavedo, albedo and pomace were separated before carrying out the drying. Flavedo and albedo after washing were shredded into small shreds with the help of knife before drying. The following drying modes were used for the preparation of samples.

1.1 Natural sun drying

The arils (2 kg), flavedo (2 kg), albedo (0.5 kg) and pomace (0.5 kg) were spread on the perforated aluminium trays and kept in the open sun in an inclined position for drying. The material was kept till the sunset before shifting it back in the laboratory for night. All the four parts were dried in the sun till they attain a constant weight. The temperature during the natural sun drying of arils, flavedo, albedo and pomace ranged from19.5 to 24.1 °C, 20.8 to 25.5 °C and 21.2 to 26.3°C, 20.4 to 26.0 °C, respectively.

1.2 Solar tunnel drying

The arils (2 kg), flavedo (2 kg), albedo (0.5 kg) and pomace (0.5 kg) were spread on the perforated aluminium trays and put on the stands inside a solar tunnel drier of dimensions297 × 204 × 207 cm in 0.50 cm layer. This drier has been made of polyethylene sheet of thickness 0.31 mm and the temperature recorded during the solar tunnel drying of arils, flavedo, albedo and pomace ranged from 29 to 36 °C, 32 to 37 °C, 29 to 37 °C and 32to 40 °C, respectively. All the four parts were dried separately till they attain a constant weight.

1.3 Mechanical cabinet drying

The arils (2 kg), flavedo (2 kg), albedo (0.5 kg) and pomace (0.5 kg) were spread on the perforated steel trays of dimension 76 × 56 cm in 0.50 cm layer and dried at constant temperature at 50 ^{o}C inside a mechanical cabinet drier having internal dimensions of 78 × 58× 128 cm up to a constant weight.

1.4 Oven drying

The arils (2 kg), flavedo (2 kg), albedo (0.5 kg) and pomace (0.5 kg) were spread on the perforated steel trays of dimension 58 × 58 cm in 0.50 cm layer and dried at constant temperature at 50^{o}C inside a hot air oven having internal dimensions of 60 × 60 × 60 cm upto a constant weight.

1.5 Freeze drying

Lyophilization was used for drying of wild pomegranate flavedo (500 g). Before lyophilization, fresh flavedo shredded into small pieces with the help of knife and then placed in deep freezer at -20 ^{o}C for complete freezing (24 h). The mixtures were then freeze-dried using a lyophilizer (LABCONCO-Free Zone USA) at a constant temperature of -30^{o}C with 0.04 mbar vacuum pressure upto a constant weight. Dried samples obtained from all these drying modes were compared on the basis of antioxidants such as phenolics, flavonoids etc. and the best selected drying mode was used further for the preparation of flavedo powder on large scale.

1.6 Preparation of flavedo powder

The dried sample containing highest phenolics content was further utilized for making flavedo powder by pulverizer having particle size of 425 microns through 36 mesh metallic sieve and further packed in aluminium laminated pouch (ALP) and immediately stored in deep freezer (-20^{o}C) before its utilization.

Objective 2: Standardization of phenolic antioxidants extraction method

Flavedo powder of 425 microns particle size containing highest phenolics content was utilized for conducting further studies. Three different extraction methods were used for the extraction of phenolic antioxidants.

2.1 Standardization of optimum conditions for extraction of phenolics by maceration

In this method of extraction, phenolics were extracted by constant solid to solvent ratio (1:20) by different solvents with constant magnetic stirring at 30°C and 50°C for different time periods. For each treatment 10 g of flavedo powder was dissolved in 200 mL of respective solvent followed by magnetic stirring for different time periods at different temperatures. The extract obtained was further concentrated in vacuum rotatory evaporator (at 50°C) until 1/4th of the initial volume remained followed by oven drying (50°C) of extract. The treatment details (Table-2) are mentioned as below:

Table 2: Detail of treatments for extraction of phenolics by maceration

Sr. No.	Solvents	Extraction temperature (°C)		Extraction time (h)		
1	Distilled water	30	50	2.0	4.0	6.0
2	Ethanol	30	50	2.0	4.0	6.0
3	Ethanol: Distilled water (80:20)	30	50	2.0	4.0	6.0
4	Ethanol: Distilled water (60:40)	30	50	2.0	4.0	6.0
5	Ethanol: Distilled water (50:50)	30	50	2.0	4.0	6.0
6	Acetone	30	50	2.0	4.0	6.0
7	Acetone : Distilled water (50:50)	30	50	2.0	4.0	6.0
S	Ethanol: Acetone : Distilled water (1:1:1)	30	50	2.0	4.0	6.0
9	Ethyl acetate	30	50	2.0	4.0	6.0
10	Ethanol: Diethyl ether: Distilled water (80:10:10)	30	50	2.0	4.0	6.0

2.2: Standardization of optimum conditions for the extraction of phenolic antioxidants by soxhlet method

In this method of extraction, phenolics were extracted by soxhlet apparatus with different solvents and varying extraction time. The extract obtained was further concentrated in vacuum rotatory evaporator (at 50°C) until 1/4th of the initial volume remained followed by oven drying (50°C) of extract. The treatment details are mentioned as below in Table 3:

Table 3: Detail of treatments for extraction of phenolics by soxhlet method

Sr. No.	Solvents	Extraction time (h)		
1	Ethanol	2.0	4.0	6.0
2	Acetone	2.0	4.0	6.0
3	Ethyl acetate	2.0	4.0	6.0
4	Diethyl ether	2.0	4.0	6.0

2.3: Standardization of optimum conditions for the extraction of phenolic antioxidants by reflux method

In this method of extraction, constant solid to solvent ratio (1:20) was refluxed under heat with varying extraction solvents and time. For each treatment 10 g of flavedo powder was dissolved in 200 mL of respective solvent followed by refluxing under heat for different

time periods. The extract obtained was further concentrated in vacuum rotatory evaporator (at 50°C) until 1/4th of the initial volume remained followed by oven drying (50°C) of extract. The treatment details (Table-4) are mentioned as below:

Table 4: Detail of treatments for extraction of phenolics by reflux method

Sr. No.	Solvents	Extraction time (h)		
1	Distilled water	1	2	3
2	Ethanol	1	2	3
3	Ethanol; Distilled water (80:20)	1	2	3
4	Ethanol: Distilled water (60:40)	1	2	3
5	Ethanol: Distilled water (50:50)	1	2	3
6	Acetone	1	2	3
7	Acetone : Distilled water (50:50)	1	2	3
8	Ethanol: Acetone : Distilled water (1:1:1)	1	2	3
9	Ethyl acetate	1	2	3
10	Ethanol: Diethyl ether: Distilled water (80: 10:10)	1	2	3
11	Diethyl ether	1	2	3

The two best treatments from each method of extraction of above experiments were selected for further comparison by two drying modes (oven and freeze drying) to select the best method on the basis of various antioxidants properties. Best method was further followed to extract the phenolic antioxidants on large scale.

3. Microencapsulation of phenolic antioxidant extract

Maceration (ethanol: distilled water (60:40) at 30°C for 6h was selected for the extraction of phenolic antioxidants on large scale. The extracted phenolics were concentrated by evaporating the solvent in vacuum rotatory evaporator (at 50°C) until 1/4th of the initial volume remained. Maltodextrin (20 DE) was added to the concentrated extract to obtain different ratios of phenolic extract to maltodextrin, followed by constant stirring for 2 hoursfor complete homogenization. Before lyophilisation of extract the mixture was put at -20°Cin deep freezer for complete freezing (24 h). The mixture was then freeze-dried using a lyophilizer (LABCONCO-FreeZone USA) at a constant temperature of -30°C at 0.04 mbar vacuum pressure. The dried samples were ground using a mortar and pestle and the powder was packed in ambered colored glass vials and stored at -20°C until further analysis. Out of different treatments the best one on the basis of phenolics, flavonoids, water activity, bulk density, water holding capacity, SEM analysis was preferred for further storage studies. The treatment details are mentioned as below:

Table 5: Treatment detail of microencapsulation of phenolic extract powder

Treatment	T_1	T_2	T_3	T_4	T_5	T_6
Pan of phenolic extract	1	1	1	1	1	1
Part of maltodextrin	1	2	4	6	8	10

3.1 Packaging and storage of microencapsulated phenolic extract powder

The sample of selected treatment was packed in glass vials (transparent and amber coloured) each of 5 mL capacity and stored under ambient (9-21°C) and refrigerated temperature conditions (4-7°C) for four months. All the observations were carried out at zero, two and four months of storage.

4. Development of phenolic antioxidants enriched food products

Yoghurt and mango drink enriched with phenolic antioxidants were prepared by incorporating encapsulated powder of phenolic antioxidants. Prepared products were further packed and stored under refrigerated and ambient temperature conditions for further evaluation.

4.1 Yoghurt

4.1.1 Standardization of concentration of microencapsulated phenolic extract powder for enrichment of yoghurt

Standard method was followed for the activation of freeze dried yoghurt culture and for the preparation of yoghurt. Microencapsulated phenolics powder was incorporated in pre-pasteurized milk at different levels (Table 6), heated and cooled prior to aseptic inoculation with cultures of *Lactobacillus delbrueckii* subsp. *bulgaricus* and *Streptococcus thermophiles* @ 1 per cent. After inoculation, milk was poured in polystyrene cups (200 mL) and kept in incubator for 4-6 h at 42°C to allow setting of yoghurt.

Table 6: Concentration of microencapsulated phenolic extract powder added in yoghurt

Treatment	Microencapsulated phenolic extract powder (%)
G_1	0
G_2	0.5
G_3	1.0
G_4	2.0
G_5	3.0
G_6	4.0
G_7	5.0
G_8	6.0

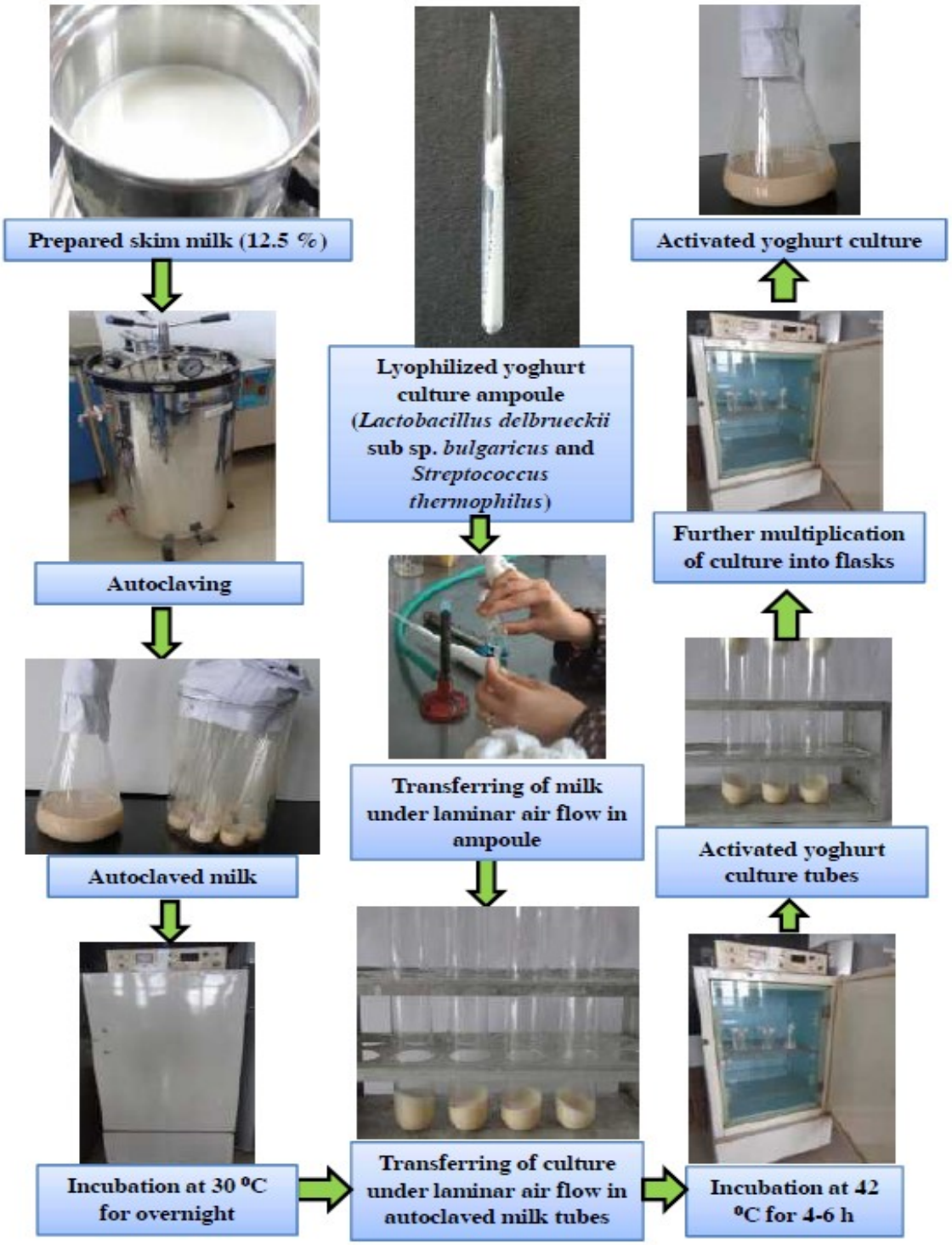
4.1.2 Storage of yoghurt

The yoghurt was packed in pre-sterilized polystyrene cups (200 mL), labelled and stored under refrigerated temperature (4-7^{o}C) conditions for fourteen days. The physico chemical, antioxidant properties and sensory characteristics of the products were estimated at zero, seven and fourteen days of storage.

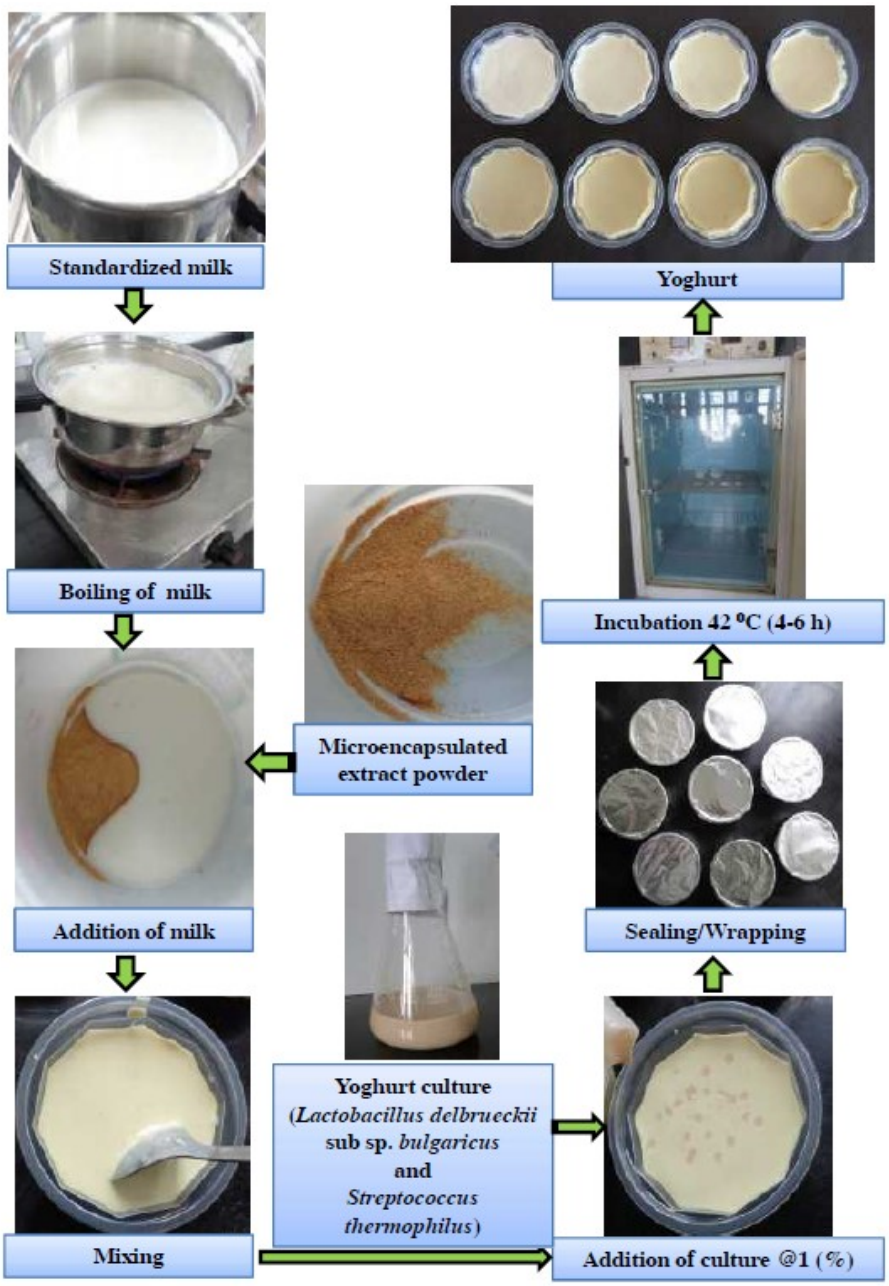
4.2 Drink

4.2.1 Standardization of concentration of microencapsulated phenolic extract powder for enrichment in mango drink

Fruit drink was prepared by mixing constant proportions of mango pulp in constant concentrations of sugar syrup as given in Table 7. To get the desirable concentration of acid (0.40 %) in fruit drink, citric acid was added in different treatment combinations. KMS (122ppm) was added in all the treatments at the end of product preparation as a preservative.



Unit operations for the activation of lyophilized culture



Unit operations for the preparation of microencapsulated phenolic extract powder enriched yoghurt

Table 7: Concentration of microencapsulated phenolic extract powder added in mango drink

Treatment	**D_1**	**D_2**	**D_3**	**D_4**	**D_5**	**D_6**	**D_7**	**D_8**
Pulp (%)	19.5	19.5	19.5	19.5	19.5	**19.5**	19.5	19.5
TSS (^oB)	15	15	15	15	15	**15**	15	15
Microencapsulated phenolic extract powder (**%**)	0	0.5	1.0	2.0	3.0	4.0	5.0	6.0

4.2.2 Storage of drink

The best recipe was selected on the basis of sensory characteristics for storage studies. The drink was packed in pre-sterilized PET bottles (200 mL) and bottles of packed products were properly labelled and stored in ambient (9.7-24^{o}C) and refrigerated temperature (4-7^{o}C) conditions for six months. The physico-chemical, antioxidant properties and sensory characteristics of all the products were estimated at zero, three and six months of storage.

Experimental results

1. Standardization of drying modes for the preparation of samples

The phenolics and antioxidant properties of different parts of fruits such as arils, albedo, flavedo and pomace were found highest at Karsog and Basantpur locations. Therefore, fruits from one location (Karsog location) on the basis of various antioxidant characteristics were selected further for carrying out drying of different parts under different drying modes. Data pertaining to various physico-chemical characteristics and antioxidants of dried forms of wild pomegranate fruits under various drying modes (natural sun drying, solar tunnel drier, mechanical cabinet, oven and freeze drying) indicate that highest DPPH anti-oxidant activity, metal chelating activity, FRAP anti-oxidant activity and reducing power as 82.41 per cent, 58.65 per cent, 326.54 µM Fe2+/100 g, and 1.725, respectively were recorded in mechanical cabinet dried flavedo. Infrared spectra of mechanical cabinet dried arils and flavedo indicated the presence of significant amount of phytochemicals in both the dried samples. The comparison of physicochemical characteristics and antioxidants of flavedo dried in mechanical cabinet and freeze drier indicate that higher amount of these parameters were found in freeze dried samples. The mechanical dried samples containing highest phenolics content were further utilized for making flavedo powder with the help of pulverizer having particle size of 425 microns through 36 mesh metallic sieve.

2. Standardization of phenolic antioxidants extraction method

Three different extraction methods like maceration, soxhlet and reflux were used for the extraction of phenolic antioxidants in which solid to solvent ratio was kept 1:20 indifferent solvents, at 30^{o}C and 50^{o}C for different time periods. The two best selected treatments from each method were compared on the basis of extract yield, total phenolics and flavonoids content after oven and freeze drying. While comparing the effect of drying methods on wild pomegranate flavedo extract, higher retention of phenolics and flavonoids in lyophilized flavedo extract was recorded than oven dried extract. Best method with highest phenolics content was selected for the extraction ofphenolic antioxidants on large scale. Antibacterial activity of lyophilized phenolic extracts of wild pomegranate flavedo against *Staphylococcus aureus* and *E. coli* shows that there was a general increasing trend in inhibition zone (mm) of different lyophilized phenolic extracts against *Staphylococcus aureus* with the increase in the concentration of extract from 25 ppm to 100 ppm. Maximum (18.75 mm) zone of inhibition was found in treatment T_1[ethanol and distilled water (60:40) extract after 6h of extraction at 30 ºC by maceration method] and minimum (13.62 mm) in treatment T_6 [acetone and distilled water (50:50) extract after 1h of extraction by reflux method. The maximum amount of phenolics and flavonoids as well as maximum antibacterial activity against *Staphylococcus aureus* and *E. coli* recorded in combination of ethanol and distilled water (60:40) lyophilized extract after 6h of extraction at 30 ºC by maceration method was selected as best method for the extraction of phenolic antioxidants on large scale. The prepared lyophilized extract powder was further analyzed for its various physicochemical characteristics, antioxidant properties, antimicrobial activity and functional groups by FT-IR analysis.

3 Microencapsulation of phenolic antioxidant extract and its packaging and storage

The concentration of carrier (maltodextrin) for microencapsulation of wild pomegranate phenolic extract was optimized on the basis of various physico-chemical characteristics, functional properties and structural morphology of microencapsulated phenolic extract. Out of different treatments, the best one was preferred on the basis of different observations for further storage studies. Eight combinations for the preparation of microencapsulated phenolic extract were tried and the 1:2 ratio of phenolics to carrier (maltodextrin) was optimized on the basis of various physico-chemical characteristics and functional properties as well as structural morphology of microencapsulated extract powder. Treatment T2 (1:2) retained higher phenolics and total flavonoids as compared to other treatments besides treatment T1 (1:1) in which uneven coating on particle surface was observed through SEM examination. Further, based on SEM analysis in treatment T2 most of particles showed a unimodal distribution, indicating a good powder homogeneity without agglomeration and representing a predominant size without using higher concentration of carrier material as compared to T3 (1:4). Microencapsulated phenolic extract powder could be stored safely for a period of four months under both storage conditions and also in both packaging materials. However, minimum changes in microencapsulated phenolic extract powder packed in amber coloured glass vials and stored under refrigerated temperature conditions were observed. The cost of production of flavedo powder (1 kg), lyophilized phenolic extract powder (1 kg) and microencapsulated phenolic extract powder (1 kg) in aluminium laminated pouches and in amber coloured glass vials was calculated as Rs. 59.47, 7104.66 and 3564.44, respectively.

4. Development of phenolic antioxidants enriched food products

The prepared microencapsulated phenolic extract was further utilized for enrichment of yoghurt and mango drink.

4.1 Yoghurt

Eight different treatment combinations were tried by addition of different concentrations of microencapsulated phenolic extract powder in yoghurt. Out of eight treatment combinations yoghurt (G4) enriched with 2 per cent microencapsulated phenolic extract powder was found to be best on the basis of various sensory characteristics. The significant increase in total phenols, total flavonoids and various antioxidant properties were observed after incorporation of 2 per cent microencapsulated phenolic extract powder as compared to normal yoghurt. Yoghurt could be stored safely for a period of 14 days under refrigerated temperature conditions (4-7 °C) in polystyrene cups with minimum changes in chemical and sensory attributes. The cost of production of microencapsulated phenolic extract powder enriched products like yoghurt (100 mL) in polystyrene cups was observed as Rs. 27.46.

4.2 Mango Drink

Out of eight treatment combinations mango drink with 19.5 per cent mango pulp and15^{o}B TSS (D4) with 2 per cent phenolic extract powder was found to be best on the basis of its sensory parameters. The significant increase in total phenols, total flavonoids and various antioxidant properties were observed after incorporation of micro-encapsulated phenolic extract (2 %) in enriched drink as compared to control drink. Antioxidants enriched mango drink could be stored safely for a period of six months under both storage conditions in PET bottles. However, comparatively minimum changes in drink packed in PET bottle and stored under refrigerated temperature conditions were observed as compared to ambient

conditions (9.7-24 °C). The cost of production of microencapsulated phenolic extract powder enriched products like mango drink (200 mL) PET bottles was observed as Rs. 30.94.

Conclusion and Recommendation

1. It can be concluded from above studies that wild pomegranate fruits of Karsog location of HP were found most suitable for the production of phenolic antioxidants. Highest amount of phenolic antioxidants were recorded in the flavedo part of the wild pomegranate fruit of Karsog location, which was further converted into powder form of 425 microns particle size with the help of pulverizer.

2. From this flavedo powder phenolic antioxidants were extracted successfully by the solvent which was a combination of ethanol and distilled water (60:40) by maceration method after 6h of extraction at 30 ºC followed by concentration of extract in rotary vacuum evaporator and then lyophilization.

3. Phenolic antioxidant extract was encapsulated successfully with maltodextrin in the ratio of 1:2. Microencapsulated phenolic extract powder could be stored safely for a period of four months under both storage conditions and also in both packaging materials with minimum changes in antioxidant attributes under refrigerated storage.

4. The microencapsulated phenolic extract powder further can be utilized for enrichment of food products like yoghurt and mango drink. Both the products could be enriched with 2 per cent micro-encapsulated phenolic extract powder successfully.

5. Yoghurt packed in polystyrene cups could be stored safely for a period of fourteen days and mango drink for six months in PET bottles under refrigerated temperature conditions. Hence flavedo part of this fruit can be utilized for the extraction of phenolic antioxidants on commercial scale as well as for the development of high antioxidant products like yoghurt and mango drink besides the major use of its arils in anardana production.

6. The cost of production of products yoghurt and mango drink enriched with micro-encapsulated phenolic extract powder was comparable to the cost of the similar products in the market.

Annexure–15

Sub-Project: **Strategy for the utilization of apple pomace for the preparation of functional rolls**

The present investigation was focused to evaluate the suitability of utilizing fresh apple pomace for the development of pomace based functional rolls. Apple is the most favored temperate fruit across the world and it is mostly used for table and juice purpose. Apple pomace is a bio-waste of apple juice processing industry containing several health promoting components. Therefore, utilization of apple pomace in fresh form for the development of value-added product was optimized. The fresh apple pomace is a good source of total dietary fibre (25.87–37.45%), polyphenols (64.91–77.31 mg/ 100 g) and ascorbic acid (5.27–5.68 mg/ 100 g) with 61.75–77.31 per cent antioxidant activity. In present study, 3 types of fresh pomace were used i.e. HPMC pomace, whole apple pomace and pomace without peel and core. The slurry prepared using 85:15 per cent apple pomace with water/ juice for whole apple pomace and HPMC pomace while 90:10 per cent for without peel and core pomace was optimized. Organoleptically, best rated slurries with 25ºB total soluble solids by using sugar/ jaggery and 0.65% titratable acidity (as % malic acid) were optimized and subjected for dehydration at 60+2^{o}C. The prepared rolls exhibited higher antioxidant activity (65.27-84.52%), total dietary fibers (48.17-69.74%) and polyphenolics (22.61–37.53 mg/ 100 g). The developed rolls for each type of pomace slurries were further analyzed for various physico-chemical, nutritional and sensory attributes during storage of 6 months. During storage, the rolls exhibited marginal changes in various physico-chemical and sensory attributes however, they were shelf-stable and acceptable at the ambient temperature (7.8-32.6^{o}C). The findings of the investigations reflected that the fresh apple pomace can successfully be utilized for the development of a very popular snack item containing a considerable quantity of functional food ingredients. Subsequently, the developed product had better taste, palatability, nutritional and functional food value. Therefore, the application of the developed technology at industrial scale will definitely generate extra income to the proprietors of the apple juice processing units besides, benefitting the farmers with remunerative prices for their produce and consumers with a new functional food product.

Details of Experiments conducted:

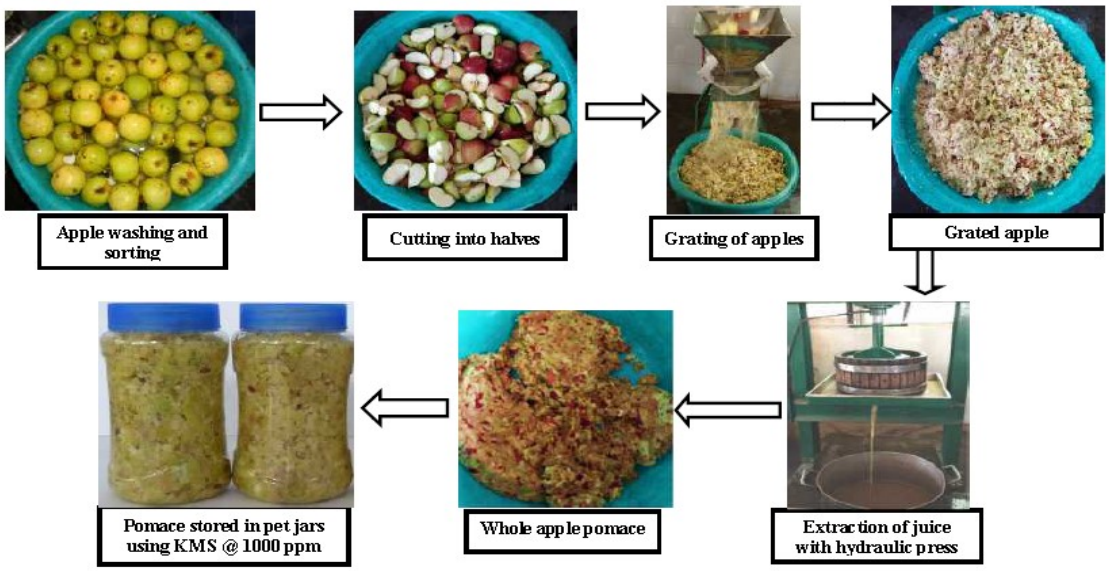
Objective1: Standardization of technique for preparation of apple pomace slurry and evaluation of its quality during storage

1.1 Preparation of apple pomace

Two different types of pomace were developed as per the requirement while the third type of pomace was procured from HPMC Parwanoo, Solan**,** Himachal Pradesh. For the preparation of whole apple pomace, fruits were sorted, thoroughly washed and cut into halves using stainless steel knife. The fruit halves were then passed through grater followed by juice extraction using hydraulic press. However, for obtaining apple pomace without peel and core, peeling along with coring was done. The rest of the procedure was similar to preparation of whole apple pomace (Fig.1). After addition of potassium metabisulphite (KMS) @1000 ppm, the pomace was preserved in HDPE jars (10 L capacity) in refrigerated condition for further use. Apple pomace was also stored in PET jars (500 g) at ambient temperature (3.2-25.4^{o}C) for the quality evaluation at different storage intervals (0, 30, 60, 90 days).

1.2 Standardization of pre-treatments for the optimization of water or juice ratio in apple pomace for the preparation of slurry

Different proportions of apple pomace (with/ without peel and core) and water/ jaggery (Table 1 a and b) were mixed and then subjected to heat for 4-5 min to obtain a homogeneous mixture. The mixing was done thoroughly in a mixer/ grinder to prepare slurry.



Unit operations for preparation of whole apple pomace

The best treatment was selected keeping in view the minimum addition of water/ juice as to make it economically beneficial.

Table 1a: Proportion of pomace and water (Pomace with peel/ without peel)

Apple variety	Proportion	Pomace (%)	Water (%)
Mixture of 3 varieties (with peel)	P_1	90	10
	P_2	85	15
	P_3	80	20
Pomace from HPMC	P_4	90	10
	P_5	85	15
	P_6	80	20
Mixture of 3 varieties (without peel)	P_7	90	10
	P_8	85	15
	P_9	80	20

Table 1b: Proportion of pomace and juice (Pomace with peel/ without peel)

Apple variety	Proportion	Pomace (%)	Juice (%)
Mixture of 3 varieties (with peel)	P_{10}	90	10
	P_{11}	85	15
	P_{12}	80	20
Pomace from HPMC	P_{13}	90	10
	P_{14}	85	15
	P_{15}	80	20
Mixture of 3 varieties (without peel)	P_{16}	90	10
	P_{17}	85	15
	P_{18}	80	20

Objective -2. Standardization of recipe for the preparation of apple pomace slurry and jaggery based rolls

2.1 Optimization of citric acid and total soluble solids (TSS) of the selected apple pomace slurry (pomace: Water and Juice) for the preparation of fruit rolls

The selected pomace slurries from the earlier treatments followed in (1.2. Table 1a and 1b) were added with citric acid and different proportions of sugar/ jaggery as per the requirement. After that the slurries with different proportion sugar/ jaggery Tables 2 (a-d) were subjected to drying in a dehydrator at a temperature of 60±2°C. The prepared rolls were subjected to sensory evaluation by a panel of ten judges on 9-point Hedonic scale. The best treatment was selected keeping in view the better scores for colour, flavour, texture and overall acceptability.

A) Preparation of functional rolls based on apple pomace

Table 2a: Total soluble solids of pomace and water slurry using white sugar

Selected slurry proportion (pomace-water)	Treatment. (Slurry with white sugar)	Total soluble solids (°B)
Mix varieties pomace slurry with peel (Best proportion with water to be taken)	S_1	15
	S_2	20
	S_3	25
HPMC pomace slurry (Best proportion with water to be taken)	S_4	15
	S_5	20
	S_6	25
Mix varieties pomace slurry without peel (Best proportion with water to be taken)	S_7	15
	S_8	20
	S_9	25

Table 2b: Total soluble solids of pomace and juice slurry using white sugar

Selected slurry proportion (pomace-Juice)	Treatment (slurry with white sugar)	Total soluble solids (°B)
Mix varieties pomace slurry with peel (Best proportion with juice to be taken)	S_{10}	15
	S_{11}	20
	S_{12}	25
HPMC pomace slurry (Best proportion with juice to be taken)	S_{13}	15
	S_{14}	20
	S_{15}	25
Mix varieties pomace slurry without peel (Best proportion with juice to be taken)	S_{16}	15
	S_{17}	20
	S_{18}	25

Table 2c: Total soluble solids of pomace and water slurry using jaggery

Selected slurry proportion (pomace-water)	Treatment (slurry with jaggery)	Total soluble solids (°B)
Mix varieties pomace slurry with peel (Best proportion with water to be taken)	J_l	15
	J_2	20
	J_3	25
HPMC pomace slurry (Best proportion with water to be taken)	J_4	15
	J_5	20
	J_6	25
Mix varieties pomace slurry without peel (Best proportion with water to be taken)	J_7	15
	J_8	20
	J_9	25

Table 2d: Total soluble solids of pomace and juice slurry using jaggery

Selected slurry proportion (pomace-Juice)	Treatment (slurry with jaggery)	Total soluble solids (°B)
Mix varieties pomace slurry with peel (Best proportion with juice to be taken)	J_{I0}	15
	J_{I1}	20
	J_{I2}	25
HPMC pomace slurry (Best proportion with juice to be taken)	J_{I3}	15
	J_{I4}	20
	J_{I5}	25
Mix varieties pomace slurry without peel (Best proportion with juice to be taken)	J_{I6}	15
	J_{I7}	20
	J_{I8}	25

B) Selection of best recipe for preparation of apple pomace based functional rolls

The functional rolls prepared from best combinations selected under section 2.1.A (Tables 2 (a-d)) were further subjected to sensory evaluation by a panel of ten judges using 9-point Hedonic scale. The best treatment was selected on the basis of higher overall acceptability scores and the same was taken as best recipe for preparation of functional rolls for storage studies. Titratable acidity of the final recipes was kept constant i.e. 0.65% on the basis of overall acceptability scores from the sensory evaluation. Best treatments of apple pomace-based functional roll of 25^{o}B total soluble solids having 0.65% titratable acidity were selected from each of the pomace types from the Tables 2a, 2b, 2c and 2d. Thickness of the pomace slurry before drying was kept constant in each treatment i.e. 6 mm.

2.2 Packaging and storage of pomace based functional rolls

The apple pomace based functional rolls of different selected treatments were packed in LDPE pouches and aluminum laminated pouches (ALP). The product was stored under ambient conditions for further investigation at different storage intervals (0, 3 and 6 months). During storage, the functional rolls were evaluated for various chemical, sensory and microbiological characteristics.

3. Cost of production of apple pomace based functional rolls

The raw material used for this study i.e. HPMC pomace, apple fruits, sugar, jaggery, packaging material etc. were procured as per the prices prevailing in the market. The cost of production of apple pomace based functional rolls was calculated by taking into account the cost of raw material, other ingredients used, packaging material and adding the processing cost @ 10% to work out the total price of the product.

Experimental results

1. Composition of raw material

1.1 Apple pomace: Two types of apple pomace i.e. whole apple pomace along with and without peel and core were developed in the laboratory by following the standard processing method as applicable however; the 3rd type of pomace was procured from HPMC processing plant at Parwanoo. All three types of pomace were evaluated for their physico-chemical parameters i.e. moisture content of 83.70, 81.40 and 85.70 per cent, total soluble solids 10.02, 12.00 and11.50 ºB, polyphenols 70.90, 75.07 and 64.91 mg/ 100 g, pectin 7.85, 6.25 and 3.82 per cent, total dietary fibre 37.45, 34.73

and 25.87 per cent were observed. However, antioxidant activity was recorded to be 73.08, 77.31 and 61.75 per cent.

1.2 Standardization of pre-treatments for the optimization of water or juice ratio in apple pomace for the preparation of slurry

Among different combinations tried for the optimization of water/ juice ratio for the formulation of apple pomace slurries, a combination of 85:15 per cent apple pomace with water/ juice was optimized for the preparation of pomace slurry using whole apple pomace and HPMC procured pomace whereas, a proportion of 90:10 per cent for apple pomace without peel and core were found to be the best based on sensory evaluation on 9-point Hedonic scale. Further, among four different combinations tried for the standardization of total soluble solids (TSS) in apple pomace slurries, the slurries with TSS of 25ºB using sugar/ jaggery was adjudged the best in terms of colour, texture, taste and overall acceptability while the final titratable acidity (as % malic acid) was maintained at 0.65 per cent. Hence, these combinations were used for preparation of apple pomace based rolls.

2. Standardization of recipe for the preparation of apple pomace slurry and jaggery based rolls

2.1 Preparation of functional rolls based on apple pomace

a) HPMC pomace based functional rolls

In HPMC pomace based functional rolls, moisture (21.15 – 22.77%), ash (1.23 – 2.84%), ascorbic acid (13.31 – 16.84 mg/ 100 g), titratable acidity (1.61 - 2.03%), pH (3.16 – 3.67), reducing sugars (26.24 – 29.41%), total sugars (56.81 – 60.87%), total dietary fibre (65.43 – 69.74%), antioxidant activity (68.62 – 78.56%), total phenols (28.37 – 33.85 mg/100 g) and pectin (10.17 – 11.86%) were recorded.

b) Whole apple pomace based functional rolls

In whole apple pomace based functional rolls, moisture (20.95 – 22.44%), ash (1.23 –2.64%), ascorbic acid (12.56 – 15.20 mg/ 100 g), titratable acidity (1.97 – 2.09%), pH (3.13 –3.71), reducing sugars (28.73 – 32.31%), total sugars (57.13 – 62.28%), total dietary fibre (60.92 – 65.26%), pectin (9.93 – 11.26%) and slightly higher values of antioxidant activity (78.16 – 84.52) and total phenols (31.14 – 37.53 mg/ 100 g) were observed.

c) Without peel and core pomace based functional rolls

In without peel and core pomace based functional rolls, moisture (23.27 – 25.08%), ash (1.36 – 2.84%), ascorbic acid (11.67 – 14.56 mg/ 100 g), titratable acidity (2.03 – 2.17%), pH (3.16 – 3.76), reducing sugars (26.42 – 30.37%), total sugars (53.34 – 59.12%), total dietary fibre (48.17 – 52.12%), antioxidant activity (65.27 – 75.56%), total phenols (22.61 –25.54 mg/ 100 g) and pectin (7.21 – 8.17%) were recorded.

2.2 Effect of storage and packaging material on physico-chemical characteristics and sensory attributes of

a) Whole apple pomace based functional rolls

A slight increase in moisture, pH and reducing sugars was observed whereas, the ash, total soluble solids, titratable acidity, ascorbic acid, total sugars, total dietary fibre, pectin, antioxidant activity and total phenols decreased up to 180 days of storage period. The total plate count was observed to be safe at ambient temperature (7.8-32.6^{o}C) during

the storage period of 6 months. Although, the sensory quality of whole apple pomace-based rolls decreased slowly during storage but, the rolls had their sensory score was within acceptable range of more than 7 on 9-point Hedonic scale. Thus, this study revealed that the freshly prepared pomace can successfully be utilized for the preparation of excellent quality of rolls with appreciable amount of functional chemical constituents.

b) HPMC pomace based functional rolls

A slight increase in moisture, pH and reducing sugars was observed whereas, the ash, total soluble solids, titratable acidity, ascorbic acid, total sugars, total dietary fibre, pectin, antioxidant activity and total phenols decreased up to 180 days of storage period. The total plate count was observed to be safe at ambient temperature (7.8-32.6^{o}C) during the storage period of 6 month. The sensory quality of HPMC pomace based functional rolls decreased during storage as the sensory score was recorded below the acceptable range of 6 on 9-point Hedonic scale.

c) Without peel and core pomace based functional rolls

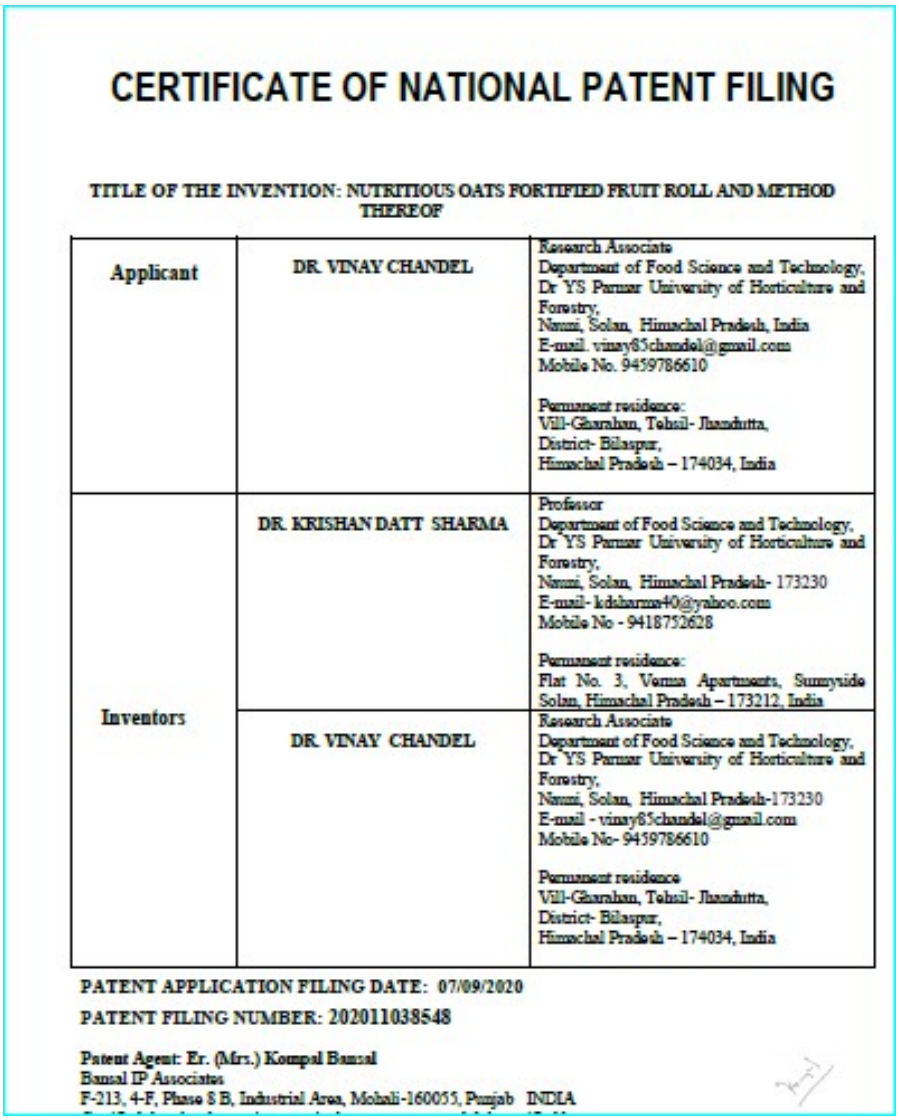
A slight increase in moisture, pH and reducing sugars was observed whereas, the ash, total soluble solids, titratable acidity, ascorbic acid, total sugars, total dietary fibre, pectin, antioxidant activity and total phenols decreased up to 180 days of storage period. The total plate count was observed to be safe at ambient temperature (7.8-32.6^{o}C) during the storage period of 6 months. Although, the sensory quality of without peel and core pomace-based rolls decreased slightly during storage however, the rolls had their sensory score within acceptable range of more than 7 on 9-point Hedonic scale. Thus, this study revealed that the freshly prepared pomace can successfully be utilized for the preparation of excellent quality of rolls.

Conclusion and Recommendation

1. Apple pomace, a bio-waste of apple juice processing industry, has a comparable nutritional profile as that of fresh apple fruit. The waste by-product which otherwise has negligible value can successfully be utilized in its fresh as well as preserved form for the development of value-added products.
2. Functional fruit rolls prepared from the apple pomace slurry containing 10-15 per cent water/ juice, 25ºB total soluble solids and 0.65 per cent titratable acidity were adjudged the best.
3. Overall acceptability sensory score and chemical analysis of the rolls developed in the study revealed that the product had better taste, palatability and nutritive value up to 6months of storage.
4. The cost of production revealed that the preparation of a snack item (Rolls) rich in antioxidants and fibers at a reasonable cost is a practical solution for the utilization of huge bio-waste generated by the apple juice processing units in the country and globally. The commercial application of the technology at industrial scale will definitely generate extra income to the proprietors of the apple juice processing units besides, benefitting the farmers with remunerative prices to their produce and consumers with a new functional food.

Patents Published

1. No.202011038548 filed on 07/09/2020 (Nutritious oat-fortified fruit rolls and method thereof) by KD Sharma and Vinay Chandel
2. No.202111011583 filed on 18/03/2021 (Healthful rolls of apple pomace bio-waste & method thereof) by KD Sharma and Vivek Mehta
3. No. 202111048886 filed on 26/10/2021 (Process of preparation of carrot juice concentrate and product thereof) by KD Sharma and Sakshi Sharma



CERTIFICATE OF NATIONAL PATENT FILING

TITLE OF THE INVENTION: NUTRITIOUS OATS FORTIFIED FRUIT ROLL AND METHOD THEREOF

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PATENT APPLICATION FILING DATE: 07/09/2020

PATENT FILING NUMBER: 202011038548

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F-213, 4-F, Phase 8 B, Industrial Area, Mohali-160055, Punjab INDIA

CERTIFICATE OF NATIONAL PATENT FILING

TITLE OF THE INVENTION: HEALTHFUL ROLLS OF APPLE POMACE BIOWASTE AND METHOD THEREOF

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PATENT APPLICATION FILING DATE: 18/03/2021

PATENT FILING NUMBER: 202111011583

CERTIFICATE OF NATIONAL PATENT FILING

TITLE OF THE INVENTION: PROCESS OF PREPARATION OF CARROT JUICE CONCENTRATE AND PRODUCT THEREOF

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PATENT APPLICATION FILING DATE: 26/10/2021

PATENT FILING NUMBER: 202111048886

Patent Agent: Er.(Mrs.)Kompal Bansal
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Certified that the above given particulars are correct and duly verified by me.

Annexure-17

Research Publications/ Manual

1. Bhatt K, Thakur NS, Hamid, Thakur A and Sharma C. 2020. Optimization of juice and total Soluble solids concentration for the preparation of wild jamun syrup: Effect of packaging materials and temperature conditions on nutritional quality during storage. *Current Journal of Applied Science and Technology,* 39(5): 116-124.
2. Bhatt K, Thakur NS, Thakur A, Hamid and Sharma C. 2020. Standardization of recipe for the preparation of wild jamun squash: effect of packaging materials and temperature conditions on nutritional quality during storage. *International Research Journal of Pure and Applied Chemistry,* 21(12): 34-44
3. Gautam A, Dhiman AK, Attri S and Kathuria D. 2020. Nutritional and functional characteristics of ripe persimmon fruit. *Journal of Pharmacognosy and Phytochemistry,* 9(4): 3364-3367
4. Gautam A. Dhiman AK, Attri S and Kathuria D. 2020. Formulation and storage studies of herbal based RTS beverages from persimmon fruit. *Annals of Phytomedicine,* 9(2): 155-163
5. Gautam A. Dhiman AK, Attri S and Kathuria D. 2020. Optimization of pulping method for extraction of pulp from ripe persimmon and its stability during storage. *Journal of Applied and Natural Science*, 12(4): 618-627
6. Sharma B and Sharma KD. 2020. Nutritional quality assessment of oilseed powder enriched biscuits. *Food and Nutrition Journal,* 5(2): 223-228
7. Sharma S and Sharma KD. 2020. Development of carrot juice concentrate enriched functional cookies. *International Journal of Current Microbiology and Applied Sciences,* 9(12): 3129-3135
8. Sharma S and Sharma KD. 2020. Nutritional characteristics of different types of carrot. *International Journal of Chemical Studies,* 8(6): 2275-2278
9. Kumar P, Thakur NS, Sharma KD, Hamid and A Thakur. 2020. Effect of type and permeability behaviour of packaging material on the quality characteristics of dried carrot roundels during storage. *Current Journal of Applied Science and Technology*, 39(7): 83-92
10. Soni P, Sharma KD, Sharma S, Mehta V and Attri S. 2020. Development of apple pomace enriched oat floor biscuits and their quality evaluation during storage. *International Journal of Current Microbiology and Applied Science*, 9(8): 2642-2652
11. Thakur NS, Aarti, Gautam S, Chandel A, Rana N, Thakur A and Hamid. 2020. Comparative assessment of Rhododendron (*Rhododendron arboreum* Sm.) flowers extract beverages through biochemical analysis and its quality evaluation during storage. *Annals of Phytomedicine,* 9(2): 222-230
12. Thakur NS, Aarti, Hamid, Thakur A and Gautam S. 2020. Utilization of edible rhododendron (*Rhododendron arboreum* Sm.) flowers for development of spiced beverage (appetizer) and its shelf-life evaluation during storage. *International Research Journal of Pure and Applied Chemistry,* 21(7): 52-62

List of Manuals:

1. Phalon se pey pardarath. (No. of pages: 20)
2. Seb se banaye jane wale khadya pardarath. (No. of pages: 4)
3. Papita phal se banaye jane wale functional khadya pardarath. (No. of pages: 8)
4. Phalon aur sabzion se nirmit madhyavarti nami wale khadya pardarath. (No. of pages:12)
5. Phalon aur sabzion se nirmit aachaar, chutney avum tamatar se banaye jane wale khadya pardarath. (No. of pages: 4)
6. Kaddu se banaye jane wale functional khadya pardarath. (No. of pages: 24)

Proof of Publications:

Title: Bhatt K, Thakur NS, Hamid, Thakur A and Sharma C. 2020. Optimization of juice and total soluble solids concentration for the preparation of wild jamun syrup: Effect of packaging materials and temperature conditions on nutritional quality during storage. *Current Journal of Applied Science and Technology,* 39(5): 116-124.

Current Journal of Applied Science and Technology

39(5): 116-124, 2020; Article no.CJAST.55661
ISSN: 2457-1024
(Past name: British Journal of Applied Science & Technology, Past ISSN: 2231-0843, NLM ID: 101664541)

Optimization of Juice and Total Soluble Solids Concentration for the Preparation of Wild Jamun Syrup: Effect of Packaging Materials and Temperature Conditions on Nutritional Quality during Storage

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Authors' contributions

This work was carried out by author KB during M.Sc. in Food Technology under the guidance of author NST. All authors have helped in preparation of manuscript and approved the final manuscript.

Article Information

DOI: 10.9734/CJAST/2020/v39i530553
Editor(s):
(1) Dr. Ekpenyong, Christopher Edet, University of Uyo, Nigeria.
Reviewers:
(1) Aaradhana Patel, Swami Vivekanand University, India.
(2) Omaima Mohamed Hafez, National Research Centre, Egypt.
Complete Peer review History: http://www.sdiarticle4.com/review-history/55661

Original Research Article

Received 28 January 2020
Accepted 04 April 2020
Published 10 April 2020

ABSTRACT

Jamun (*Syzygium cumini* L.) is a wild fruit with major importance due to its antioxidant activity, anthocyanins content and exotic taste besides high medicinal value. This fruit is known for its antidiabetic properties as its seeds contain glucoside "Jamboline". Due to its perishable nature and neutraceutical importance present studies have been conducted for the preparation of syrup. Various TSS (65 and 70 °B) and juice (25, 30, 35 and 40%) ratios have been attempted to optimize proper syrup combination. The two packaging materials i.e. glass and PET (Polyethylene terephthalate) bottles were used to pack jamun syrup prepared by the best selected combination and stored for 6 months under ambient (18-22°C) and refrigerated temperature conditions (4–7°C). Based on organoleptic and some physico-chemical characteristics, syrup prepared with 35% jamun juice, 65°B TSS and 1.50% acid was considered best among 8 different treatment combinations of juice and TSS. Jamun syrup could be stored safely for a duration of six months under both the

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Title: Bhatt K, Thakur NS, Thakur A, Hamid and Sharma C. 2020. Standardization of recipe for the preparation of wild jamun squash: effect of packaging materials and temperature conditions on nutritional quality during storage. *International Research Journal of Pure and Applied Chemistry,* 21(12): 34-44

International Research Journal of Pure & Applied Chemistry

21(12): 34-44, 2020; Article no.IRJPAC.59757
ISSN: 2231-3443, NLM ID: 101647669

Standardization of Recipe for the Preparation of Wild Jamun Squash: Effect of Packaging Materials and Temperature Conditions on Nutritional Quality during Storage

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Authors' contributions

This work was carried out by author KB during M.Sc. in Food Technology under the guidance of author NST. All authors have helped in preparation of manuscript and approved the final manuscript.

Article Information

DOI: 10.9734/IRJPAC/2020/v21i1230232
Editor(s):
(1) Dr. Wolfgang Linert, Vienna University of Technology Getreidemarkt, Austria.
Reviewers:
(1) Giullian César Da Silva Sá, Universidade Federal do Rio Grande do Norte, Brazil.
(2) Aumreetam Dinabandhu, National Institute for Plant Biotechnology, India.
Complete Peer review History: http://www.sdiarticle4.com/review-history/59757

Original Research Article

Received 02 June 2020
Accepted 08 August 2020
Published 19 August 2020

ABSTRACT

Jamun (*Syzygium cumini* L.) an evergreen wild fruit of utmost importance belongs to Myrtaceae family and grows throughout the Asian subcontinent, Eastern Africa, South America, Madagascar to USA. It is an edible antidiabetic fruit rich in anthocyanins native to India and West Indies. Thus, an attempt was made to develop squash from its fruit and determine quality changes during storage. Various combinations of enzyme assisted extracted juice and sugar syrup were tried and analyzed on the basis of sensory quality attributes to standardize proper combination for squash. The recipe with 35 per cent juice and 40°B TSS was rated best on the basis of sensory and some physico-chemical characteristics packed in glass and PET bottles and stored for six months under ambient (20-25°C) and refrigerated temperature conditions (4-7°C). Squash could be safely stored for a period of six months under both the ambient and refrigerated conditions with mild change in various quality characteristics. Although, the changes in the quality characteristics of the squash were slower in refrigerated storage conditions

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Title: Gautam A, Dhiman AK, Attri S and Kathuria D. 2020. Nutritional and functional characteristics of ripe persimmon fruit. *Journal of Pharmacognosy and Phytochemistry,* 9(4): 3364-3367

Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
www.phytojournal.com
JPP 2020; 9(4): 3364-3367
Received: 12-05-2020
Accepted: 14-06-2020

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Nutritional and functional characteristics of ripe persimmon (*Diospyros kaki* L.) fruit

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DOI: https://doi.org/10.22271/phyto.2020.v9.i4ah.12138

Abstract
Persimmon (*Diospyros kaki* L), is an ornamental tree known for its delicious berry like fruits. The fruit is appreciated for its nutritional value, health benefits and rich flavor. The physico-chemical properties of the fruit are an important indicator for its quality. Persimmon fruit part varies with sufficient amount of nutritional characteristics. Therefore, fruit with and without peel had significant effect on the chemical characteristics. Hence the study was under taken to analyze the physical and nutritional characteristics of *Fuyu* cultivar of persimmon. On ripening, the fruit consists of 7.98 Kg/cm^2 firmness with flesh content of 85.82%. In case of nutritional characteristics, the fruit with peel had greater amount of functional components like fibre (0.69%), ascorbic acid (15.90 mg/100g), β-carotene (250 mg/100g) and total phenols (3.87 mg/100g).

Keywords: Ripe persimmon, physical properties, nutritional properties, minerals, phenols

Introduction

Persimmon (*Diospyros kaki* L.) is a perennial, sub tropical and warm temperate climate fruit, belongs to the family Ebenaceae and genus *Dioaspyros*. The fruit is commonly known as '*Japaniphal*' which is cherished for its unique flavor and high nutritional content. It is mainly originated from China, Japan and Korea (Lucas-Gonzalez *et al.,* 2017) [1] and is cultivated in warm region of China, Japan, Brazil, Italy and Mediterranean region (Bubba *et al.*, 2009) [2]. There are more than 700 species of persimmon planted worldwide, but *Dispyros kaki, Diospyros virginiana, Diospyros oleifera* and *Diospyros lotus* that do posses' significant importance. Further persimmon is also widely distributed from tropical to temperate regions of Asia, Africa and central South America (Yokozawea *et al.,* 2007) [3]. According to FAO, the total world production of persimmon is more than 7.9 million tonnes of which China, Japan and Korea account 85 per cent in 2018 (FAO, 2018) [4]. In India, the agro-climatic conditions of northern states such as Himachal Pradesh, Jammu and Kashmir, Uttrakhand and parts of Nilgiri Hills of south are suitable for cultivation of persimmon (Mehta *et al.*, 2005) [5]. In Himachal Pradesh, district Mandi is the highest producer of persimmon followed by Kullu and Shimla. The area under cultivation is reported to be 421 hectare with the production of 943 metric ton (Anonymous, 2017) [6].

A fleshy and fibrous ripe persimmon fruit is categorized into two different varieties i.e. astringent and non astringent. The astringent varieties (Red Saijo, Honan, Triumph, and Hachiya) consist of high levels of soluble tannins while the non astringent varieties (*Fuyu*, Gosho, Imato and Izo) contain small amount of tannins (Singh *et al.,* 2011) [7]. *Fuyu* is the most commonly grown non-astringent variety. Its fruits are flat, squat, round and the surface of the fruit is smooth, shining with thin shell and yellow to red orange in colour and appearance like orange tomatoes. The fruit is good source of prominent nutrients such as moisture (80.3%), protein (0.58%), lipids (0.19%), total carbohydrate (18.6%), vitamins, minerals (potassium, magnesium, zinc, iron, copper, manganese) and organic acids (Ozen *et al.,* 2004) [8]. It also contain different bioactive compounds like ascorbic acid (7.5 mg), tocopherol,

Title: Gautam A. Dhiman AK, Attri S and Kathuria D. 2020. Formulation and storage studies of herbal based RTS beverages from persimmon fruit. *Annals of Phytomedicine,* 9(2): 155-163

Annals of Phytomedicine 9(2): 155-163, 2020

DOI: http://dx.doi.org/10.21276/ap.2020.9.2.13

Annals of Phytomedicine: An International Journal

http://www.ukaazpublications.com/publications/index.php

Print ISSN : 2278-9839 Online ISSN : 2393-9885

Original article: Open access

Formulation and storage studies of herbal based RTS beverages from persimmon (*Diospyros kaki* L.) fruit

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Article Info

Article history
Received 6 August 2020
Revised 1 October 2020
Accepted 5 October 2020
Published online 30 December 2020

Keywords
Rite persimmon
RTS
Herbal RTS
Storage
Quality evaluation
Ginger

Abstract

A ready-to-serve (RTS) beverage was developed using pulp, extracted by the cold and hot pulping method. Among different combinations of TSS (10, 12, 15 °Brix), pulp concentration (10, 15, 20 %) and acidity (0.2, 0.3, 0.4 %) beverage developed in which treatment T_1 at 10°Brix using cold extracted pulp and in treatment T_2 at 12 °Brix using hot extracted pulp was found to be the best on the basis of sensory evaluation. They exhibited ascorbic acid (2.26 and 1.44 mg/100 g), β-carotene (0.040 and 0.054 µg/100 g) and total phenols (0.58 and 0.55 mg/100 g). Further, comparing the nutritional and sensory characteristics of the RTS beverage, the use of hot extracted pulp was selected for the preparation of herbal RTS beverage (ginger, ginger-mint). Persimmon RTS beverage was evaluated for quality and stability during storage. Though, sensory scores decreased significantly with the advancement of storage but processed products of all the treatments were well above the acceptable limits. The study indicated that the RTS beverage can be stored safely for a period of six months with minimal changes in chemical and sensory attributes.

1. Introduction

Different types of RTS beverages available in the market include synthetic, carbonated, fruit juice based, *etc*. The pulp/juice extracted from fruits and vegetables when used to prepare beverage is usually referred to as fruit beverage. The nutritive value of fruit based beverages is much more than that of the synthetic products. If, synthetic drinks are substituted with fruit beverages, it would be beneficial to the consumers as well as to the fruit growers. Different researchers had used different fruits for the preparation of RTS beverages. Ripe pumpkin based RTS beverage was developed by Dhiman *et al*. (2017) by using various combinations of pulp (10, 13, 15 and 17 %) and TSS (10, 13 and 15 °Brix) with lime, hill lemon and citric acid as acidulants. Mulberry (*Morus alba* L.) RTS was prepared by Hamid *et al.* (2017) with different combinations of juice (8, 10, 12, 14 and 16 %) and TSS (12 and 15 °Brix). The RTS beverage prepared with different combinations of juice (10, 12, 14 and 16 %) and TSS (12 and 15 °Brix) from wild aonla *(Phyllanthus emblica* L.) was evaluated for quality by Thakur *et al.* (2018). In addition, novel techniques are also involved for the processing of beverages. Nguyen (2020) prepared dragon fruit beverage using acoustic treatment by varying acoustic power, duration and temperature. Further, incorporation of herbal extracts in RTS beverage helps in maintaining health and treating chronic diseases (Alam, 2019). Dhiman *et al*. (2017) also developed ginger, mint, ginger-mint flavoured RTS beverages using ripe pumpkin pulp. Looking upon the demand for natural beverages, there exists a great scope for the preparation of beverages by utilizing fruit juices and pulps.

Persimmon (*Diospyros kaki* L.) is a fleshy fibrous perennial and sub tropical deciduous fruit belongs to the family Ebenaceae. The fruit is known as Oriental or Japanese persimmon and is commonly called as 'Japaniphal'. It is widely cultivated in warm regions of China, Japan, Korea, Brazil, Italy and Mediterranean region (Bubba *et al*., 2009). As per FAO report, the total world production of persimmon is more than 7.9 million tonnes of which China, Japan and Korea account 85 % in 2018 (FAO, 2018). Persimmon fruit is potentially a rich source of carbohydrates, organic acids, vitamins and minerals as well as functional components such as ascorbic acid, carotenoids, polyphenolic compounds (tannins), flavanoids and flavonols. It is an excellent source of vitamin A that constitutes about 5400 IU and minerals such as calcium (9 mg/100 g), phosphorus (27 mg/100 g), potassium (203 mg/100 g) and magnesium

Title: Gautam A. Dhiman AK, Attri S and Kathuria D. 2020. Optimization of pulping method for extraction of pulp from ripe persimmon and its stability during storage. *Journal of Applied and Natural Science*, 12(4): 618-627

ANSF APPLIED AND NATURAL SCIENCE FOUNDATION

Journal of Applied and Natural Science
12(4): 618 - 627 (2020)
Published online: December 9, 2020
ISSN : 0974-9411 (Print), 2231-5209 (Online)
journals.ansfoundation.org

Research Article

Optimization of pulping method for extraction of pulp from ripe persimmon (*Diospyros kaki* L.) and its stability during storage

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Article Info
https://doi.org/10.31018/jans.v12i4.2430
Received: October 28, 2020
Revised: December 3, 2020
Accepted: December 6, 2020

How to Cite
Gautam A. et al. (2020). Optimization of pulping method for extraction of pulp from ripe persimmon (*Diospyros kaki* L.) and its stability during storage. *Journal of Applied and Natural Science*, 12(4): 618 - 627. https://doi.org/10.31018/jans.v12i4.2430

Abstract
Persimmon fruit (*Diospyros kaki* L.) is a highly nutritious fruit with bestowed antioxidant properties. But due to its perishable nature, it is produced for a very shorter period of time. Preservation of fruit in the form of pulp acts as a suitable method to provide availability of the fruit throughout the year. The main objective of this investigation was to develop persimmon pulp from the cold and hot pulping method and to assess the best preservation method for storage. Among six different treatments in cold pulping method (T_1 to T_2 x 2), treatment T_2 (10 % water) and among 18 different treatment in hot pulping method (T_1 to T_9 x 2), treatment T_5 (10 % water + 10 minutes cooking time) using fruit with peel was selected on the basis of nutritional and sensory attributes. Further, the pulp was preserved via heat and chemical methods. Among six different treatments, T_5 (Pulp + pasteurization + 1000 ppm potassium metabisulphite (KMS) in glass bottles) was found to be best in the type of pulp. This treatment was able to retain the maximum amount of ascorbic acid (13.733 and 8.043 mg/100 g), β-carotene (173 and 86 µg/100 g) and total phenols (3.093 and 2.873 mg/100 g), respectively during storage of 6 months. Hence, it can be suggested from the study that nutritionally rich persimmon pulp can be prepared with better storage stability which can be used by both small and large scale industries at a lower cost of production.

Keywords: Ripe persimmon, Pulp, Pulping method, Pulp preservation, KMS

INTRODUCTION

Fruits and vegetables are the most perishable food products that get spoiled as early as possible, so they need to be converted into edible products. The most important way to utilize fruits and vegetables is to produce semi-finished products such as pulps, purees, juices, etc. The pulp can be extracted by employing various methods such as hot and cold pulping, enzymatic treatment, microwave extraction, high-pressure treatment, ultrasonic extraction, etc. The quality of fruit pulps must be maintained using various quality control methods, in order to offer a high nutritional, microbiological and sensory quality product to the consumers, serve the nutrition, color and taste of the fruit pulp. To check efficacy and effects on microbial culture growth use of chemical preservatives is of prime importance (Khattak *et al*., 2014).

Persimmon (*Diospyros kakai* L.) is a Japanese fruit commonly known as *Japani phal*. The word persimmon is derived from Algonquian called as "dry fruit". Ancient refers persimmon fruit as "Food for the Gods" where *Dios* means God and *pyros* means food or grain. The fruit is native to China, Korea and Japan, but is widely cultivated in warm regions of Brazil, Italy and the Mediterranean region as well (Bubba *et al*., 2009). As per FAO report, the total annual production

Title: Sharma S and Sharma KD. 2020. Development of carrot juice concentrate enriched functional cookies. *International Journal of Current Microbiology and Applied Sciences,* 9(12): 3129-3135

Int.J.Curr.Microbiol.App.Sci (2020) *9*(12): 3129-3135

International Journal of Current Microbiology and Applied Sciences
ISSN: 2319-7706 **Volume 9 Number 12 (2020)**
Journal homepage: http://www.ijcmas.com

Original Research Article https://doi.org/10.20546/ijcmas.2020.912.372

Development of Carrot Juice Concentrate Enriched Functional Cookies

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Keywords
Carrot juice Concentrate, Functional cookies

Article Info
Accepted:
27 November 2020
Available Online:
10 December 2020

ABSTRACT

This study was conducted to investigate the potential of utilization of carrot juice concentrate for the preparation of functional cookies. Cookies were supplemented with different levels of carrot juice concentrate (5, 10, 15, 20 and 25%) and best treatment was selected on the basis of sensory evaluation. The best treatment was further examined for various physico-chemical parameters. It was observed that addition of carrot juice concentrate has improved the functional properties of cookies without compromising the sensory qualities. Cookies prepared with 15 per cent carrot juice concentrate were adjudged best by the panelists in terms of sensory score i.e. color (8.15), texture (8.12), taste (7.98) and overall acceptability (8.10). The study suggested that carrot juice concentrate can be successfully be utilized in development of nutritionally and functionally enriched cookies.

Introduction

Carrot (*Daucuscarota sativus*) is one of the most important seasonal root vegetable belonging to family *Apiaceae* (*Umbelliferae*) and is grown extensively in India during winter season for its edible taproot. It is considered to be native of Afghanistan (Banga, 1957). The earliest known mention of domesticated carrots dates back to the 10th century in Persia and Asia Minor; then it spreads to all Asia, Europe, North Africa and the Mediterranean region (Kalra *et al.,* 1987; Mazza, 1989). Nutritionally, carrot is rich in both antioxidants i.e. lipophilic (xanthophylls, carotenoids) and hydrophilic (phenols), phosphorus and extraordinary pectin fibers (Sharma *et al.,* 2012; Aadil *et al.,* 2013; Leja *et al.,* 2013; Mazzoni *et al.,* 2016; Kaur *et al.,* 2018). Carotenes which is the major pigment present in carrot and a well-known precursor of vitamin A, have long been recognized for their role in vision, cataract prevention but more recently claims has been made for its anti-cancer properties and its role in prevention of cardiovascular diseases (Breithaupt and Bamedi, 2001). Carrots are consumed as raw (fresh, whole or baby carrots) and processed or manufactured form (canned foods, soups, juice and frozen products). One of the most important processed forms is carrot juice which is

Title: Sharma S and Sharma KD. 2020. Nutritional characteristics of different types of carrot. *International Journal of Chemical Studies,* 8(6): 2275-2278

International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
www.chemijournal.com
IJCS 2020; 8(6): 2275-2278

Received: 06-08-2020
Accepted: 13-09-2020

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Nutritional characteristics of different types of carrot

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DOI: https://doi.org/10.22271/chemi.2020.v8.i6ag.11111

Abstract
Carrots are the most common vegetable after potato. Among thirty-eight fruits and vegetables, carrot ranked tenth with respect to nutritional quality and seventh for its contribution to nutrition. It is often claimed to be the perfect health food. It is highly nutritious and functionally enriched vegetable. Carrots are particularly good source of beta-carotene, fiber, vitamins, minerals, ascorbic acid, antioxidants and polyphenols. Epidemiological and nutritional studies have exhibited that carrot phytochemical can play significant part in the prevention and degenerative disorders like diabetes, cancer and cardiovascular diseases. Carrots are found in many colours, including white, orange, red, purple and deep purple/ black. This paper includes the physical, chemical and functional properties of four types of carrot.

Keywords: Carrot, functional, nutritional

Introduction

Carrot (*Daucus carota* Sativus) is one of the most important seasonal root vegetable belonging to family *Apiaceae* (*Umbelliferae*) and is grown extensively in India during winter season for its edible taproot. It is considered to be native of Afghanistan (Banga, 1976) [6]. The earliest known mention of domesticated carrots dates back to the 10th century in Persia and Asia Minor; then it spreads to all Asia, Europe, North Africa and the Mediterranean region (Kalra *et al.,* 1987; Mazza, 1989) [12, 18]. Although it has been widely cultivated for many centuries, the use of carrot as a food dates only from the early twentieth century. According to botanical classification of carrot seeds, they are separated in two groups. The anthocyanin group (*Daucus carota* ssp. *Sativus* var. *Atrorubens Alef.*) and the carotene group (*Daucus carota* ssp. *Sativus* var.). Although orange colored carrot varieties are more common, consumption of black or purple carrots (*Daucus carota* L. ssp. *sativus* var. *atrorubens Alef.*) is currently increasing in world due to its health benefits. Black carrot has attracted the attention of the scientific community due to their phenolic compounds, vitamins and anthocyanins which are significantly related to its antioxidant capacity (Alasalvar *et al.,* 2001; Priya and Santhi, 2015) [1, 20]. Total area of the world is 13466 million hectares, India ranks seventh area wise (accounts for 329 million hectares i.e. 2.4%) after Russian Federation, Canada, USA, China, Brazil, and Australia. However, out of this (329 million hectares) only 159 million hectares is the arable land. Further, World's economically active population in agriculture is around 1310 million; 267 million (20.40%) of which is located in India. India's diverse climate ensures availability of all varieties of fresh fruits and vegetable throughout the year. Our presence in global market is significant and it is a matter of satisfaction that India is the second largest producer of vegetables and fruits. India has witnessed significant progress in horticulture production over the last few years. Over the last decade, the area under horticulture grew by 2.60 per cent per annum and annual production increased by 4.80 per cent during 2017-18. The world production of fruits and vegetable crops was 866.00 million tonnes and 1075.00 million tonnes, respectively. However, the production of vegetables has increased from 101.20 Million Tonnes to 184.40 Million Tonnes and production of fruits has increased from 50.90 Million Tonnes to 97.35 Million Tonnes since 2004-05 to 2017-18 in India.

According to recent estimate of crop-wise area and production of horticulture Crops for three years carrot accounts for 82, 86, 97 (000 Ha) and 1338, 1350 and 1648 (000MT) are and production in the year 2015-16, 2016-17 and 2017-18, respectively. Carrot is grown extensively throughout India as one of the major vegetable. Major carrot producing states are

Title: Kumar P, Thakur NS, Sharma KD, Hamid and A Thakur. 2020. Effect of type and permeability behaviour of packaging material on the quality characteristics of dried carrot roundels during storage. *Current Journal of Applied Science and Technology*, 39(7): 83-92

Current Journal of Applied Science and Technology

39(7): 83-92, 2020; Article no.CJAST.56125
ISSN: 2457-1024
(Past name: British Journal of Applied Science & Technology, Past ISSN: 2231-0843, NLM ID: 101664541)

Effect of Type and Permeability Behaviour of Packaging Material on the Quality Characteristics of Dried Carrot Roundels during Storage

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Authors' contributions

This work was carried out in collaboration among all authors. Author PK designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors NST, Hamid and AT managed the analyses of the study. Author KDS managed the literature searches. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/CJAST/2020/v39i730579
Editor(s):
(1) Dr. Ming-Chih Shih, Chinese Culture University, Taiwan.
Reviewers:
(1) Joseph Nunoo, Biotechnology and Nuclear Agriculture Research Institute, Ghana.
(2) K. C. Yadav, Tribhuvan University, Nepal.
(3) Tamer El Sisy, Agriculture Research Center, Egypt.
Complete Peer review History: http://www.sdiarticle4.com/review-history/56125

Original Research Article

Received 16 February 2020
Accepted 22 April 2020
Published 29 April 2020

ABSTRACT

Carrot (*Daucus carota* L) is a carotenoids rich vegetable which is mainly consumed raw, converted to various products and cooked vegetable dishes. Present studies were carried out to study the changes observed in quality characteristics of dried carrot roundels during storage. Steam blanching and KMS dipping of carrot roundels followed by mechanical cabinet drying was found to be the best pretreatment for drying of carrot roundels as discussed earlier. These dried carrot roundels were further packed and stored under refrigerated (4-7°C) and ambient (11.6-26.2°C) storage conditions for 12 months. The dried carrot roundels packed in aluminium laminated pouches and stored under refrigerated conditions showed minimum increase in physico-chemical characteristics like moisture content (11.03%), water activity (0.310), pH (6.04), reducing sugars (21.00%), total sugars (35.36%) and retained highest amounts of titratable acidity (0.73%), carotenoids (29.40mg/100g), total

Title: Soni P, Sharma KD, Sharma S, Mehta V and Attri S. 2020. Development of apple pomace enriched oat floor biscuits and their quality evaluation during storage. *International Journal of Current Microbiology and Applied Science*, 9(8): 2642-2652

Int.J.Curr.Microbiol.App.Sci (2020) *9*(8): 2642-2652

International Journal of Current Microbiology and Applied Sciences
ISSN: 2319-7706 **Volume 9 Number 8 (2020)**
Journal homepage: http://www.ijcmas.com

Original Research Article https://doi.org/10.20546/ijcmas.2020.908.302

Development of Apple Pomace Enriched Oat Flour Biscuits and its Quality Evaluation during Storage

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Keywords

Oat flour, Apple pomace powder, Total phenols, Crude fibre and biscuit

Article Info

Accepted:
22 July 2020
Available Online:
10 August 2020

ABSTRACT

This study was conducted to investigate the physico-chemical characteristics of oat flour and apple pomace enriched oat flour biscuits. Biscuits were prepared with different level of oat flour and apple pomace powder and the physico-chemical properties were examined after the evaluation of sensory characteristics. Total phenols and crude fibre content of apple pomace enriched biscuits are more than the control biscuits. Among different combinations tried 70% oat flour and 30% apple pomace powder forbiscuits was optimized for the preparation of acceptable and palatable bakery products. The study suggested that oat flour along with apple pomace powder can successfully be utilized in biscuit due to their enhanced nutritional, functional and sensory characteristics.

Introduction

Oat is an important cereal crop of developing world, belongs to family Poaceae (Butt *et al.,* 2008). The common oat (*Avena sativa* L.) is most widely used species for food and feed purpose, has a hulled grain and depending on the colour of hull can be divided into white, yellow and black varieties (Kourimska *et al.,* 2018).It is a cereal crop of Mediterranean, Middle East origin and domestication of oats occurred much later than for wheat and barley (Q and Hoffman, 1992).

Oat is also known as "Super grain" due to its rich nutritional profile (Kaur *et al.,* 2019). It has been reported that the grains contain high dietary fibre content and bioactive compounds. Chemically, it consists of 8.22 per cent moisture content, 66.27 per cent carbohydrates, 16.89 per cent protein, 9.70 per cent fibre and 6.90 per cent lipids (Sterna *et al.,* 2016). The oat is considered to be a good source of polyunsaturated essential fatty acid (Biel *et al.,* 2009). The proportion of unsaturated fatty acids i.e. oleic, linoleic and linolenic acid in oat is about 75 per cent of all fatty acid. Rybicka and Swiglo (2017) have

Title: Thakur NS, Aarti, Gautam S, Chandel A, Rana N, Thakur A and Hamid. 2020. Comparative assessment of Rhododendron (*Rhododendron arboreum* Sm.) flowers extract beverages through biochemical analysis and its quality evaluation during storage. *Annals of Phytomedicine,* 9(2): 222-230

Annals of Phytomedicine 10(1): 263-276, 2021

DOI: http://dx.doi.org/10.21276/ap.2021.10.1.29

Annals of Phytomedicine: An International Journal

http://www.ukaazpublications.com/publications/index.php

Print ISSN : 2278-9839 Online ISSN : 2393-9885

Original article: Open access

Studies on storage quality evaluation of drink prepared from Rhododendron (*Rhododendron arboreum* Sm.) flowers extract

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Article Info

Article history
Received 10 May 2021
Revised 27 June 2021
Accepted 28 June 2021
Published online 30 June 2021

Keywords
Antioxidant
Drink
Packaging
Rhododendron
RTS

Abstract

Rhododendron (*Rhododendron arboreum* Sm.) is one of the wild flower of Himachal Pradesh (India) which can be of great economic importance because of its high antioxidants, colour pigments and other quality parameters besides its medicinal properties. Drink or RTS beverage is quite popular product because of longer shelf-life and less loss of nutrients during processing. In present investigation, effect of packaging and storage conditions on the various quality parameters of rhododendron drink was studied. The physico-chemical and sensory characteristics of rhododendron drink packed in pre-sterilized glass and PET (Polyethylene terephthalate) bottles stored in ambient (20-25°C) and refrigerated temperature (4-7°C) conditions were estimated at 0, 3 and 6 months of storage. Drink could be safely stored for a period of six months under both the storage conditions without much change in the various physicochemical and sensory characteristics. The various physicochemical characteristics like total soluble solids (12.00 to 12.47 °B), reducing sugars (7.05 to 8.62 %), titratable acidity (0.30 to 0.26 %), ascorbic acid (1.43 to 0.28 mg/100 ml), anthocyanins (9.68 to 6.33 mg/100 ml), total phenols (14.24 to 12.63 mg GAE/100 ml) and antioxidant activity (9.66 to 7.44 %) increased/decreased during the storage period. However, these changes were slower in refrigerated storage conditions as compared to that under ambient conditions. The drink stored in PET and glass bottles was found suitable for consumption, with comparatively less changes occurring in glass bottles stored under refrigerated conditions.

1. Introduction

Rhododendron (*Rhododendron arboreum* Sm.) commonly known as "Burans" is an evergreen shrub or small tree with highly valued wild edible flowers. The term rhododendron has been derived from two Greek words "rhodo" and "dendron" which means rose and tree, respectively. So, the rhododendron can be regarded as rose tree (Srivastava, 2012). It belongs to family Ericaceae, comprising of 8 genera and 850 species which is mainly found growing between 1500 and 2400 meters above mean sea level (Stevens *et al.*, 2004; Sharma *et al.*, 2009; Negi *et al.*, 2013). The genus is mostly concentrated in the temperate regions of northern hemisphere (especially in Eastern Himalayas and Western China) and further extended towards southern China as well as to north-eastern China and Japan (Bhattacharyya and Sanjappa, 2008). In India, 80 species of rhododendron are found in various states like Arunachal Pradesh, Himachal Pradesh, Jammu and Kashmir, Manipur, Nagaland, Sikkim and Uttrakhand (Katoch, 2014). In Himachal Pradesh, three species with sweetish sour taste and have been found to be rich source of carbohydrates, amino acids, sugars, pectin, anthocyanins and vitamin C (Solanki *et al.*, 2013; Purohit, 2014; Kashyap *et al.*, 2017). The health benefits of rhododendron flowers includes prevention and treatment of diseases associated with heart, dysentery, diarrhea, detoxification, inflammation, fever, constipation, bronchitis and asthma. These flowers are traditionally used in the preparation of various value added products like pickle, juice, jam, syrup, honey, squash, *etc.* (Nisar *et al.*, 2013; Kumar *et al.*, 2019). Shelf life of various value added products is the maximum time during which the food retains an acceptable quality and can be used safely under specified environmental conditions of temperature, moisture and exposure to light. It generally depends upon various factors like packaging and storage conditions which play an important role in retaining the nutritional, sensory and microbiological quality along with enhanced shelf-life of any processed product during handing, transportation and storage

Title: Thakur NS, Aarti, Hamid, Thakur A and Gautam S. 2020. Utilization of edible rhododendron (*Rhododendron arboreum* Sm.) flowers for development of spiced beverage (appetizer) and its shelf-life evaluation during storage. *International Research Journal of Pure and Applied Chemistry,* 21(7): 52-62

International Research Journal of Pure & Applied Chemistry

21(7): 52-62, 2020; Article no.IRJPAC.57165
ISSN: 2231-3443, NLM ID: 101647669

Utilization of Edible Rhododendron (*Rhododendron arboreum* Sm.) Flowers for Development of Spiced Beverage (Appetizer) and Its Shelf Life Evaluation during Storage

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Authors' contributions

This study was designed by 'Author NS' and the research work was carried out by 'author Aarti' under the guidance of author NS. All authors has helped in preparation of manuscript and statistical analysis, managed literature searches of study and approved the final manuscript.

Article Information

DOI: 10.9734/IRJPAC/2020/v21i730180
Editor(s):
(1) Dr. Hao-Yang Wang, Shanghai Institute of Organic Chemistry, China.
Reviewers:
(1) Adeyeye, Samuel Ayofemi Olalekan, Ton Duc Thang University, Vietnam.
(2) Rosa Perestrelo, Universidade da Madeira, Portugal.
Complete Peer review History: http://www.sdiarticle4.com/review-history/57165

Original Research Article

Received 12 March 2020
Accepted 19 May 2020
Published 28 May 2020

ABSTRACT

In India, various types of unexplored edible flowers are being utilized traditionally as food and medicine by the rural communities since ancient time only during their flowering time due to short post harvest life. These flowers are rich in phytochemical (e.g. polyphenolics, anthocyanins) which possess numerous health benefits. So, the present investigations were conducted to develop a spiced beverage/appetizer (spiced squash) from rhododendron flower petals and its quality evaluation during storage. Different combinations of petals extract and total soluble solids (TSS) were tried to standardize proper combination for spiced beverage. Appetizer recipe (T_3) prepared with 35% extract, 40°B TSS and 1.20% acid was found to be best based on quality characteristics of the product. The best-selected appetizer recipe was packed in glass and PET bottles and stored for 6 months under ambient (15-25°C) and refrigerated temperature conditions (4-7°C). Overall effect of packaging and storage revealed that various quality characteristics like TSS, apparent viscosity, reducing and total sugars of appetizer increased slightly, whereas, other chemical characteristics like acidity, ascorbic acid, anthocyanins, total phenols and sensory characteristics scores of colour,

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Detail of trainings conducted under the project

Annexure 18

Trainings and Demonstrations organized under Functional Foods project at 4 KVK's of Himachal Pradesh during 2019–2020

03 days training camps organized at different locations of Himachal Pradesh under the project "Establishment of functional foods R&D Centre and dissemination of the developed technology for the livelihood, nutritional security and entrepreneurship of the farm women of HP"

1. **Karalash (Ward No. 1) at Rohru, District Shimla from 23-07-2019 to 25-07-2019:** During the training camp different fruits and vegetable products i.e. papaya jam, mango squash, mango nectar and mix vegetable pickle were prepared. Further recipe for the preparation of ketchup and puree from tomato was given to the participants during the camp (**No. of Participants = 28)**.

2. Karalash (Ward No. 2) at Rohru, District Shimla from 02-08-2019 to 04-08-2019: In this training camp, various technical sessionswere organized for the farm women in which the processed products likeapplejam, mango squash and tomato ketchupwere prepared. Detailed lectures on know how aboutthe functional value of foods was given to the participants during the camp (**No. of Participants = 21)**.

3. Shudarng, District Kinnaur from 05-08-2019 to 07-08-2019: During the three days technical session, papaya jam, mango squash and mango nectar and detailed knowhow to make various functional foods to the participants were also made available (**No. of Participants = 30)**.


4. **Kalpa, District Kinnaur from 12-08-2019 to 14-08-2019:** During the three days technical session, papaya jam, mango squash and mango nectar were prepared. The detailed information about the functional and nutritional aspects was also shared with the farm women (**No. of Participants = 30)**.

5. **Bhanauta, District Chamba from 16.08.2019 to 18.08.2019:** During the three days training program, the demonstrations about the preparation ofpapaya jam, mango squash and mango nectar and tomato ketchup were given to the farm women. The recipe regarding preparation of pickles and technique regarding dehydration of fruits and vegetables were also shared with the participants during the camp **(No. of participants = 31).**

6. **Udaipur, District Chamba from 19.08.2019 to 21.08.2019:** During the three days technical session, apple jam, pomegranate squash, tomato ketchup, mix vegetable pickle and chilli pickles were made and detailed know-how about maintaining functional and nutritional aspects of foods was shared with the participants during the camp (**No. of Participants = 21)**.

7. **Mangla, District Chamba from 22.08.2019 to 24.08.2019:** Three days training was organized for the farm women regarding the preparation of various processed products from locally available fruits and vegetables like pear Jam, lemon squash, tomato puree and tomato ketchup. The detailed recipes regarding preparation of fruit chutney and various types of pickles were also shared with the farm women (**No. of Participants = 31)**.

7. **Ledang, District of Lahaul & Spiti from 26.08.2019 to 28.08.2019:** During the three days training program technical session regarding the preparation of various processed products like apple jam, lemon squash, tomato puree and tomato ketchup were organized. The

detailed knowledge about the functional and nutritional aspects was also shared with the participants during the camp (**No. of Participants = 30)**.

9. **Khwangi, Kinnaur district from 29.08.2019 to 31.08.2019:** The three-day training program was organized for the farm women regarding the preparation of processed products from locally available fruits and vegetables like pear jam, pear chutney, apple rings, tomato puree and tomato ketchup. The awareness about the functional aspects of foods was created among the participants during the camp (**No. of Participants = 30)**.
10. **Manne, District of Lahaul & Spiti from 29.08.2019 to 31.08.2019:** During the three days training program technical session was organized regarding preparation of Apricot Jam, Apricot Squash, Apple rings and Dehydration of Apricot. The detailed information about the drying and dehydration of fruits and vegetables was given to the participants during the camp (**No. of Participants = 30)**
11. **Poh, District of Lahaul & Spiti from 02.09.2019 to 04.09.2019:** During the three days technical session apricot jam, apricot squash, tomato puree and dehydration of apricot was done. The detailed know-how about the preparation of various functional foods was also given to the participants during the camp (**No. of Participants = 30)**.

12. **Bhoot at Panchayat Jagrothi, District Shimla from 05.09.2019 to 07.09.2019:** During the three days technical sessionapple jam, apple chutney, tomato puree and tomato ketchup and apple rings were prepared and detailed know how to make various functional foods was also given to the participants attending the training program **(No. of Participants = 27).**

13. **Draman, District Chamba from 20.01.2020 to 22.01.2020:** During the three days technical session papayajam, papayachutney, tomato puree, orange squash and tomato ketchup were prepared and detailed know how to make various functional foods was also given to the participants attending the training program **(No. of Participants = 30)**

14. **Shaho, District Chamba from 23.01.2020 to 25.01.2020:** Three days training was organized for the farm women regarding the preparation of various processed products from locally available fruits and vegetables like pear Jam, lemon squash, tomato puree, mushroom pickles, papaya chutney and tomato ketchup. The detailed recipes regarding preparation of fruit chutney and various types of pickles were also shared with the farm women **(No. of Participants = 30).**

Annexure-19

Trainings and Demonstrations organized under Functional Foods project at 4 KVK's of Himachal Pradesh during 2020–2021

1. **Sheigo, district Lahaul and Spiti from 27.08.2020 to 29.08.2020:** The three days training camp was organized at Shiego, district L&S, HP. The trainees were provided with the literature comprising of pamphlets/booklets containing procedure of various functional foods and were also taught about incorporating functional foods in their regular diet. The processed products like apple jam, apple murraba, tomato ketchup, Barley (Sattu) cake and laddoo were prepared from locally grown fruits vegetables and cereals. **(No. of Participants = 10)**

2. **Hurling, district Lahaul and Spiti from 06.09.2020 to 08.09.2020:** The three days training camp was organized at Hurling, district L&S, HP. The demonstrations regarding preparation of processed products like apple jam, apple murraba, tomato ketchup, Barley (Sattu) cake and laddoo from locally grown cereals, fruits and vegetables were given to the farm women. The trainees were also provided with the literature comprising of pamphlets/booklets containing procedure of various functional foods and were also taught about the benefits of functional foods. **(No. of Participants = 10)**

3. **Roghi, district Kinnaur from 07.09.2020 to 09.09.2020:** The three days training camp was organized at Roghi Panchayat of Kalpa Block, District Kinnaur, HP. The trainees were provided with pamphlets/booklets containing procedure of various functional foods and were also taught about the benefits of functional foods and encouraged for enterprising on small scales. The processed products were prepared from locally grown fruits and vegetables like tomato ketchup, apple *chutney,* mixed pickle, cauliflower preserve and sauerkraut. All the trainees showed keen interest during the preparation of products and also helped along. **(No. of Participants = 10)**

4. **Baror, district Chamba from 12.10.2020 to 14.10.2020:** The three days training camp was organized at Baror, District Chamba, HP. The trainees were provided know-how about the procedure of preparation of various functional foods and were also taught about incorporating functional foods in their regular diet. The processed

products like Apple jam, apple murraba, tomato ketchup and mixed vegetable pickles were prepared from locally grown fruits and vegetables. **(No. of Participants = 10)**

5. **Tabo, district Lahaul and Spiti from 12.10.2020 to 14.10.2020:** The three days training camp was organized at Tabo, District Lahaul and Spiti, HP. The demonstrations regarding preparation of processed products like Apple jam, apple murraba, tomato ketchup, Barley (Sattu) cake and laddoo from locally grown cereals, fruits and vegetables were given to the farm women. The trainees were also provided with the literature comprising of pamphlets/booklets containing procedure of various functional foods and were also taught about the benefits of functional foods. **(No. of Participants = 10)**

6. **Mudgram, Udaipur, district Lahaul & Spiti on 13.10.2020**: The Principal Investigator of Functional foods project organized one day training camp during which lecture, exhibition and practical demonstrations were given to 20 farm women at Mudgram, Udaipur, district Lahaul & Spiti. The functional food products like apple pulp, apple jam, apple juice, tomato juice and tomato puree were prepared during training camp. **(No. of Participants = 20)**

7. **Stingri, Keylong, district Lahaul & Spiti on 14.10.2020:** The Principal Investigator of Functional foods project organized one day training camp for 20 farm women at Stingri, Keylong, district Lahaul & Spiti. The lecture, exhibition and practical demonstrations regarding preparation of functional food products like apple pulp, apple jam, apple juice, tomato juice and tomato puree were given to the trainees. **(No. of Participants = 16)**

8. **Shindwadi, district Lahaul & Spiti on 15.10.2020:** The Principal Investigator of Functional foods project organized lecture, exhibition and practical demonstration to 20 farm women during one day training camp at Shindwadi, district Lahaul & Spiti. The functional food products like apple pulp, apple jam, apple juice, tomato juice and tomato puree were prepared by the trainees. **(No. of Participants = 20)**

9. **Billing, Keylong, district Lahaul & Spiti on 16.10.2020:** The Principal Investigator of Functional foods project organized one day training camp for 20 farm women at Billing, Keylong, district Lahaul & Spiti. The lecture, exhibition and practical

demonstration along with know how regarding preparation of functional food products like apple pulp, apple jam, apple juice, tomato juice and tomato puree was given to the trainees. **(No. of Participants = 27)**

10. **Guwad, district Chamba from 15.10.2020 to 17.10.2020:** The three days training camp was organized at Guwad, Tehsil- Bharmour, District Chamba, HP. The demonstrations regarding preparation of processed products like Apple jam, apple murraba, tomato ketchup, mixed vegetable pickle and apple chutney were given to the farm women. The trainees were also familiarized about the health benefits and procedure of preparation of various functional foods from locally grown fruits and vegetables. **(No. of Participants = 10)**

11. **Sarahan, district Chamba from 18.10.2020 to 20.10.2020:** The three days training camp was organized at Sarahan Panchayat of Chamba Block, District Chamba, HP. The trainees were also taught about the benefits of functional foods and encouraged for enterprising on small scales. The processed products were prepared from locally grown fruits and vegetables like tomato ketchup, apple *chutney,* garlic pickle and orange squash. All the trainees showed keen interest during the preparation of products and also helped along. **(No. of Participants = 10)**

12. **Saru, district Chamba from 21.10.2020 to 23.10.2020:** The three days training camp was organized at Saru, District Chamba, HP. The demonstrations regarding preparation of processed products like apple jam, apple murraba, tomato ketchup and mixed vegetable pickle from locally grown fruits and vegetables were given to the farm women. The trainees were also taught about the benefits of functional foods. **(No. of Participants = 10)**

13. **Noi, district Shimla from 27.11.2020 to 29.11.2020:** The three days training camp was organized at Noi, Panchayat- Jagrothi, Rohru District Shimla, HP. The trainees were provided know-how about the procedure of preparation of various functional foods and were also taught about incorporating functional foods in their regular diet. The processed products like Apple jam, apple chutney, ginger pickle and mixed vegetable pickles (cauliflower, carrot) were prepared from locally grown fruits vegetables and fruits. **(No. of Participants = 30)**

14. **Pangi, Kalpa district Kinnaur from 03.12.2020 to 05.12.2020:** The three days training camp was organized at Pangi Panchayat of Kalpa Block, District Kinnaur, HP. The demonstrations regarding preparation of processed products like apple *chutney* mixed pickle and cauliflower preserve and tomato ketchup from locally grown fruits and vegetables were given to the farm women. The trainees were provided with pamphlets/booklets containing procedure of various functional foods and were also taught about the benefits of functional foods and encouraged for enterprising on small scales. **(No. of Participants = 30)**

15. **Powari, Kalpa district Kinnaur from 07.12.2020 to 09.12.2020:** The three days training camp was organized at Powari (Tangling) Panchayat of Kalpa Block, District Kinnaur, Himachal Pradesh. The demonstrations regarding preparation of processed products like apple *chutney* mixed pickle, sauerkraut and tomato ketchup from locally grown fruits and vegetables were given to the farm women. During the three days training camp the trainees were provided with pamphlets/booklets containing procedure of various functional foods. The trainees were also taught about the benefits of functional foods and encouraged for enterprising on small scales. **(No. of Participants = 30)**

16. **Rathi, district Shimla from 08.12.2020 to 10.12.2020:** The three days training camp was organized at Rathi, Panchayat Balara, Rohru District Shimla, HP. The demonstrations regarding preparation of processed products like Apple chutney, lemon squash and tomato ketchup from locally grown fruits and vegetables were given to the farm women. The trainees were also familarised about the health benefits and procedure of preparation of various functional foods. **(No. of Participants = 30)**

17. **Sapni, Kalpa district Kinnaur from 10.12.2020 to 12.12.2020:** The three days training camp was organized at Sapni Panchayat of Kalpa Block, District Kinnaur, Himachal Pradesh. The demonstrations regarding preparation of processed products like apple *chutney* mixed pickle, sauerkraut and tomato ketchup from locally grown fruits and vegetables were given to the farm women. The trainees were provided with pamphlets/booklets containing procedure of various functional foods and were also taught about the benefits of functional foods and encouraged for enterprising on small scales. **(No. of Participants = 30)**

18. **Kamroo, district Kinnaur from 14.12.2020 to 16.12.2020:** The three days training camp was organized at Kamroo Panchayat, District Kinnaur, Himachal Pradesh. The demonstrations regarding preparation of processed products like apple *chutney* mixed pickle, marmalade and tomato ketchup from locally grown fruits and vegetables were given to the farm women. During the three days training camp the trainees were provided with pamphlets/booklets containing procedure of various functional foods. The trainees were also taught about the benefits of functional foods and encouraged for enterprising on small scales. **(No. of Participants = 30)**

19. **Karalash, Rohru district Shimla from 15.12.2020 to 17.12.2020:** The three days training camp was organized at Karalash Panchayat of Rohru Block, District Shimla, HP. The trainees were provided with pamphlets/booklets containing procedure of various functional foods and were also taught about the benefits of functional foods and encouraged for enterprising on small scales. The processed products were prepared from locally grown fruits and vegetables like apple *chutney,* lemon squash and tomato ketchup. All the trainees showed keen interest during the preparation of products and also helped along. **(No. of Participants = 30)**

20. **Urni, Nichar district Kinnaur from 17.12.2020 to 19.12.2020:** The three days training camp was organized at Urni Panchayat of Nichar Block, District Kinnaur, Himachal Pradesh. The demonstrations regarding preparation of processed products like apple *chutney* mixed pickle, sauerkraut, apple jam and tomato ketchup from locally grown fruits and vegetables were given to the farm women. During the three days training camp the trainees were provided with pamphlets/booklets containing procedure of various functional foods. The trainees were also taught about the benefits of functional foods and encouraged for enterprising on small scales. **(No. of Participants = 30)**

21. **Kothi, Kalpa district Kinnaur from 21.12.2020 to 23.12.2020:** The three days training camp was organized at Kothi Panchayat of Kalpa Block, District Kinnaur, Himachal Pradesh. The demonstrations regarding preparation of processed products like apple *chutney* mixed pickle and tomato ketchup from locally grown fruits and vegetables were given to the farm women. During the three days training camp the trainees were provided with pamphlets/booklets containing procedure of various functional foods. The trainees were also taught about the benefits of functional foods and encouraged for enterprising on small scales. **(No. of Participants = 30)**

22. **Sirkund, district Chamba from 28.01.2021 to 30.01.2021:** The three days training camp was organized at Sirkund, panchayat of District Chamba, HP. The trainees were provided know-how about the procedure of preparation of various functional foods and were also taught about incorporating functional foods in their regular diet. The processed products like Apple jam, apple murraba, tomato ketchup and lemon pickles were prepared from locally grown fruits and vegetables. **(No. of Participants = 14)**

23. **Nihuin, district Chamba from 31.01.2021 to 02.02.2021:** The three days training camp was organized at Nihuin, District Chamba, HP. The demonstrations regarding preparation of processed products like Apple jam, apple murraba, tomato ketchup, mixed vegetable pickle and apple chutney from locally grown fruits and vegetables were given to the farm women. The trainees were also familarised about the health benefits and procedure of preparation of various functional foods. **(No. of Participants = 19)**

24. **Chammui, district Chamba from 03.02.2021 to 05.02.2021:** The three days training camp was organized at Chammui, Village of Chamba Block, District Chamba, HP. The processed products were prepared from locally grown fruits and vegetables like tomato ketchup, apple *chutney,* garlic pickle and orange squash. All the trainees showed keen interest during the preparation of products and also helped along. **(No. of Participants = 29)**


25. **Kumarkha, district Chamba from 06.02.2021 to 08.02.2021:** The three days training camp was organized at Kumarkha, District Chamba, HP. The demonstrations regarding preparation of value-added products like Apple jam, apple murraba, tomato ketchup and mixed vegetable pickle from locally grown fruits and vegetables were given to the farm women. The trainees were also provided know how of about various functional foods and benefits of functional foods. **(No. of Participants = 20)**

26. **Mukleni, district Chamba on 09.02.2021:** The one-day training camp was organized at Mukleni, District Chamba, HP. The trainees were provided know-how about the procedure of preparation of various functional foods and were also taught about incorporating functional foods in their regular diet. The processed products like Apple jam, tomato ketchup and mixed vegetable pickles were prepared from locally grown fruits vegetables and cereals. **(No. of Participants = 23)**

27. **Sarol, district Chamba on 10.02.2021:** The one-day training camp was organized at Sarol, District Chamba, HP. The demonstrations regarding preparation of processed products like Apple jam, apple, tomato ketchup, and apple chutney from locally grown fruits and vegetables were given to the farm women. The trainees were also familiarized about the health benefits and procedure of preparation of various functional foods. **(No. of Participants = 13)**

28. **Shaktidehra, district Chamba from 11.02.2021 to 13.02.2021:** The three days training camp was organized at Shaktidehra village of Chamba Block, District Chamba, HP. The trainees were taught about the benefits of functional foods and encouraged for enterprising on small scales. The processed products were prepared from locally grown fruits and vegetables like tomato ketchup, apple *chutney,* garlic pickle and orange squash. All the trainees showed keen interest during the preparation of products and also helped along. **(No. of Participants = 21)**

29. **Saru, district Chamba from 14.02.2021 to 16.02.2021:** The three days training camp was organized at Saru, District Chamba, HP. The trainees were provided know-how about the procedure of preparation of various functional foods and were also taught about incorporating functional foods in their regular diet. The processed products like Apple jam, apple murraba, tomato ketchup and mixed vegetable pickles were prepared from locally grown fruits vegetables and cereals. **(No. of Participants = 28)**

30. **Gharoti, district Chamba from 17.02.2021 to 19.02.2021:** The three days training camp was organized at Gharoti, District Chamba, HP. The demonstrations regarding preparation of processed products like Apple jam, apple murraba, tomato ketchup, mixed vegetable pickle and apple chutney from locally grown fruits and vegetables were given to the farm women. **(No. of Participants = 15)**

31. **Kiani, district Chamba from 20.02.2021 to 22.02.2021:** The three days training camp was organized at Kiani Panchayat of Chamba Block, District Chamba, HP. The trainees were taught about the benefits of functional foods and products like tomato ketchup, apple *chutney,* mixed vegetable pickle and orange squash were prepared. All the trainees showed keen interest during the preparation of products and also helped along. **(No. of Participants = 29)**

32. **Sari Basa, district Shimla from 21.02.2021 to 23.02.2021:** The three days training camp was organized at Sari Basa, Jubbal block of District Shimla, HP. The trainees were provided with pamphlets/booklets containing procedure of various functional foods and were also taught about the benefits of functional foods. The demonstrations regarding preparation of value added products like Apple jam, apple murraba, tomato ketchup and mixed vegetable pickle from locally available fruits and vegetables were given to the farm women. **(No. of Participants = 33)**

33. **Ribba, district Kinnaur from 22.02.2021 to 24.02.2021:** The three days training camp was organized at Ribba village of Kinnaur, district. The trainees were provided with pamphlets/booklets containing procedure of various functional foods and during the technical session Pear Jam, Pear Chutney, mixed vegetable pickle and Tomato Puree were made by the participants during the camp. **(No. of Participants = 30)**

34. **Chebri, district Shimla from 24.02.2021 to 25.02.2021:** The two days training camp was organized at Chebri, District Shimla, HP. The trainees were provided with pamphlets/booklets containing procedure of various functional foods and were also taught about the benefits of functional foods. The demonstrations regarding preparation of value added products like Apple jam, apple murraba, tomato ketchup and mixed vegetable pickle from locally available fruits and vegetables were given to the farm women. **(No. of Participants = 30)**

35. **Rekong-peo, district Kinnaur from 25.02.2021 to 27.02.2021:** The three days training camp was organized at Rekong- peo village of Kinnaur, district. The trainees were provided with pamphlets/booklets developed on the basis of research conducted at university main campus, Solan and were also taught about the benefits of functional foods. During the three days technical session, pear Jam, mix vegetable pickle, Tomato Puree and Tomato Squash and other functional foods were made and detailed know how to make various functional foods was given to the participants during the camp. **(No. of Participants = 30)**


36. **Karalesh, district Shimla from 26.02.2021 to 28.02.2021:** The three days training camp was organized at Karalesh, Rohru block, District Shimla, HP. The trainees were provided with pamphlets/booklets containing procedure of various functional foods and were also taught about the benefits of functional foods and encouraged for enterprising on small scales. The processed products were prepared from locally grown fruits and vegetables like tomato ketchup, apple *chutney,* lemon pickle and apple jam. All the trainees showed keen interest during the preparation of products and also helped along. **(No. of Participants = 30)**

37. **Rohal, district Shimla from 01.03.2021 to 03.03.2021:** The three days training camp was organized at Rohal, Chirgoan block, District Shimla, HP. The trainees were provided with pamphlets/booklets containing procedure of various functional foods and were also taught about the benefits of functional foods and encouraged for enterprising on small scales. The processed products were prepared from locally grown fruits and vegetables like tomato ketchup, apple *chutney,* lemon pickle and apple jam. All the trainees showed keen interest during the preparation of products and also helped along. **(No. of Participants = 36)**

38. **Devnagar, district Shimla from 05.03.2021 to 07.03.2021:** The three days training camp was organized at Devnagar, Rampur block, District Shimla, HP. The trainees were provided with pamphlets/booklets containing procedure of various functional foods. The processed products like tomato ketchup, apple *chutney,* lemon pickle and apple jam were prepared from locally grown fruits and vegetables. All the trainees showed keen interest during the preparation of products and also helped along. **(No. of Participants = 55)**

39. **Manne (Yogma), district Lahaul and Spiti from 10.03.2021 to 12.03.2021:** The three days training camp was organized at Manne (Yogma) village District Lahaul and Spiti, HP. The trainees were taught about the benefits of functional foods and encouraged for enterprising on small scales. The processed products were prepared

from locally grown fruits and vegetables like Preparation of bakery products from sattu, preparation of tomato sauce, tomato pickle, peas pickle and Mushroom pickle. **(No. of Participants = 20)**

40. **Manne (Gogma), district Lahaul and Spiti from 13.03.2021 to 15.03.2021:** The three days training camp was organized at Manne (Gogma) village District Lahaul and Spiti, HP. The trainees were taught about the benefits of functional foods and encouraged for enterprising on small scales. The processed products were prepared from locally grown fruits and vegetables like Preparation of bakery products from sattu, preparation of tomato sauce, tomato pickle, peas pickle and Mushroom pickle. All the trainees showed keen interest during the preparation of products and also helped along. **(No. of Participants = 20)**

41. **Duni, district Kinnaur from 15.03.2021 to 17.03.2021:** The three days training camp was organized at Duni village of Kinnaur, district. The trainees were provided with pamphlets/booklets containing procedure of various functional foods and were also taught about the benefits of incorporating functional foods into their diet. During the three days of training demonstrations regarding preparation of pear Jam, apple chutney, Tomato Puree and Tomato Squash and other functional foods were given to the participants. **(No. of Participants = 30)**

42. **Lippa, district Kinnaur from 18.03.2021 to 20.03.2021:** The three days training camp was organized at Lippa village of Kinnaur, district. The trainees were provided with pamphlets/booklets containing procedure of various functional foods and were also taught about the benefits of incorporating functional foods into their diet. During the three days technical session, pear jam, dry fruit chutney, Tomato Puree and Mix-Vegetable Pickle and other functional foods were made and detailed know how to make various functional foods was given to the participants during the camp. **(No. of Participants = 30)**

43. **Jangi, district Kinnaur from 18.03.2021 to 20.03.2021:** The three days training camp was organized at Jangi village of Kinnaur, district. The trainees were provided with pamphlets/booklets containing procedure of various functional foods and were also taught about the benefits of incorporating functional foods into their diet. During the three days of training demonstrations regarding preparation of Apple Jam, dry fruit chutney, Tomato Puree and other functional foods were given to the participants. **(No. of Participants = 30)**

44. **Kaina, district Shimla from 18.03.2021 to 20.03.2021:** The three days training camp was organized at Kaina, Jubbal block, District Shimla, HP. The trainees were provided with pamphlets/booklets containing procedure of various functional foods and were also taught about the benefits of incorporation of functional foods into yheir diet and encouraged for enterprising on small scales. The processed products were prepared from locally grown fruits and vegetables like tomato ketchup, apple *chutney,* lemon pickle and apple jam. All the trainees showed keen interest during the preparation of products and also helped along. **(No. of Participants = 30)**

45. **Sundli, district Shimla from 21.03.2021 to 23.03.2021:** The three days training camp was organized at Sundli, Jubbal block, District Shimla, HP. The trainees were provided with pamphlets/booklets containing procedure of various functional foods and were also taught about the benefits of functional foods and encouraged for enterprising on small scales. The processed products were prepared from locally grown fruits and vegetables like tomato ketchup, apple *chutney,* lemon pickle and apple jam. **(No. of Participants = 30)**

46. **Rarang, district Kinnaur from 22.03.2021 to 24.03.2021:** The three days training camp was organized at Rarang village of Kinnaur, district. The trainees were provided with pamphlets/booklets containing procedure of various functional foods and were also taught about the benefits of incorporating functional foods into their diet. During the three days technical session Pear Jam, mixed vegetable pickle, dry fruit chutney and Tomato Squash and other functional foods were made and detailed know how to make various functional foods was given to the participants during the camp. **(No. of Participants = 30)**

47. **Rispa, district Kinnaur from 22.03.2021 to 24.03.2021:** The three days training camp was organized at Rispa village of Kinnaur, district. The trainees were provided with pamphlets/booklets containing procedure of various functional foods and were also taught about the benefits of incorporating functional foods into their diet. During the three days of training demonstrations regarding preparation of Apple Jam, mixed vegetable pickle, dry fruit chutney, Tomato Puree and Tomato Squash and other functional foods were given to the participants. **(No. of Participants = 30)**

48. **Bashol, district Shimla from 24.03.2021 to 26.03.2021:** The three days training camp was organized at Bashol, Rampur block, District Shimla, HP. The processed functional food products like tomato ketchup, apple *chutney,* lemon pickle and apple jam were prepared from locally grown fruits and vegetables. The trainees were provided with pamphlets/booklets containing procedure of various functional foods and were also taught about the benefits of functional foods and encouraged for enterprising on small scales. All the trainees showed keen interest during the preparation of products. **(No. of Participants = 35)**

49. **Katgoan, district Kinnaur from 25.03.2021 to 27.03.2021:** The three days training camp was organized at Katgoan village of Kinnaur, district. The trainees were provided with pamphlets/booklets containing procedure of various functional foods and were also taught about the benefits of incorporating functional foods into their diet. During the three days technical session, pear Jam, mixed vegetable pickle, dry fruit chutney, Tomato Puree and Tomato Squash and other functional foods were made and detailed know how to make various functional foods was given to the participants during the camp. **(No. of Participants = 30)**

50. **Kafnoo, district Kinnaur from 25.03.2021 to 27.03.2021:** The three days training camp was organized at Kafnoo village of Kinnaur, district. The trainees were provided with pamphlets/booklets containing procedure of various functional foods and were also taught about the benefits of incorporating functional foods into their diet. During the three days of training demonstrations regarding preparation of pear jam, mixed vegetable pickle, dry fruit chutney, Tomato Puree and Tomato ketchup and other functional foods were given to the participants. **(No. of Participants = 30)**

Annexure-20

Trainings and Demonstrations organized under Functional Foods project at 4 KVK's of Himachal Pradesh during 2021–2022

1. **Bhagi, Lowerkoti (Rohru), District Shimla from 09.03.2022 to 11.03.2022:** Three days training was organized for the farm women regarding the preparation of various processed products from locally available fruits and vegetables like pear Jam, lemon squash, tomato puree and tomato ketchup. The detailed recipes regarding preparation of fruit chutney and various types of pickles were also shared with the farm women **(No. of Participants = 32)**
2. **Nandla, Chirgaon, District Shimla from 14.03.2022 to 16.03.2022:** During the three days training program technical session regarding the preparation of various processed products like apple jam, lemon squash, tomato puree and tomato ketchup were organized. The detailed knowledge about the functional and nutritional aspects was also shared with the participants during the camp (**No. of Participants = 30)**.
3. **Sandhasu, Chirgaon, District Shimla from 17.03.2022 to 19.03.2022:** Three days training was organized for the farm women regarding the preparation of various processed products from locally available fruits and vegetables like pear Jam, lemon squash, tomato puree and tomato ketchup. The detailed recipes regarding preparation of fruit chutney and various types of pickles were also shared with the farm women **(No. of Participants = 31)**

4. **Badiyara, Chirgaon District Shimla from 23.03.2022 to 25.03.2022:** During the three days training program technical session regarding the preparation of various processed products like apple jam, lemon squash, tomato puree and tomato ketchup were organized. The detailed knowledge about the functional and nutritional aspects was also shared with the participants during the camp (**No. of Participants = 31)**.

Exposure visit

During 2021-2022, 9.02.2022 to 11.02.2022 conducted one number of three day farmer local visit at UHF Nauni. (**No. of Participants = 30)**.

Detail of trainings conducted under the project during 2021-2022- KVK Chanba

1. **Kandi, District Chamba from 15.02.2022 to 17.02.2022:** During the three days training program technical session regarding the preparation of various processed products like apple jam, tomato puree and tomato ketchup were organized. The detailed knowledge about the functional and nutritional aspects was also shared with the participants during the camp (**No. of Participants = 30)**.
2. **Jhummar, District Chamba from 18.02.2022 to 20.02.2022:** The three-day training program was organized for the farm women regarding the preparation of processed products from locally available fruits and vegetables like pear jam, pear chutney, apple rings, tomato puree and tomato ketchup. The awareness about the functional aspects of foods was created among the participants during the camp (**No. of Participants = 30)**
3. **Kiri, District Chamba from 21.02.2022 to 23.02.2022:** The trainees were provided know-how about the procedure of preparation of various functional foods and were also taught about incorporating functional foods in their regular diet. The processed products like Apple jam, apple murraba, tomato ketchup and mixed vegetable pickles were prepared from locally grown fruits and vegetables. **(No. of Participants = 30)**

4. **Dulla, District Chamba from 24.02.2022 to 26.02.2022:** During the three days training program technical session regarding the preparation of various processed products like apple jam, tomato puree and tomato ketchup were organized. The

detailed knowledge about the functional and nutritional aspects was also shared with the participants during the camp (**No. of Participants = 30)**.

5. **Bhedog, District Chamba from 27.02.2022 to 01.03.2022:** The trainees were provided know-how about the procedure of preparation of various functional foods and were also taught about incorporating functional foods in their regular diet. The processed products like Apple jam, apple murraba, tomato ketchup and mixed vegetable pickles were prepared from locally grown fruits and vegetables. **(No. of Participants = 30)**
6. **Paleur, District Chamba from 02.03.2022 to 04.03.2022:** During the three days training program technical session regarding the preparation of various processed products like apple jam, tomato puree and tomato ketchup were organized. The detailed knowledge about the functional and nutritional aspects was also shared with the participants during the camp (**No. of Participants = 30)**.

7. **Sahoo, District Chamba from 05.03.2022 to 07.03.2022:** The three-day training program was organized for the farm women regarding the preparation of processed products from locally available fruits and vegetables like pear jam, pear chutney, apple rings, tomato puree and tomato ketchup. The awareness about the functional aspects of foods was created among the participants during the camp (**No. of Participants = 30)**.
8. **Oberi, District Chamba from 08.03.2022 to 10.03.2022:** The trainees were provided know-how about the procedure of preparation of various functional foods and were also taught about incorporating functional foods in their regular diet. The processed products like Apple jam, apple murraba, tomato ketchup and mixed vegetable pickles were prepared from locally grown fruits and vegetables. **(No. of Participants = 30)**
9. **Panjeela, District Chamba from 11.03.2022 to 13.03.2022:** The three-day training program was organized for the farm women regarding the preparation of processed products from locally available fruits and vegetables like pear jam, pear chutney, apple rings, tomato puree and tomato ketchup. The awareness about the functional aspects of foods was created among the participants during the camp (**No. of Participants = 30)**.
10. **Sarol, District Chamba from 14.03.2022 to 16.03.2022:** During the three days training program technical session regarding the preparation of various processed products like apple jam, tomato puree and tomato ketchup were organized. The detailed knowledge about the functional and nutritional aspects was also shared with the participants during the camp (**No. of Participants = 30)**.

Detail of trainings conducted under the project during 2021-2022 at Lahaul and Spiti

1. **Kaza, District Lahaul and Spiti from 12.04.2021 to 14.04.2021**: During the three days training program technical session regarding the preparation of various processed products like apple jam, lemon squash, tomato puree and tomato ketchup were organized. The detailed knowledge about the functional and nutritional aspects was also shared with the participants during the camp (**No. of Participants = 25)**.

2. **Hikkim, District Lahaul and Spiti from 15.07.2021 to 17.07.2021:** Three days training was organized for the farm women regarding the preparation of various processed products from locally available fruits and vegetables like pear Jam, lemon squash, tomato puree and tomato ketchup. The detailed recipes regarding preparation of fruit chutney and various types of pickles were also shared with the farm women (**No. of Participants = 25)**.

3. **Lanza, District Lahaul and Spiti from 30.07.2021 to 01.08.2021**: During the three days training program technical session regarding the preparation of various processed products like apple jam, lemon squash, tomato puree and tomato ketchup were organized. The detailed knowledge about the functional and nutritional aspects was also shared with the participants during the camp (**No. of Participants = 25)**.
4. **Schiling, District Lahaul and Spiti from 14.08.2021 to 16.08.2021:** Three days training was organized for the farm women regarding the preparation of various processed products from locally available fruits and vegetables like pear Jam, lemon squash, tomato puree and tomato ketchup. The detailed recipes regarding preparation of fruit chutney and various types of pickles were also shared with the farm women (**No. of Participants = 25)**.

5. **Tabo, District Lahaul and Spiti from 29.11.2021 to 01.12.2021:** During the three days training program technical session regarding the preparation of various processed products like apple jam, lemon squash, tomato puree and tomato ketchup were organized. The detailed knowledge about the functional and nutritional aspects was also shared with the participants during the camp (**No. of Participants = 25)**.

Exposure Visit

1. During 2021-22, 19th December to 27th December,2021 conducted one number of nine day farmer local visit at UHF Nauni, DMR Chambaghat, KVK Kandaghat and various department and farms at CSKHPKV Palampur and food processing plant Nagrota Baghwan**. (No. of Participants = 15)**
2. During 2021-22,12th February to 20th February 2022 conducted one number of nine day farmer local visit at UHF Nauni, DMR Chambaghat, KVK Kandaghat and various department and farms at CSKHPKV Palampur and food processing plant Nagrota Baghwan. **(No. of Participants = 15).**

Detail of trainings conducted under the project

(2019-2022)

03 days training camps organized at different locations of Himachal Pradesh under the project "Establishment of functional foods R&D Centre and dissemination of the developed technology for the livelihood, nutritional security and entrepreneurship of the farm women of HP

1. **Shudarang, District Kinnaur from 05/08/19 to 07/08/19:** The trainees were provided with the literature comprising of pamphlets/booklets containing procedure of various functional foods and were also taught about incorporating functional foods in their regular diet. The processed products like apple jam, apple murraba, tomato ketchup, Barley (Sattu) cake and laddoo were prepared from locally grown fruits vegetables and cereals. **(No. of Participants = 30)**

2. **Kalpa, District Kinnaur from 12/08/19 to 14/08/19:** The trainees were provided with pamphlets/booklets containing procedure of various functional foods and were also taught about the benefits of functional foods and encouraged for enterprising on small scales. The processed products were prepared from locally grown fruits and vegetables like tomato ketchup, apple *chutney,* mixed pickle, cauliflower preserve and sauerkraut. All the trainees showed keen interest during the preparation of products and also helped along. **(No. of Participants = 30)**

3. **Khawangi, District Kinnaur from 29/08/19 to 31/08/19:** The trainees were provided know-how about the procedure of preparation of various functional foods and were also taught about incorporating functional foods in their regular diet. The processed products like Apple jam, apple murraba, tomato ketchup and mixed vegetable pickles were prepared from locally grown fruits and vegetables. **(No. of Participants = 30)**

4. **Roghi, District Kinnaur from 07/09/20 to 09/09/20:** During the three days training program technical session regarding the preparation of various processed products like apple jam, tomato puree and tomato ketchup were organized. The detailed knowledge about the functional and nutritional aspects was also shared with the participants during the camp (**No. of Participants = 10)**.

5. **Pangi, District Kinnaur from 03/12/20 to 05/12/20:** The three-day training program was organized for the farm women regarding the preparation of processed products from locally available fruits and vegetables like pear jam, pear chutney, apple rings, tomato puree and tomato ketchup. The awareness about the functional aspects of foods was created among the participants during the camp (**No. of Participants = 30)**.

6. **Powari, District Kinnaur from 07/12/20 to 09/12/20:** The trainees were provided with pamphlets/booklets containing procedure of various functional foods and were also taught about the benefits of functional foods and encouraged for enterprising on small scales. The processed products were prepared from locally grown fruits and vegetables like tomato ketchup, apple *chutney,* mixed pickle, cauliflower preserve and sauerkraut. All the trainees showed keen interest during the preparation of products and also helped along. **(No. of Participants = 30)**

7. **Sapni, District Kinnaur from 10/12/20 to 12/12/20:** The trainees were provided know-how about the procedure of preparation of various functional foods and were also taught about incorporating functional foods in their regular diet. The processed products like Apple jam, apple murraba, tomato ketchup and mixed vegetable pickles were prepared from locally grown fruits and vegetables. **(No. of Participants = 30)**

8. **Kamroo, District Kinnaur from 14/12/20 to 16/12/20:** The trainees were provided know-how about the procedure of preparation of various functional foods and were also taught about incorporating functional foods in their regular diet. The processed products like Apple jam, apple murraba, tomato ketchup and mixed vegetable pickles were prepared from locally grown fruits and vegetables. **(No. of Participants = 30)**

9. **Urni, District Kinnaur from 17/12/20 to 19/12/20:** The trainees were provided with pamphlets/booklets containing procedure of various functional foods and were also taught about the benefits of functional foods and encouraged for enterprising on small scales. The processed products were prepared from locally grown fruits and vegetables like tomato ketchup, apple *chutney,* mixed pickle, cauliflower preserve and sauerkraut. All the trainees showed keen interest during the preparation of products and also helped along. **(No. of Participants = 30)**

10. **Kothi, District Kinnaur from 21/12/20 to 23/12/20:** The trainees were provided know-how about the procedure of preparation of various functional foods and were also taught about incorporating functional foods in their regular diet. The processed products like Apple jam, apple murraba, tomato ketchup and mixed vegetable pickles were prepared from locally grown fruits and vegetables. **(No. of Participants = 30)**

11. **Ribba, District Kinnaur from 22/02/21 to 24/02/21:** The trainees were provided know-how about the procedure of preparation of various functional foods and were also taught about incorporating functional foods in their regular diet. The processed products like Apple jam, apple murraba, tomato ketchup and mixed vegetable pickles were prepared from locally grown fruits and vegetables. **(No. of Participants = 30)**

12. **Kalpa, District Kinnaur from 25/02/21 to 27/02/21:** The trainees were provided with pamphlets/booklets containing procedure of various functional foods and were also taught about the benefits of functional foods and encouraged for enterprising on small scales. The processed products were prepared from locally grown fruits and vegetables like tomato ketchup, apple *chutney,* mixed pickle, cauliflower preserve and sauerkraut. All the trainees showed keen interest during the preparation of products and also helped along. **(No. of Participants = 30)**

13. **Duni, District Kinnaur from 15/03/21 to 17/03/21:** The trainees were provided know-how about the procedure of preparation of various functional foods and were also taught about incorporating functional foods in their regular diet. The processed products like Apple jam, apple murraba, tomato ketchup and mixed vegetable pickles were prepared from locally grown fruits and vegetables. **(No. of Participants = 30)**

14. **Jangi, District Kinnaur from 18/03/21 to 20/03/21:** The trainees were provided know-how about the procedure of preparation of various functional foods and were also taught about incorporating functional foods in their regular diet. The processed

products like Apple jam, apple murraba, tomato ketchup and mixed vegetable pickles were prepared from locally grown fruits and vegetables. **(No. of Participants = 30)**

15. **Lippa, District Kinnaur from 18/03/21 to 20/03/21:** The three-day training program was organized for the farm women regarding the preparation of processed products from locally available fruits and vegetables like pear jam, pear chutney, apple rings, tomato puree and tomato ketchup. The awareness about the functional aspects of foods was created among the participants during the camp (**No. of Participants = 30)**.

16. **Rispa, District Kinnaur from 22/03/21 to 24/03/21:** The trainees were provided know-how about the procedure of preparation of various functional foods and were also taught about incorporating functional foods in their regular diet. The processed products like Apple jam, apple murraba, tomato ketchup and mixed vegetable pickles were prepared from locally grown fruits and vegetables. **(No. of Participants = 30)**

17. **Rarang, District Kinnaur from 22/03/21 to 24/03/21:** The three-day training program was organized for the farm women regarding the preparation of processed products from locally available fruits and vegetables like pear jam, pear chutney, apple rings, tomato puree and tomato ketchup. The awareness about the functional aspects of foods was created among the participants during the camp (**No. of Participants = 30)**.

18. **Kafnoo, District Kinnaur from 25/03/21 to 27/03/21:** The trainees were provided know-how about the procedure of preparation of various functional foods and were also taught about incorporating functional foods in their regular diet. The processed products like Apple jam, apple murraba, tomato ketchup and mixed vegetable pickles were prepared from locally grown fruits and vegetables. **(No. of Participants = 30)**

19. **Katgaon, District Kinnaur from 25/03/21 to 27/03/21:** The three-day training program was organized for the farm women regarding the preparation of processed products from locally available fruits and vegetables like pear jam, pear chutney, apple rings, tomato puree and tomato ketchup. The awareness about the functional aspects of foods was created among the participants during the camp (**No. of Participants = 30)**.

20. **Mebar, District Kinnaur from 03/03/22 to 05/03/22:** The trainees were provided know-how about the procedure of preparation of various functional foods and were also taught about incorporating functional foods in their regular diet. The processed products like Apple jam, apple murraba, tomato ketchup and mixed vegetable pickles were prepared from locally grown fruits and vegetables. **(No. of Participants = 30**

21. **Brua, District Kinnaur from 03/03/22 to 05/03/22:** The trainees were provided with pamphlets/booklets containing procedure of various functional foods and were also taught about the benefits of functional foods and encouraged for enterprising on small scales. The processed products were prepared from locally grown fruits and vegetables like tomato ketchup, apple *chutney,* mixed pickle, cauliflower preserve and sauerkraut. All the trainees showed keen interest during the preparation of products and also helped along. **(No. of Participants = 30)**

22. **Bari , District Kinnaur from 06/03/22 to 08/03/22:** The three-day training program was organized for the farm women regarding the preparation of processed products

from locally available fruits and vegetables like pear jam, pear chutney, apple rings, tomato puree and tomato ketchup. The awareness about the functional aspects of foods was created among the participants during the camp. **(No. of Participants = 30)**

23. **Ponda, District Kinnaur from 06/03/22 to 08/03/22:** The trainees were provided with pamphlets/booklets containing procedure of various functional foods and were also taught about the benefits of functional foods and encouraged for enterprising on small scales. The processed products were prepared from locally grown fruits and vegetables like tomato ketchup, apple *chutney,* mixed pickle, cauliflower preserve and sauerkraut. All the trainees showed keen interest during the preparation of products and also helped along. **(No. of Participants = 30)**

24. **Spillo, District Kinnaur from 09/03/22 to 11/03/22:** The trainees were provided know-how about the procedure of preparation of various functional foods and were also taught about incorporating functional foods in their regular diet. The processed products like Apple jam, apple murraba, tomato ketchup and mixed vegetable pickles were prepared from locally grown fruits and vegetables. **(No. of Participants = 30)**

25. **Kanam- I, District Kinnaur from 09/03/22 to 11/03/22:** During the three days training program technical session regarding the preparation of various processed products like apple jam, tomato puree and tomato ketchup were organized. The detailed knowledge about the functional and nutritional aspects was also shared with the participants during the camp (**No. of Participants = 30)**.

26. **Kanam- II, District Kinnaur from 12/03/22 to 14/03/22:** The trainees were provided with pamphlets/booklets containing procedure of various functional foods and were also taught about the benefits of functional foods and encouraged for enterprising on small scales. The processed products were prepared from locally grown fruits and vegetables like tomato ketchup, apple *chutney,* mixed pickle, cauliflower preserve and sauerkraut. All the trainees showed keen interest during the preparation of products and also helped along. **(No. of Participants = 30)**

27. **Yangpa- I, District Kinnaur from 14/03/22 to 16/03/22:** The three-day training program was organized for the farm women regarding the preparation of processed products from locally available fruits and vegetables like pear jam, pear chutney, apple rings, tomato puree and tomato ketchup. The awareness about the functional aspects of foods was created among the participants during the camp (**No. of Participants = 30)**.

28. **Huri, District Kinnaur from 17/03/22 to 19/03/22:** The trainees were provided know-how about the procedure of preparation of various functional foods and were also taught about incorporating functional foods in their regular diet. The processed products like Apple jam, apple murraba, tomato ketchup and mixed vegetable pickles were prepared from locally grown fruits and vegetables. **(No. of Participants = 30)**

29. **Rakhcham, District Kinnaur from 22/03/22 to 24/03/22:** During the three days training program technical session regarding the preparation of various processed products like apple jam, tomato puree and tomato ketchup were organized. The detailed knowledge about the functional and nutritional aspects was also shared with the participants during the camp (**No. of Participants = 30)**.

30. **Chansu, District Kinnaur from 22/03/22 to 24/03/22:** The trainees were provided with pamphlets/booklets containing procedure of various functional foods and were also taught about the benefits of functional foods and encouraged for enterprising on small scales. The processed products were prepared from locally grown fruits and vegetables like tomato ketchup, apple *chutney,* mixed pickle, cauliflower preserve and sauerkraut. All the trainees showed keen interest during the preparation of products and also helped along. **(No. of Participants = 30)**

31. **Moorang, District Kinnaur from 25/03/22 to 27/03/22:** The three-day training program was organized for the farm women regarding the preparation of processed products from locally available fruits and vegetables like pear jam, pear chutney, apple rings, tomato puree and tomato ketchup. The awareness about the functional aspects of foods was created among the participants during the camp (**No. of Participants = 30)**.

32. **Sunnam-I (Gompha), District Kinnaur from 25/03/22 to 27/03/22:** During the three days training program technical session regarding the preparation of various processed products like apple jam, tomato puree and tomato ketchup were organized. The detailed knowledge about the functional and nutritional aspects was also shared with the participants during the camp (**No. of Participants = 30)**.

33. **Sunnam-II (Khargyab), District Kinnaur from 25/03/22 to 27/03/22:** The trainees were provided know-how about the procedure of preparation of various functional foods and were also taught about incorporating functional foods in their regular diet. The processed products like Apple jam, apple murraba, tomato ketchup and mixed vegetable pickles were prepared from locally grown fruits and vegetables. **(No. of Participants = 30)**

34. **Majhgaon (Ruppi), District Kinnaur from 28/03/22 to 30/03/22:** The three-day training program was organized for the farm women regarding the preparation of processed products from locally available fruits and vegetables like pear jam, pear chutney, apple rings, tomato puree and tomato ketchup. The awareness about the functional aspects of foods was created among the participants during the camp (**No. of Participants = 30)**.

35. **Shigarcha (Ruppi), District Kinnaur from 28/03/22 to 30/03/22: :** During the three days training program technical session regarding the preparation of various processed products like apple jam, tomato puree and tomato ketchup were organized. The detailed knowledge about the functional and nutritional aspects was also shared with the participants during the camp (**No. of Participants = 30)**.


फंक्शनल खाद्य पदार्थ बनाने हेतु किसान महिलाओं
के लिए प्रशिक्षण शिविर
कृषि विज्ञान केन्द्र, शारदो (किन्नौर)
एवं
खाद्य विज्ञान एवं प्रौद्योगिकी विभाग






ACKNOWLEDGMENTS

We acknowledge the financial support of National Mission on Himalayan Studies for smooth running and successful completion of the project, “Establishment of functional foods R&D Centre and dissemination of the developed technology for the livelihood, nutritional security and entrepreneurship of the farm women of Himachal Pradesh”. We would also like to acknowledge the infrastructural, technical and scientific support provided by Dr YS Parmar University of Horticulture and Forestry, Nauni- Solan (HP) and various KVKs of the University for effective Implementation and dissemination of the technologies. The facilities provided by the State Horticulture and Agriculture Departments are also acknowledged.

We would like to express our heart full gratitude to Dr Rakesh Sharma, Associate Professor, Department of Food Science and Technology, Dr YS Parmar University of Horticulture and Forestry, Nauni- Solan (HP) for his services to compile the Final Technical Report of the project.

Principal Investigator

Annexure-I & II

Consolidated and Audited Utilization Certificate (UC) and Statement of Expenditure (SE)

NATIONAL MISSION ON HIMALYAN STUDIES (GBPNIHESD)
FORM GFR 12 – A
[(See Rule 238 (1)]

UTILIZATION CERTIFICATE FOR THE YEAR 2021-22 (1st April, 2021 – 31stMarch, 2022)
in respect of Recurring and Non- Recurring Grants

1. Name of the Project/Fellowships : **Establishment of functional foods R&D Centre and dissemination of the developed technology for the livelihood, nutritional security and entrepreneurship of the farm women of Himachal Pradesh (NMH-006-05 -58-59-60-72)**

2. Whether recurring grant : Yes

3. Name of the Grantee Org. : Department of Food Science & Technology, Dr Y S Parmar University of Horticulture & Forestry Nauni- Solan (Himachal Pradesh)-India

4. Grants position at the beginning of the financial year:
   (i) Cash in Hand/Bank : Rs. 5,96,943.00
   (ii) Unadjusted advances : Rs. 0.00
   (iii) Total : Rs. . 5,96,943.00

5. Detail of grants received, expenditure incurred and closing balances:

Unspent Balances of Grants received years	Interest Earned thereon	Interest deposited back to the Govt.	Grant received during the year			Total Available funds (1+2+3+4)	Expenditure (excluding commitments)	Closing Balances (5-6)
1	2	3	4			5	6	7
5,96,943.00	4381 (w.e.f.01.04. 2021 to 31.03.2022)		No. GBPNI/NMHS-2017-18/MG-08/550/42/106/113/329/389/464/348/26/-179	01.11.2021	32,01,645.00			
5,96,943.00	4381				**3201645**	38,02,969.00	16,95,492.00	21,07,477.00

Component wise utilization of grants:

Grant-in-aid– General	Grant-in-aid– Salary	Grant-in-aid–creation of capital assets	Total
16,80,459.00	15033.00		16,95,492.00

Details of grants position as on 31stMarch, 2022
(i) Cash in Hand/Bank : Rs.**21,07,477.00**
(ii) Unadjusted Advances : 0.00
(iii) Total : Rs. **21,07,477.00**

Cont.....2

Certified that I have satisfied myself that the conditions on which grants were sanctioned have been duly fulfilled/are being fulfilled and that I have exercised following checks to see that the money has been actually utilized for the purpose for which it was sanctioned:

(i) The main accounts and other subsidiary accounts and registers (including assets registers) are maintained as prescribed in the relevant Act/Rules/Standing instructions (mention the Act/Rules) and have been duly audited by designated auditors. The figures depicted above tally with the audited figures mentioned in financial statements/accounts.

(ii) There exist internal controls for safeguarding public funds/assets, watching outcomes and achievements of physical targets against the financial inputs, ensuring quality in asset creation etc. & the periodic evaluation of internal controls is exercised to ensure their effectiveness.

(iii) To the best of our knowledge and belief, no transactions have been entered that are in violation of relevant Act/Rules/standing instructions and scheme guidelines.

(iv) The responsibilities among the key functionaries for execution of the scheme have been assigned in clear terms and are not general in nature.

(v) The benefits were extended to the intended beneficiaries and only such areas/districts were covered where the scheme was intended to operate.

(vi) The expenditure on various components of the scheme was in the proportions authorized as per the scheme guidelines and terms and conditions of the grants-in-aid.

(vii) It has been ensured that the physical and financial performance under has been according to the requirements, as prescribed in the guidelines issued by Govt. of India and the performance/targets achieved statement for the year to which the utilization of the fund resulted in outcomes given at Annexure – I duly enclosed.

(viii) The utilization of the fund resulted in outcomes given at Annexure – II duly enclosed (to be formulated by the Ministry/ Department concerned as per their requirements/ specifications.)

(ix) Details of various schemes executed by the agency through grants-in-aid received from the same Ministry or from other Ministries is enclosed at Annexure –II (to be formulated by the Ministry/Department concerned as per their requirements/ specifications).

Date:.....
Place : Nauni

Signature
Name:
PI

Signature
Name:
Finance Officer

Signature
Name:
Head of the Organization

Director of Research
Dr. YS Parmar University of Horticulture & Forestry
Nauni, Solan-173230

Joint Controller (Audit)
HP State Audit Department
Resident Audit Scheme
Dr Y S Parmar UHF,
Nauni-Solan (HP) 173230

EXPENDITUE STATEMENT
NATIONAL MISSION ON HIMALAYAN STUDIES

Statement showing the expenditure of the period from : 1st April, 2021 to 31March, 2022
Sanction No. & Date : GBPNI/NMHS-2017-18/MG-08/550 Dated: 26.02.2018
1. Total outlay of the project/Fellowship : Rs. 1, 48, 85,680.00
2. Date of Start of the Project/fellowship : 26/05/2018
3. Duration : 3 years
4. Date of Completion : 30-11-2021
a) Amount received during the financial year : Rs. 3201645
b) Unspent amount carried forward from pervious Financial year : Rs. 596943
Accrued bank Interest : Rs. 4381
c) Total amount available for Expenditure (a+b) : Rs. 3802969

Sr. No	Budget head	Amount Carried forward (Rs.)	Amount received (Rs.)	Amount received + amount carried forward (Rs.)	Expenditure (Rs.)	Amount Balance/ excess expenditure (Rs.)
1	Salaries	-52830	1490724	1437894	15033	1422861
2	Permanent Equipment Purchased (Item-wise	208	0.00	208		208
3	Travel	345078	167992	513070	189203	323867
4	Consumables	0	33750	33750	32861	889
5	Contingency	2355	67264	69619	69145	474
6	Activities	161600	1441915	1603515	1389250	214265
7	Institutional charges	0	0	0	0	0
8	Accrued bank Interest	140532	4381	144913	0	144913
9	Total	596943	3206026	3802969	16,95,492	2107477
10	Amount to be Refunded to funding agency					2107477

Certified that the expenditure of Rs.16,95,492/-[Rupees sixteen lakh ninety five thousand four hundred ninety two] only mentioned against Sl, No.9 was actually incurred on the project/ scheme for the purpose it was sanctioned.
Date:

Principal Investigator
NMH-006-05
Department of [illegible] and Technology
Dr. YS Parmar University of Horticulture and
Forestry Nauni, Solan (HP)

(Signature of Principal Investigator)

Comptroller,
Dr. YS Parmar University of
Horticulture & Forestry,
Nauni, Solan-173230

(Signature of Registrar/ Finance Officer)

Director of Research
Dr. YS Parmar University of
Horticulture & Forestry
Nauni, Solan-173230

(Signature of Head of the Organization)

ACCEPTED AND COUNTERSIGNED
Date

COMPETENT AUTHORITY

for Joint Controller (Audit)
HP State Audit Department
Resident Audit Scheme
Dr Y S Parmar UHF,
Nauni-Solan (HP) 173230

Annexure-III

List or Inventory of Assets/ Equipment/ Peripherals

Sr No	Name of equipment	Quantity	Sanctioned cost	Actual purchased cost	Purchase detail
1	Test Sieves 170 mesh 200 mesh 240 mesh 13-30 mesh	 1 No 1 No 1 No 2 No	885/ 972/- 1062/ 1600/- 80/- 1400/-	 855/- 972/- 1062/- 1600/- -80/- +1440/- Include sgst/cgst	Invoice No LB 1153 dt 31-10-2018 from M/s Labrex biological Near Employment Exchange, The Mall Solan. -do -do Invoice No 034 dt 30-07-19 from M/s Biomedia , Scientific and Surgical, Shamti, Solan
2	Portable Water Purification system UV+ UF	5 No	8999/-	44995/- Included SGST/CGST	Invoice no 3342 dt 22-11-18 from M/s Vinod Trading company swami Daya Nand marg Sri Ganganager Rajasthan
3	IFB Microwave oven Grill, And convection 25 BC 4 black Body	5 No	13311/-	66555/- Included SGST/CGST	Invoice No 894 dt 18-12-18 from GeM Indu furniture Rajgarh Anand complex near SBI Road Solan
4	HP Desk Top 280 G4 MT HP V203 Monitor	1 No 1 No	54660/17 5508.47	54660.17 60168.64 70998.82 Include SGST/CGST	Invoice no SDC/ RMP/1819-1049 dt 9-01-19 Satluj Dacoment company Rampur Distric Shimla HP
5	Godrej RT EON 260 P2.4 Frost Free Refrigerator 255 Lt	5 No	21830/	1,09,150/- Include SGST/CGST	Invoice no 916 dt 2-01-29 from Gem Indu furniture NCC Rajgarh Solan
6	HP Laserjet Printer M1005	1 No	16097/46	18995/- Include SGST/CGST	Invoice no RNPL/18-19/1566 dt 21-12-2018 Raman Network PVT. New sona sweet 55 Nehru place New Delhi
7	Ultrasonic Bath 6 Lt	1 No	26999/	26999/- Include SGST/CGST-	Invoice No GST/2018-19/593 dt 24-12-2018 Raman Network PVT. New sona sweet 55 Nehru place New Delhi
8	Weighing Balance SEC 204 Weighing balance biogen	1 no 5 No	42203/- 5523/80	49800/- Inclued SGST/CGST 29000/-	Invoice no IGL- 138/2018-19 dt 27-12-2018 from M/s Igene lebser PVT Subhash Nagar , New Delhi

	Small			28999.95 Or 29000/- Include SGST/CGST	Invoice No BGS-18-19/120 dt 28-03-2019 from M/s Igene lebser PVT Subhash Nagar , New Delhi
9	8504 UPS Microtek 1 KVA APC 2.0 KVA Online UPS with battery	1 No 1 No	6271/19 73136/44	7400/- Include IGST- 86301/- Include SGST/IGST	Invoice no RNPL/18-19/1579 dt 24-12-2018 Raman Network PVT. New sona sweet 55 Nehru place New Delhi Invoice no SD/RMP/18-19/1088 dt 21-01.2018 from M/S Satluj Doucument Company
10	Heat pillars (Belco)	5 No	3150/-	15750/- Include sgst/cgst	Invoice no 990 dt 5-03-2019 from M/S Satluj Doucument Company
11	Stapler DS-23S24 FL	1 No	1790/-	1790/- Inclued sgst/cgst	Invoice no 817 dt 7-03-2019 from M/s Deep Enterprises, Manohar Complex, Nauni, Solan
12	Utility Knife	5 set (6 each)	340/-	1700/-	Invoice No SLGST37027 dated 27-02-2019 from M/s Ganpati Departmental Store, Solan
13	Apple Cutter(Slicer with circular cutting knife	5 No	135/-	675/-	Invoice no SLGST-37027 dated 27-02-2019 from M/s Ganpati Departmental Store, Solan
14	Chop Board AJ 18”x12”	5 No	750/-	3750/-	Invoice no SLGST-37027 dated 27-02-2019 from M/s Ganpati Departmental Store, Solan
15	Patila Flate 4 kg cap	5 No	425/-	2225/-	Invoice no SLGST-37027 dated 27-02-2019 from M/s Ganpati Departmental Store, Solan
16	Patila Flat 6 kg capacity	5 No	480/-	2400/-	Invoice no SLGST-37027 dated 27-02-2019 from M/s Ganpati Departmental Store, Solan
17	Patila S Bott 8 kg cap	5 No	1250/-	6250/-	Invoice no SLGST-37027 dated 27-02-2019 from M/s Ganpati Departmental Store, Solan
18	Ladle(Kadchhi) Large	5No	65/-	650/-	Invoice no SLGST-37027 dated 27-02-2019 from M/s Ganpati Departmental Store, Solan
19	Thantha Light (SS Palta)	5 No	65/-	325/-	Invoice no SLGST-37027 dated 27-02-2019 from M/s Ganpati Departmental Store, Solan
20	Jharni Light (Pony)	10 No	55/-	550/-	Invoice no SLGST-37027 dated 27-02-2019 from M/s Ganpati Departmental Store, Solan
21	Parat SS 22 G	10 No	440/-	4400/-	Invoice no SLGST-37027

					dated 27-02-2019 from M/s Ganpati Departmental Store, Solan
22	Kadukas Super	5 No	105/-	525/-	Invoice no SLGST-37027 dated 27-02-2019 from M/s Ganpati Departmental Store, Solan
23	Pressure Cooker 5 Lt	5 No	2720/-	13600/-	Invoice no SLGST-37027 dated 27-02-2019 from M/s Ganpati Departmental Store, Solan
24	SS Pressure 10 Lt Pressure Cooker 10 Lt	4 No 1 No	4335/- 4335/-	17340/- 4335/-	Invoice no SLGST-37027 dated 27-02-2019 from M/s Ganpati Departmental Store, Solan
25	Soup strainer SS	5 No	220/-	1100/-	Invoice no SLGST-37027 dated 27-02-2019 from M/s Ganpati Departmental Store, Solan
26	Sidu maker (steam Blancher)	5 No	925/-	4625/-	Invoice no SLGST-37027 dated 27-02-2019 from M/s Ganpati Departmental Store, Solan Invoice no SLGST-37027 dated 27-02-2019 from M/s Ganpati Departmental Store, Solan
27	Orange Sqeeze (Citrus juice extractor)	1 No	1520/-	1520/-	Invoice no SLGST-37027 dated 27-02-2019 from M/s Ganpati Departmental Store, Solan
28	Hand Juicer	5 No	370/-	1850/-	Invoice no SLGST-37027 dated 27-02-2019 from M/s Ganpati Departmental Store, Solan
29	Tray SS	2 No 3N0	450/- 450/-	900/- 1350/-	Invoice no SLGST-37027 dated 27-02-2019 from M/s Ganpati Departmental Store, Solan
30	Tray (plastic 16”)	5 No	225/-	1125/-	Invoice no SLGST-37027 dated 27-02-2019 from M/s Ganpati Departmental Store, Solan
31	Glass (juice glasses)	20 No	345/-	6900/-	Invoice no SLGST-37027 dated 27-02-2019 from M/s Ganpati Departmental Store, Solan
32	Desert Spoon	10 No	120/-	1200/-	Invoice no SLGST-37027 dated 27-02-2019 from M/s Ganpati Departmental Store, Solan
33	Karahi PLN AL with cover	5 No	585/-	2925/-	Invoice no SLGST-37027 dated 27-02-2019 from M/s Ganpati Departmental Store, Solan
34	Plate Round 6	5 No(set)	410/-	2050/-	Invoice no SLGST-37027 dated 27-02-2019 from M/s Ganpati Departmental Store, Solan
35	Soup bowl	10	130/-	1300/-	Invoice no SLGST-37027

	(acrylic)	No(set)			dated 27-02-2019 from M/s Ganpati Departmental Store, Solan
36	Plastic Bucket 18 Lt	5 No	260/-	1300/-	Invoice no SLGST-37027 dated 27-02-2019 from M/s Ganpati Departmental Store, Solan
37	Balti SS	5 No	500/-	2500/-	Invoice no SLGST-37027 dated 27-02-2019 from M/s Ganpati Departmental Store, Solan
38	Jug Classic 2 Lt	5No	670/-	3350/-	Invoice no SLGST-37027 dated 27-02-2019 from M/s Ganpati Departmental Store, Solan
39	Sauce pan with lid (3-4 Lt)	10No	700/-	7000/-	Invoice no SLGST-37027 dated 27-02-2019 from M/s Ganpati Departmental Store, Solan
40	Chilmachi (SS Tub) 6-7 Lt cap	5 No	260/-	1300/-	Invoice no SLGST-37027 dated 27-02-2019 from M/s Ganpati Departmental Store, Solan
41	Drum (Plastic barrels) 19-20 Lt	20 No	330/-	6600/-	Invoice no SLGST-37027 dated 27-02-2019 from M/s Ganpati Departmental Store, Solan
42	Hand Blender	5 No	2275/-	11375/-	Invoice no SLGST-37027 dated 27-02-2019 from M/s Ganpati Departmental Store, Solan
43	Mixer and Grinder	4 No	3200/-	12800/-	Invoice no SLGST-37027 dated 27-02-2019 from M/s Ganpati Departmental Store, Solan
44	Water Dispenser	5 No	2370/--	11850/-	Invoice no SLGST-37027 dated 27-02-2019 from M/s Ganpati Departmental Store, Solan
45	Magna Plus(Hot Plate)	5 No	3500/-	17500/-	Invoice no SLGST-37027 dated 27-02-2019 from M/s Ganpati Departmental Store, Solan
46	Pedal bin Large	5 No	265/-	1325/-	Invoice no SLGST-37027 dated 27-02-2019 from M/s Ganpati Departmental Store, Solan
47	Apron Printed	10 No	165/-	1650/-	
48	Fry pan IB	5 No	1325/-	6625/-	Invoice no SLGST-37027 dated 27-02-2019 from M/s Ganpati Departmental Store, Solan
49	LI-2800 Spectrophotometer	1 No	192805/-	2,27,510.00 Inclueds gst/igst	Invoice no IGL-12/2019-20 dated 02-05-2019 from M/s
50	Refractometer	1 Set	6600/-	7,392.00 Include sgst/sgst	Invoice No.81 dt 18-07-2019 from Sandeep Instruments and chemicals 69-Pocket C-7

					Sec-7 Rohini, New Delhi
51	Wet Grinder	5 No	8482/14	47,500.00 Include sgst/igst	Invoice No EXR/2019-20071 dt 31-07-2019 from Exergy 360, D-113 Greenwood city, Near Bagpat Byepass, Godwin Complex, Meerut, 250002UP
52	Cork Borer	1 No(12 patterns)	2700/-	2,700.00	Invoice No 034 dt 30-07-2019 from Bio media Scientific and surgical PO Shamti, Solan
53	HPLC –SMC Tray Drive Assembly		153930/- 104239/- -	1,81,637.00 Include sgst/cgst 1,25,462.00 Includes gst/cgst	Invoice No GCH81900823 dt 29-03-2019 from Waters (India) Private Limited , Unit No 514, Block C, Elante Industrial & Business Park Chandigarh -do-
54	HPLC AMSC Fan 487	1N0 1N0	150000/- 2738/-	1,77,000 3344 Includes gst/cgst	-do
55	HPLC Valve, ceramic PKG(2) 1/16 Rotar seal	2N0 1n0	14523/- 26141/-	66,424 Include sgst/cgct	-do-
56	HPLC sunfire		39421/-	47,447 Include sgst/cgst	-do-
57	Double distillation unit All Glass		236666/66	2,48,500 Include sgst/cgst	Invoice No IGL-86/2019-20 dt 03-09-2019 from M/s IGENE LSBSERVE Pvt. Lmt. 16/2, Ground Floor, Front side Mukund Lal Katyal Marg, ashok Nagar , Newa Delhi, 110018
58	Vacuum Packaging Machine	1 No	98495/-	98495 Include sgst/cgst	Invoice no AE/054/2019 dt 04-09 -2019 from Ascencion Electronics , A-75 @nd Floor Dew Delhi 110064
59	Ultra Water Purification System	1 No	400000/-	4,20,000 Include sgst/cgst	Invoice no TSPL/19-20/047 dt 22-12-2019 from Techem Solutions Pvt Lmt 103, First Floor Plot No A/140 Block A, Seactor 63, Noidda, UP 201301
60	Scissor	1no 1 No 1 No	440/68	130.51 111.86 198.31	Invoice no DE/2020-21 /0209 dt 8-07-2020 from M/s Deep Enterprises , Manohar complex Nauni, Solan
61	Stapler HP-45	5 No	201/--	1005\ Include sgst/cgst	Invoice no DE/2020-21/ 0341 dt 20-08-2020 from M/s Deep Enterprises, Manohar Complex, Nauni, Solan
62	Keyboard Mouse combo Kit	1 No	850/-	950 Include sgst/cgst	--do--

63	Baking Oven	5 no	46500/-	2,74,350 Include sgst/cgst	Invoice No 184 dt 29-09-2020 fromM/s Aruna Enterprises Vill Bhanat PO Ghatti Teh and Distt solan
64	Crown corking machine	4no	10250/-	48,380 Include sgst/cgst	Invoice no 1736 dt 7-11-2020 M/s Indu Furnitures NearNCC Office , Rajgarh Road, Solan
65	Vertex Mixer	1 No	11428/-	12,000 Include sgst/cgst	Invoice no EXR/2020-21/017 dt 29-11-2020 from Exergy - 360,D-113, Greeenwood City Near Bagpat Byepass , Godwin Complex, MeerutUP
66	Cake Mould	4 No 4 no	440/- 380/-	820 Include sgst/cgst	Invopice No GS/0000034264 dt 17/02/21 from M/s Ganapati Departmental Store, Solan
67	Digital Clip board	6 no	17100/- 34200/-	51,300	Invoice no 0398 dt 20-3-2021 from M/s Bhhupinder Art Point, Shop No- 2 Oberoi Complex, Shoolini Mata Main Gate, Solan
68	Stabilizer 4.0 KVA	2 No	2203/-	5,200 Include sgst/cgst	Invoice no 1864 dt 20-03-2021 from M/s Indu Furniture Near NCC Office, Solan
69	SS Table 8'"x4"x4	3 No 1 No	40000/- 47,200	1,41,600 Include sgst/cgst 47,200 Include sgst/cgst	Invoice No 1855 dt 15-03-2021 from M/s Indu Furniture, Near NCC Office, Solan Invoice no 1865 dt 20-03-2021 from M/s Indu Furniture , Solan
70	UPS1000KVA	1 No	4788/-	5,650 Include sgst/cgst	Invoice No 35 dated 30-07-2021 from M/s Shyam Kunj, Nagra Road Hathras -726 Bhawan Estate Sinkandrabad Road Agra

(PROJECT INVESTIGATOR)
(Signed and Stamped)

(Head of the Department)
(Signed and Stamped)

(HEAD OF THE INSTITUTION)
(Signed and Stamped)

Annexure-IV

Letter of Head of Institution/Department confirming Transfer of Equipment Purchased under the Project to the Institution/Department

To,

The Convener, Mountain Division
Ministry of Environment, Forest & Climate Change (MoEF&CC)
Indira Paryavaran Bhawan
Jor Bagh, New Delhi-110003

Sub.: Transfer of Permanent Equipment purchased under Research Project titled "Establishment of Functional Foods R&D Centre and Dissemination of the Developed Technology for the Livelihood, Nutritional Security and Entrepreneurship of the Farm Women of Himachal Pradesh" funded under the NMHS Scheme of MoEF&CC – reg.

Sir/ Madam,

This is hereby certified that the following permanent equipments purchased under the aforesaid project have been transferred to the Implementing Organization/ Nodal Institute after completion of the project:

S. No.	Name of Equipments	
1	Weighing Balance Biogen BGS-LB (small)	(5 No.)
2	Spectrophotometer	(1 No.)
3	Prestige Wet Grinder	(5 No.)
4	Double distillation unit All-Glass 2.5 L with Vacuum pump	(1 No.)
5	Vacuum Packaging Machine	(1 No.)
6	Fruit Grating Machine	(4 No.)
7	Pulper	(4 No.)
8	Hydraulic juice press	(4 No.)
9	Hand Refractrometer	(5 No.)
10	Mechanical Dehydrator	(4 No.)
11	HPLC Tray drive assembly	(01 No.)
12	Ultrapure water purification system	(01 No.)
13	Baking Oven	(5 No.)
14	Crown corking machine	(4 No.)
15	Vortex Mixer	(1 No.)
16	Stainless Steel Table (8X4X4)	(4 No.)

Head of the Depatment
Stamp/ Seal: