NMHS-Himalayan Institutional Project Grant

NMHS-FINAL TECHNICAL REPORT (FTR)

NMHS Grant Ref. No.:	NMHS/2018-19/SG51/06

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ENHANCING THE LIVELIHOOD OF FARMERS IN SIKKIM AND DARJEELING HIMALAYAN BELT THROUGH POSSIBLE INTERVENTION IN PROCESSING AND VALUE ADDITION OF UNDERRATED HORTICULTURE AND SPICE CROP

Project Duration: *from* (**01/02/19**) *to* (**31/03/23**).

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DSL: Date of Sanction Letter

2	9	0	1	2	0	1	9
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DPC: Date of Project Completion

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Part A: Project Summary Report

1. Project Description

i.	Project Grant Ref. No.:	NMHS/2018-19/SG51/06
ii.	Project Category:	Small Grant ✓ Medium Grant Large Grant
iii.	Project Title:	Enhancing the Livelihood of Farmers in Sikkim and Darjeeling Himalayan Belt through Possible Intervention in Processing and Value Addition of Underrated Horticulture and Spice Crops
iv.	Project Sites (IHR States/ UTs covered)	Sikkim and West Bengal (Kalimpong area) *Location Maps attached in Appendix 1*
v.	Scale of Project Operation:	Local ✓ Regional Pan-Himalayan
vi.	Total Budget:	₹ 48.93 Lakhs
vii.	Lead Agency:	College of Agricultural Engineering and Post harvest Technology (Central Agricultural University) Ranipool, Sikkim
	Lead PI/ Proponent:	Dr. Sujata Jena Professor & Head Department of Processing and Food Engineering College of Agricultural Engineering and Post-Harvest Technology, Ranipool, Gangtok, Sikkim
	Co-PI/ Proponent:	Dr. Said P. P Assistant Professor Department of Processing and Food Engineering, CAEPHT, Ranipool, Gangtok, Sikkim
viii.	Implementing Partners:	NA
	Key Persons (Contact Details, Ph. No., E-mail):	NA

2. Project Outcomes

2.1. Abstract/ Summary

Background**:** The project was undertaken to develop and popularize small primary processing equipment and technologies for value added products from underrated crops like cherry pepper (*Capsicum annuum var. cerasiforme*) and chayote (*Sechium edule*) which can be adopted by SHGs/ many communities in the rural areas Sikkim and Darjeeling Himalayan Belt for enhancing their livelihood.

Objectives/Aim:

- Determination of socioeconomic status and benchmark survey using participatory rural appraisal approach before and after project work.
- Physico-chemical evaluation of cherry pepper and chayote fruits from different locations.
- Development of small-scale primary processing machines for cherry pepper and chayote fruits.
- Optimization of process technology for value added cherry pepper and chayote fruit products.
- Popularization of developed technologies through extension activities.

Methodology/Approach:

Baseline survey and identification of socio economic status was done through Participatory rural appraisal prior to project work. Total eight villages from Sikkim and two villages from Kalimpong, Darjeeling hills, West Bengal were surveyed for socioeconomic status. Physical and chemical properties viz., pH, TSS, vitamin C content and proximate composition of chayote and cherry pepper collected from different locations were evaluated according to standard methods using standard instruments. The blanching parameters for red cherry pepper was optimized for production of cherry pepper based value added products. Different peeling methods for chayote was tested and compared. Two primary processing equipment viz., hand operated chayote corer and cherry pepper destemmer prototype were designed using CATIA and fabricated. Different value added products viz., Chayote based RTS beverages, Chayote papad, chayote root chips, cherry pepper flakes, powder and chutney powder were developed and evaluated for its physico-chemical and sensory quality. Nine point hedonic scale was used for sensory evaluation of all products developed. Optimization of the developed technologies was carried out based on the qualities studied.

Results/ Outcomes: From the baseline survey of all ten selected villages, majority of the selected population belonged to marginal and small farmers group, maximum of 51.82% belongs to Schedule caste (SC), and about 27.92% (highest) of studied population lie in the income group of ₹10,000 – ₹15,000 per month. The literacy rate of people in the studied project area varied between 60.42% and 89.36%. From ANOVA of chemical properties and proximate composition of chayote, the variation in fat and protein content was found to be non significant where as the variation in all other properties

was significant ($p<0.05$). In case of cherry pepper, significant variation in pH of samples were observed whereas the variation in all other properties were found to be nonsignificant. Out of all the peeling methods, lye (NaOH) peeling of chayote was found to be suitable with highest peeling percentage of 93.44 %, peel loss of 4.20%, unpeeled percentage of 5.78% and peelability of 84.22% at 12 % NaOH concentration, 90°C temperature and 6 minutes time. A prototype of cherry pepper destemming unit with a capacity of 40.2 kg/h was developed and successfully tested. A hand operated chayote corer of capacity 111 kg/h with coring efficiency of about 77% was developed and successfully tested. Optimized process technology for 06 value added products viz., red cherry pepper flakes, red cherry pepper powder, red cherry pepper chutney powder, chayote-mandarin blended RTS beverage, chayote papad and chayote tuber chips were developed. The developed technologies were popularized in the selected villages through various capacity building programs.

Conclusions: A new database on physio-chemical properties of chayote and cherry pepper collected from various locations of Sikkim and Kalimpong area could be generated through the project. Two primary processing equipment and six process technology for different value added products from chayote and cherry pepper could be successfully developed and popularized among women SHG groups.

Recommendations/ Way Forward with Exit Strategy*:* Out of various products developed chayote papad and chayote tuber chips were found to be of promise for adoption by beneficiaries due to its simple technology based on house hold tools/appliances. Handholding of few SHG groups out of selected beneficiaries showing active interest in production of these value added products needs to be continued for sustainability of the technologies and promotion of these women SHGs. Long term impact analysis of these technologies may be carried out. The promising technologies may be popularized in other villages of Sikkim and other North Eastern Himalayan states for wide adoptability.

2.2. Objective-wise Major Achievements (Appendix 1)

S#	Objectives	Major achievements (***in bullets points***)
1.	Determination of socioeconomic status using Participatory rural appraisal approach before and after project work	• The socio-economic status of the population of ten villages from Sikkim and Kalimpong (Darjeeling area) has been identified using Participatory rural appraisal approach. • Based on the PRA survey, beneficiaries were selected from the selected villages.

2.	Physico-chemical evaluation of cherry pepper and chayote fruits collected from different locations.	• A database of physical properties viz., size, sphericity, surface area and unit mass of cherry pepper and chayote fruits collected from selected villages of Sikkim and Kalimpong was created. • A database of chemical properties viz., pH, TSS and proximate composition of the selected crops of various locations was generated.
3.	Design and fabrication of small-scale primary processing machines for cherry pepper and chayote fruits.	• A method for peeling of chayote was standardized which is applicable before development of any value added product from chayote fruit. • A hand operated manual chayote corer for removing stones/core of chayote was developed. • A prototype of cherry pepper destemming machine for removing tail/stem of cherry pepper was developed.
4.	Formulation and evaluation of new value-added products from chayote and cherry pepper.	• Optimized process for blanching of red cherry pepper was developed. • Process technology for three value added products from cherry pepper viz., red cherry pepper flakes, red cherry pepper powder, red cherry pepper chutney powder was standardized. • Process technology for 03 value added products from chayote viz., chayote-mandarin blended RTS beverage, chayote papad and chayote tuber chips was optimized. • The quality of all the developed products conform to FSSAI standards.
5.	Popularization of developed technologies through extension activities	• About 10-13 awareness programs/demonstration/ training programs were conducted to popularize the developed value added products and machines in the selected villages. • Four extension leaflets were developed for circulation among beneficiaries during demonstration programs.

2.3. Outputs in terms of Quantifiable Deliverables*

S#	Quantifiable Deliverables*	Monitoring Indicators*	Quantified Output/ Outcome achieved	Deviations, if any, & Remarks thereof:
1.	Production of 06 value added products from underrated crops like cherry pepper and chayote.	Number of value added products developed (Nos.)	06 numbers of value added products were developed.	*Appendix 1*
2.	Development of about 2-3 small scale primary processing machines for selected crops of the study (hand/ power operated).	Small scale primary processing machine developed (Nos.)	02 small scale primary processing machines for chayote core removal and cherry pepper destemming was developed	*Appendix 1*
3.	Development of new optimized technologies for production of value added products.	Number of new technologies developed (Nos.)	06 number of new optimized technologies were developed.	*Appendix 1*
4.	On farm Trainings/ Demonstrations will be organized to communicate local participants.	Organized training and Capacity building programmes (Nos.)/ Persons trained (Nos.)	• 02 nos awareness program/mela and 11 number of capacity building programmes were conducted • About 198 persons were trained	*Appendix 1/ Annexure 3*
5.	Increased livelihood of at least 500 SC/ST people in 4 districts including women	Number of beneficiaries in increase in income (Nos.)	Expected increased livelihood of at least 600 SC/ST people in the projected area including women	*Appendix 1*

6.	-	No. of Reports/ Research articles/ Policy documents prepared and published (Nos.)	• 09 No. B. Tech. (Agricultural Engg./ Food Technology) Research Project reports • 01 paper presented in national conference • 04 extension leaflets published	*Appendix 2*

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

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

S#	Particulars	Number/ Brief Details	Remarks/ Attachment
1.	New Methodology/ Technology developed, *if any*:	02 number of new methodology and 06 number of process technology	*Appendix 1*
2.	New Ground Models/ Process/ Strategy developed, *if any*:	NA	
3.	New Species identified, *if any*:	NA	
4.	New Database established, *if any:*	01 database on physico-chemical properties of chayote and cherry pepper from different locations of Sikkim was developed	*Appendix 1*
5.	New Patent, *if any*:		
	I. Filed (Indian/ International)	-	
	II. Technology Transfer, *if any*:	-	
6.	Others, *if any*	-	

Note: Further details may be summarized in DPR Part-B, Section-5. Supporting materials may be enclosed as annexure/ appendix separately to the FTR.

3. New Data Generated over the Baseline Data

S#	New Data Details	Status of Existing Baseline	Addition and Utilisation New data
1.	New database of physico-chemical properties of chayote and cherry pepper of Sikkim	Database of physical properties of cherry pepper of only one location of East Sikkim is available.	• New database of physico-chemical properties of chayote and cherry pepper from 04 districts of Sikkim were generated. • These data can be used for production of new value added products and development of machinery for processing chayote and cherry pepper.

Note: Further details may be summarized in DPR Part-B. Database files in the requisite formats (Excel) may be enclosed as annexure/ appendix separately to the soft copy of FTR.

4. Demonstrative Skill Development and Capacity Building/ Manpower Trained (*Appendix I and Appendix III*)

S#	Type of Activities	Details with number	Activity Intended for	Participants/Trained			
				SC	**ST**	**Women**	**Total**
1.	Workshops/ Awareness programs/Mela	• 01 Awareness program • 01 Technology demonstration Mela	• Familiarization of the project and its scope • Showcasing of products developed under the project	-	15	72	154
2.	On-Field Trainings	08	• Hands on training on different value added products • Demonstration of machinery developed	-	63	114	147

3.	Skill Development	03 on-campus hands on training program	• On campus hands on training and demonstration of different value added products developed • Demonstration of machinery developed	-	38	50	51
4.	Academic Supports	• 02 Junior Project Fellow were trained • 15 no. of B. Tech (Agricultural Engg. /Food Technology) students completed their research project	• Research work of project • B. Tech. Research Project work			06	17
	Others (if any)	Celebration of World Food Day 2020 on 16/10/20	-				78

Note: Further details may be summarized in DPR Part-B. Supporting materials may be enclosed as annexure/ appendix separately to the FTR.

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

S#	Linkages /collaborations	Detail of activities (No. of Events Held)*	No. of Beneficiaries
1.	Sustainable Development Goals (SDGs)/ Climate Change/INDC targets addressed	• Linkages with about 20-22 women SHG groups of various districts of Sikkim and Kalimpong were developed through 08 number of trainings conducted to promote SDG of gender equality. • Promotion of SC/ST beneficiaries to achieve SDG of reduced inequality • The project also addressed SDG of responsible consumption and production through development of 06 nos. value added products which aim to reduce post harvest losses through utilization of underrated crops like cherry pepper, chayote and its by-products.	238 150 258
2.	Any other:	The processing technologies developed for cherry pepper and chayote has possibility for entrepreneurship/ income generation opportunities for rural youth/women SHGs through Pradhan Mantri Formalisation of Micro food processing Enterprises (PMFME) scheme under the Aatmanirbhar Bharat Abhiyan.	-

Note: Further details may be summarized in DPR Part-B, Section-6. Supporting materials may be enclosed as annexure/ appendix separately to the FTR.

6. Project Stakeholders/ Beneficiaries and Impacts (*Appendix I*)

S#	Stakeholders	Support Activities	Impacts in terms of income generated/green skills built
1.	Line Agencies/ Gram Panchayats:	• Training/demonstration programs were conducted in the Gram panchayat offices of selected villages in presence of panch/ward member. • The beneficiaries were trained using the facilities available in gram panchayat offices	Popularization of green skills for utilizing chayote and chayote tuber in the form of value added products to reduce waste
2.	Govt Departments (Agriculture/ Forest/ Water):	Personnels from Department of Agriculture, Sikkim, and KVKs were invited in Technology Demonstration Mela, extension advisory meetings.	Wide popularization and facilitation of the green skills/technologies developed under the project for promoting self-employment/ entrepreneurship
3.	Villagers/ Farmers:	Farmers from selected villages were trained in the developed technologies.	Trained villagers in small scale processing technologies/skills to reduce losses and adverse environmental impact caused through fresh produce/ unconsumed chayote disposal
4.	SC Community:	Beneficiaries from SC communities were trained in the developed technologies	Increased awareness and developed skills in small scale processing of chayote and cherry pepper for generating employment opportunities.
5.	ST Community:	About 149 ST participants were trained in the developed technologies.	Increased awareness and skill development in small scale processing of chayote and cherry pepper in ST community for improving livelihood.

6.	Women Group:	About 238 members from about 20-22 women SHG groups were trained.	Adoption of skills/ technologies disseminated by women SHG groups. to generate income and improve livelihood.
	Others, *if any*:	-	-

Note: Further details may be summarized in DPR Part-B, Section-6. Supporting materials may be enclosed as annexure/ appendix separately to the FTR.

7. Financial Summary (Cumulative)

Consolidated and audited Utilization Certificate (UC) and Year-wise Statement of Expenditure (SE) have been attached as **Annexure I.**

8. Major Equipment/ Peripherals Procured under the Project (Annexure III and IV)

S#	Name of Equipment	Quantity	Cost (INR)	Utilisation of the Equipment after project
1.	UPS	01	4,490.00/-	For academic and research purpose
2.	Desktop computer	01	45,500.00/-	For academic and research purpose
3.	Vacuum Oven with Vacuum Pump	01	85,000.00/-	For academic and research purpose
4.	Colorimeter	01	9,96,450.00/-	For academic and research purpose
5.	Printer	01	15,550.00/-	For academic purpose
6.	Digital LCD Projector	01	31,760.00/-	For academic purpose for research seminars
7.	Autoclave	01	1,50,000.00/-	For academic and research purpose
8.	Digital Refractometer	01	44,299.00/-	For academic and research purpose
9.	Accessories for Desktop computer (Webcam, HDD and head phone)	01 each	11,234.00/-	For academic purpose

9. Quantification of Overall Project Progress

S. No.	Parameters	Total (Numeric)	Remarks/ Attachments/ Soft copies of documents
1.	IHR States/ UTs covered:	*01*	*Appendix 1*
2.	Project Sites/ Field Stations Developed:	*10*	*Appendix 1*
3.	Scientific Manpower Developed (PhD/M.Sc./JRF/SRF/ RA):	*17*	*Appendix 2*
4.	Livelihood Options promoted	*06*	*Appendix 1*
5.	Technical/ Training Manuals prepared	*04*	*Appendix 4*
6.	Processing Units established, if any	*NA*	-
7.	No. of Species Collected, if any	*NA*	-
8.	No. of New Species identified, if any	*NA*	-
9.	New Database generated (Types):	*01*	*Appendix 1*
	Others (if any)		

Note: Further details may be summarized in DPR Part-B. Supporting materials may be enclosed as annexure/ appendix separately to the FTR.

11. Knowledge Products and Publications:

S#	Publication/ Knowledge Products	*Number*		*Total Impact Factor*	*Remarks/* Enclosures
		National	International		
1.	Journal – Research Articles/ Special Issue:				*Appendix 2*
2.	Book – Chapter(s)/ Monograph/ Contributed:	-			-
3.	Technical Reports:	09			*Appendix 2*
4.	Training Manual (Skill Development/ Capacity Building):	04			*Appendix 4*
5.	Papers presented in Conferences/ Seminars:	01			*Appendix 2*
6.	Policy Drafts/Papers:	-			-
7.	Others, if any:	-			-

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

Particulars	Recommendations
Utility of the Project Findings:	• The physico-chemical properties database generated for chayote and cherry pepper would be useful in providing scientific information for design and development of new processing machines and technologies for these crops. • The small-scale process technologies developed for value added products from chayote can be adopted by already operating Self Help Groups especially women for income generation. • The processing technologies developed for cherry pepper has scope of entrepreneurship/income generation by rural youth with financial support from Govt. Schemes like Pradhan Mantri Formalisation of Micro food processing Enterprises (PMFME) scheme. • The primary processing machines developed for chayote and cherry pepper would be suitable for small scale mechanization at rural revel and facilitate drudgery reduction especially for women processors.
Replicability of Project/ Way Forward:	• From the findings of the project, chayote papad was found to be the most sought-after value-added product for adoption by the beneficiaries/women SHGs. Future research may be conducted for developing new formulations for other types of chayote papad. • Utilization of chayote tuber flour for development of different extruded snack/bakery products may be explored through further research. • Based on the feedback from beneficiaries during demonstration of the machinery developed, future refinements/modifications may be taken up in terms of weight reduction, mass production and ergonomic considerations before further transfer of technology. • Feasibility trials of the developed technologies may be conducted in other IHR states growing these crops to assess its adoption and impact.

Exit Strategy:	• The women SHG groups/beneficiaries who are engaged in the production of the developed value added products needs to be supported for market linkage and FSSAI licensing. • Continuous monitoring of these groups is essential for assessing the adoption rate and sustainability of the developed technologies. • Popularization of the developed technologies in other villages of Sikkim through institutional extension activities, KVK and line departments personnel of Sikkim needs to conducted for their wide acceptance. • Facilitation of rural youth, women SHGs, FPOs for developing entrepreneurship and adopting the technology under Govt. Schemes could be taken up through linkages with Micro Small and Medium Enterprise (MSME) department, Commerce and Industries Department etc. of the state. • Long term socio-economic impact of the developed technologies may be carried out through involvement of economics/ agri business management scientists/academic professionals.

(**PROJECT PROPONENT/ COORDINATOR**)

(Signed and Stamped)

(**HEAD OF THE INSTITUTION**)

(Signed and Stamped)

Place: Ranipool

Date: 11/08/23

PART B: DETAILED PROJECT REPORT

1 EXECUTIVE SUMMARY

Sikkim is a North Eastern and Himalayan state with mountainous topography falling under the catchments of Teesta and Rangit rivers which originate from glaciers or high snow areas. The region falls between 27°4’46” to 28° 7’48” N and 88°58” to 88°55’25” E with an altitudinal range of 300 - 8,598 m within a short horizontal expanse of 120 km aerial distance forms different ecozones, e.g., from subtropical to alpine climatic zones. Sikkim is a North Eastern and Himalayan state with mountainous topography falling under the catchments of Teesta and Rangit rivers which originate from glaciers or high snow areas. The region falls between 27°4’46” to 28° 7’48” N and 88°58” to 88°55’25” E with an altitudinal range of 300 - 8,598 m within a short horizontal expanse of 120 km aerial distance forms different ecozones, e.g., from subtropical to alpine climatic zones. The state is regarded as a hotspot for biodiversity. It is rich in cultural diversity with distinctive ethnic groups such as the Lepchas, Bhutias, Nepalese and Limbus. The agriculture sector in Sikkim accounts for about 67 per cent of the workforce. Sikkim has been declared as ‘organic state’ since 2015 and almost all crops produced in the state is organic. In addition to agriculture, eco-tourism also contributes to the economy of the state.

The major horticultural and spice crops of Sikkim include Sikkim mandarin, Papaya, Banana, cabbage, cauliflower, broccoli, tomato, cardamom, ginger, turmeric along with wide variety of flowers including Cymbidium Orchid. Apart from these crops, there are two more crops viz., Chayote and Cherry Pepper which enjoy a lot of popularity among the local people. Cherry pepper is a traditional chilli (*Dalle Khorsani*) extremely popular locally for its pungency and unique flavour. Besides table purpose, fresh capsules are used in processing industry mainly for making pickles. Chayote is cultivated as a backyard crop in all most all parts of Sikkim and Darjeeling area. It is rich in fibers, starch, vitamin C and other micronutrient. However, the use of chayote is limited to home consumption in the form of soup and dishes. The tuberous chayote roots are currently used as cattle feed. Therefore, it remains neglected and underutilized. Due to insufficient demand of fresh chayote, perishable nature of chayote fruits, the absence of technical know-how for further processing and storage of chayote fruits, the farmers incur losses. Cherry pepper is a chilli in Sikkim popular for its pungency and characteristic flavour. The use of cherry pepper is limited to table purpose and pickles. The perishable nature of both chayote and cherry pepper calls for suitable technologies for value addition and processing.

Based on the above, the project was undertaken to develop and popularize value added products from underrated crops like cherry pepper and chayote through involvement of both men and women from rural areas by establishing small processing units. This will lead to employment generation, creation of new entrepreneurs that will facilitate increase in the socio-economic status of the small and marginal farmers through additional income. The project also aimed to address the issues of non-availability of women friendly and small scale machineries primary processing machines for these crops.

Baseline survey and identification of socio economic status was done through Participatory rural appraisal. Total eight villages from Sikkim and two villages from Kalimpong, Darjeeling hills, West Bengal were surveyed for socioeconomic status. Physical and chemical properties viz., pH, TSS, vitamin C content and proximate composition of chayote and cherry pepper collected from different locations were evaluated according to standard methods using standard instruments. The blanching parameters for red cherry pepper was optimized for production of cherry pepper-based value added products. Different peeling methods for chayote was tested and compared. Two primary processing equipment viz., hand operated chayote corer and cherry pepper destemmer unit were designed designed and developed. Six value added products viz., Chayote based RTS beverages, Chayote papad, chayote root chips, cherry pepper flakes, powder and chutney powder were developed and evaluated for its physico-chemical and sensory quality. Nine point hedonic scale was used for sensory evaluation of all products developed. Optimization of the developed technologies was carried out based on the qualities studied.

The major findings/achievements of the project are:

- The socio-economic status of eight villages of Sikkim and two villages of Kalimpong could be successfully developed through PRA survey.
- A database on physico-chemical properties of chayote and cherry pepper from various locations of Sikkim and Kalimpong could be developed which would be useful in developing other processing machines and value added products from these crops.
- Out of all the peeling methods, lye (NaOH) peeling of chayote was found to be suitable with highest peeling percentage of 93.44 %, peel loss of 4.20%, unpeeled percentage of 5.78% and peelability of 84.22% at 12 % NaOH concentration, 90°C temperature and 6 minutes time.
- A prototype of cherry pepper destemming unit with a capacity of 40.2 kg/h was developed and successfully tested. A hand operated chayote corer of capacity 111 kg/h with coring efficiency of about 77% was developed and successfully tested.
- Optimized process technology for 06 value added products viz., red cherry pepper flakes, red cherry pepper powder, red cherry pepper chutney powder, chayote-mandarin blended RTS beverage, chayote papad and chayote tuber chips were developed. The developed technologies were popularized in the selected villages through various capacity building programs.
- A hand operated chayote corer prototype could be successfully developed and demonstrated in the present study. However, more ergonomical studies are needed to make the corer women/gender friendly. Power/pedal operated corer may be developed to further increase the capacity and reduce drudgery.

- An optimized blanching method and conditions for red cherry pepper was developed which is applicable for general blanching of cherry pepper before developing any other value added product.
- The process technologies developed for red cherry pepper flakes, powder and chutney powder showed promise for livelihood generation. However, initial capital investment of ₹1.0 -1.5 lakhs would be needed for starting an enterprise. Hence, Govt. Schemes providing financial support to individual beneficiaries/SHGs may be popularized.
- The process technologies developed for chayote-mandarin blended beverage, chayote papad and chayote tuber chips were low-cost technologies without major additional investment. Chayote papad was found to be the most successful value added product out of all six products which was well received by the beneficiaries.

2 INTRODUCTION

2.1 Background

The North-Eastern Hill (NEH) region of India comprises of the states of Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim and Tripura. The region represents a distinct agro-climatic area of our country. These hill states have a total geographical area of 183,741 km^2 (5.6 % of India) and provide shelter to 1.31 % of country's population. The production of horticultural crops has great significance in these states in view of the diversified topography, agro-climatic conditions and fertile soil. Sikkim is a landlocked Indian State in the Eastern Himalayas. It is the least populous state in India and the second smallest in area after Goa. Sikkim has an area of 7,096 km and a population of 4.5 lakh with an average density of 76 persons per km. Nepal bound it on the west, on the north by Tibet, on the east by Bhutan and Tibet, and with the Darjeeling district of West Bengal stretching along its southern boundary. Sikkim Himalaya is endowed with an extraordinarily rich biodiversity. Average annual rainfall varies from 1,300 mm at the valleys to 4,300 mm at the mountain ridges, and 60-75% of this rain falls during the monsoon season, i.e., June through September. The humidity remains very high during the rainy season (85-97%). The Darjeeling Himalayas, a part of Indo-Malayan Biodiversity Hotspot (Myers and Mittermeier, 2000). harbours many fruit plants grown in wild habitats and indigenously utilized. The state of Sikkim has a wide diversity in the variety of horticultural crops that is grown across the state.

Chayote (*Sechium edule)*, a herbaceous perennial climbing plant is a member of the Cucurbitaceae family is cultivated. It is a common vegetable in the Northeastern hilly region known as squash, and it grows prolifically as a back yard crop in Meghalaya, Manipur, Mizoram, Nagaland, and Sikkim. It is known by many names such as *squash* (Sikkim), *is-kush*, squash (Nepali), *sikot* (Meghalaya), *dashkush* (Manipur), *is-kus* (Nagaland), *ishkus* (Darjeeling), and *iskut* (Mizoram). In Sikkim, eighty six different accessions of chayote were reported by Sikkim centre, ICAR. Though current data of production is not available, annual production of chayote in Sikkim was reported to be 8667 tonnes in 2013-14 and it ranks first amongst vegetables.

Cherry pepper (*Capsicum anuum var*. *cerasiforme*) locally known as '*dalley khursani*' is native to the hills of Sikkim. It is a member of the Solanaceae family and Capsicum genus. Red Cherry pepper is named as such for its resemblance in size and shape to fruits like cherries and cherry tomatoes. They are small, round shaped, fleshy and heavily seeded. They are green in colour in early stage of fruiting and turn to red when fully matured. The area under cherry pepper is about 248 hectares in Sikkim.

2.2 Overview of the major issues addressed

Chayote fruits are rich in complex carbohydrates, including dietary fibres and starch, Vitamin C, Vitamin E and folate. In chayote fruit, the calories and lipids are relatively lower than those in the young stems and tuberous roots. Moreover, the fruit of chayote contains various minerals like potassium, calcium, phosphorus and magnesium. The chayote fruits are used for weight loss due to their low-calorie count and high amount of fibre. Chayote has high levels of cucurbitacins, phenolic compounds, polysaccharides, proteins, and vitamins. Because it contains a variety of health-promoting compounds, chayote can also be used in the food, pharmaceutical, and cosmetic industries (Rosado-Pérez et al., 2019).

Chayote fruits are highly perishable due to its high moisture content of about 85-95 % and have a shelf life of 30 days at ambient temperature (Vargas, 1991). Despite being a healthy vegetable, the use of chayote is limited as soup and dishes. The tuberous sections of the chayote roots are mainly used as cattle feed. This makes it neglected and underutilized. Excess and mature chayote produced goes as waste. Due to insufficient demand, weak infrastructure, poor transportation, perishable nature of chayote fruits, the absence of adequate facilities and less technical know-how for further processing and storage of chayote fruits, the farmers sustain substantial losses and do not get the remunerative price for their commodity. Conversion of chayote into value added products would not only increase the utilization but also lead to increased income of small farmers.

Cherry pepper is extremely popular in Sikkim for its pungency and unique flavour. It contains capsaicin which produces different pungency levels as well as carotenoids and phenolic compounds and can be used as natural pigment and antioxidant agents. It is one of the hottest chilli pepper with a Scoville rating of 100,000 to 350,000 SHU (in comparison Naga King chilli has Scoville rating of 330,000-1,000,000 SHU). The local varieties of red cherry pepper include *Nagey, Sanu dalley,* and *Thullo dalley*. Besides table purpose, fresh red cherry pepper is of ideal size for pickling or brining, and they also make for an excellent garnish on a dish. Green cherry pepper is mostly consumed as fresh. Currently the uses of cherry pepper has been limited to fresh consumption, pickles, chutneys and paste. Fresh cherry pepper contains about 84-88% wb moisture content which makes it extremely perishable thus limited shelf life. This leads to lower market price by the growers.

Apart from limited uses, both chayote and cherry pepper being perishable cannot be stored for longer period and needs product diversification which would enhance the shelf life and increase the market potential. Lack of technical know-how and small scale low cost machineries in the post-harvest processing of these crops further creates roadblocks in the path of development and income generation through these crops. Sikkim has been declared as Agri-Export Zone for cherry pepper and an ‘organic state’. Hence, the products developed from these crops would have high market value and would result in enhancing the livelihoods of many communities in the state.

2.3 Baseline Data and Project Scope

The estimated net cultivable area in Sikkim is around 79,000 hectare (11.13%); with irrigated area of 15% of the total operational holdings of 1,10,000 hectare. About 80% of the people are directly or indirectly dependent on scarce land resources for their livelihood. Sikkim's economy is largely dependent on agriculture and tourism, and as of 2014 the state had the third-smallest GDP among Indian states, although it is also among the fastest-growing. The state being hilly has no scope of industrial growth, and hence, has not adequately succeeded in decreasing the pressure on agriculture/horticulture. The contribution of horticulture to the state’s domestic product is also of overwhelming importance. The sector, therefore, will have to receive priority attention for higher levels of rural prosperity. This can be achieved through participation of women in agriculture development and incorporation of research, production, post harvest management, processing, value addition and marketing in a holistic manner.

The economy of Sikkim is traditionally agrarian based on agriculture and animal husbandry. However, with the pace of development, opportunities have sprung up in other tertiary sectors, mainly tourism. It is estimated that less than 11% of the total geographical area is under agriculture. The contribution of agriculture sector to the total GSDP is diminishing, currently accounting for 16.30%. The contribution of horticulture to the state’s domestic product is also of overwhelming importance. The state is also declared as Agri Export Zone (AEZ) for cherry pepper. Processing of horticultural crops which are mostly underutilized and having high production such as Chayote and cherry pepper has significant scope in the region. Village based processing units as Self Help Groups (SHGs) will create employment opportunities leading to generation of additional income through value addition of horticultural produce. Furthermore, this will contribute to the overall growth of society and enhance the socioeconomic status of all the stakeholders.

The project idea came out of many interactions with the small scale farmers during on field extension and research activities of the college. The farmers’ produce processing cum skill development center of the college organizes monthly demonstration on operation of small processing machineries of main commercial crops viz., ginger, turmeric etc. The farmers also expressed their desire in the processing of cherry pepper and chayote during the interactive sessions of these programs.

The project aims to develop and popularize value added products from underrated crops like cherry pepper and chayote through participation of both men and women from rural areas by establishing small processing units. This will lead to employment generation, creation of new entrepreneurs that will facilitate increase in the socio-economic status of the small and marginal farmers through additional income. The women friendly technologies and small scale machineries will also be developed during the course of the project so that women Self-Help-Groups (SHGs) can independently play major role in the production of the value added products of cherry pepper and chayote.

2.4 Project Objectives and Target Deliverables

Project Objectives	Quantifiable Deliverables
• Determination of socioeconomic status and bench mark survey using Participatory rural appraisal approach before and after project work. • Physico-chemical evaluation of cherry pepper and chayote fruits from different locations • Development of small scale primary processing machines for cherry pepper and chayote fruits • Optimization of process technology for value added cherry pepper and chayote fruit products • Popularization of developed technologies through extension activities	• Production of 06 value added products from underrated crops like cherry pepper and chayote. • Development of about 2-3 small scale primary processing machines for selected crops of the study (hand/power operated). • Development of new optimized technologies for production value added products. • Increased livelihood of at least 500 SC/ST people in 4 districts including women. • On farm Trainings/ Demonstrations will be organized to communicate local participants.

3 METHODOLOGIES/STARTEGY/ APPROACH – ***Appendix 1***

3.1 Methodologies used

Based on the data of major chayote and cherry pepper producing villages obtained from Agriculture department, Govt. of Sikkim, villages were selected from four districts of Sikkim. Baseline survey and identification of socio economic status was done through Participatory rural appraisal in selected villages. Physical, textural and chemical properties of chayote and cherry pepper were determined using standard procedures and instruments.

Blanching is a pretreatment prior to drying or further processing in cherry pepper to prevent enzymatic discoloration. Optimization of blanching method and conditions is essential before developing different processes for value added products from cherry pepper. Full factorial design based blanching experiments viz., hot water blanching, chemical blanching and steam blanching were carried out to optimize blanching conditions for red cherry pepper. The optimization of method and blanching parameters was carried out based on minimum enzymatic activity, maximum Vitamin C content and maximum color retention.

For recommendation of suitable peeling method for chayote, different peeling methods viz., manual knife peeling, mechanical abrasive peeling and lye peeling were tested. Mechanical peeling was carried out in an abrasive peeler at different loading capacities and time of operation. Lye peeling experiments were conducted at various lye concentrations, lye solution temperature and treatment times. The peeling methods were evaluated based on peeling percentage, peelability, peel loss, unpeeled percentage.

Two primary processing machines viz., hand operated chayote corer and cherry pepper destemming machine were designed and fabricated. The performance evaluation of the developed machines was conducted.

Standardized process technology for three value added products of cherry pepper viz., red cherry pepper powder, flakes and chutney powder were developed. For production of red cherry pepper powder and flakes, hot air drying experiments of blanched red cherry pepper samples at various temperatures 50 - 70 °C were conducted. The dried samples were ground and evaluated for its quality. Based on the quality parameters, the temperature suitable for drying was recommended.

For development of cherry pepper chutney powder, the formulation of cherry pepper chutney (tomato, cherry pepper, ginger and sesame seeds, salt) was optimized through sensory evaluation based on nine-point hedonic scale. Hot air drying of chutney prepared at optimized formulation was carried out at different temperatures of 50° - 70°C for bed thickness of 2 - 4mm. The dried chutney sheet was ground into chutney powder. The drying parameters were optimized based on its quality parameters.

Three value added products viz., chayote-mandarin RTS beverage, chayote papad and chayote tuber chips were developed. For development of chayote-mandarin RTS beverage, juice content and ratio of chayote to mandarin juice were varied and the beverage was analyzed for its physico-chemical and sensory characteristics. Optimization of chayote and mandarin juice content in the developed beverage was done based on sensory evaluation.

Chayote papad was developed using cooked chayote pulp, black gram flour and spices. The composition of the chayote papad was standardized based on sensory evaluation and papad quality characteristics. Chayote tuber chips were developed through frying and baking. The chips were evaluated for its physico-chemical and sensory characteristics. The frying and baking conditions were optimized based on sensory evaluation and quality parameters conforming to BIS standards.

The developed technologies and machines were popularized through on-field and on-campus trainings/demonstration activities.

3.2 Data collected and Equipment utilized

For determination of socio-economic status, data on landholding, income, literacy, demography, family size and occupation were collected through PRA survey of ten selected villages of project area.

Physical properties viz., size, sphericity, surface area, of chayote and cherry pepper were determined using digital vernier calliper and standard formulae. Chemical properties viz., pH, TSS, vitamin C content and proximate composition (moisture, fat, protein, ash and carbohydrate content) of chayote and cherry pepper collected from different locations were evaluated according to standard methods using standard instruments. Moisture content was evaluated using vacuum oven and fat content was analyzed using Soxhlet apparatus. Protein content was estimated as per Kjeldahl method and ash content was determined using muffle furnace. Refractometer was utilized for TSS content measurement and pH was measured using digital pH meter. Textural properties viz., hardness of chayote and cherry pepper were determined using texture analyser.

For standardization of peeling method, manual peeling was done using a knife and mechanical peeling was carried out in a power operated abrasive peeler. The peeling methods were compared based on the data of peeling percentage, peelability, peel loss, unpeeled percentage which were generated from weights of unpeeled chayote, and peeled chayote. The weight was measured by digital electronic balance.

For performance evaluation of the developed hand operated chayote corer, data on kernel yield, pulp/fruit yield, capacity, efficiency and pulp loss were collected. The data were collected for different types of blades (plane and serrated), different lengths of handle and using different genders for operation on fruits with peel and without peel. For performance evaluation of cherry pepper destemming machine prototype, data on capacity and efficiency, and product yield were collected at various loading volumes and cutting blade angles.

The process technology for three value added products of cherry pepper viz., red cherry pepper powder, flakes and chutney powder were Standardized. For drying experiments of all products, mechanical hot air dryer was used. For grinding of samples kitchen grinder was used. For analysis of moisture content vacuum oven was used. Vitamin C content of samples were measured as per standard methods described by Dinesh et al. (2015) with minor modification. Color of samples were measured in chromameter in terms of L*, a* and b* values.

Standardized technologies for three value added products viz., chayote-mandarin RTS beverage, chayote papad and chayote tuber chips were developed. For development of chayote-mandarin RTS beverage, the beverage was analyzed for its TSS content using digital refractometer, pH using digital pH meter and acidity through titration method. Sensory evaluation data was collected on a nine-point hedonic scale.

For standardization of technology for chayote papad, dried, fried and roasted papad were analyzed for moisture content using hot air oven and color using chromameter. Frying quality of the papad was analyzed in terms of expansion ratio, oil uptake percentage. Sensory evaluation data for different attributes viz., appearance/colour, flavour/taste, mouthfeel, texture/crispiness, smell/odour, after taste and overall acceptability of both fried and roasted papad was collected.

Chayote tuber chips were developed through frying and baking. The chips were evaluated for moisture content using halogen moisture analyzer, color using chromameter, and hardness using texture analyzer. Chemical properties viz., acid insoluble ash, fat content, acid value, and peroxide value of the chips were evaluated according to the method described by BIS (12569:1989). Data on sensory characteristics viz., appearance/colour, flavour/taste, smell/odour, texture/crispiness, and overall acceptability of the chips were also obtained throughs sensory evaluation.

3.3 Details of Field Survey conducted

Total of ten villages i.e. eight villages from four districts of Sikkim (Mamzey, Dalapchand, Bikmat, lamatin-Tingmoo, Nessa, Arithang-chungrang, Ringhim-naampatam, and Toong-Naaga) and two villages from Kalimpong, Darjeeling hills (Dabling and Pakahng) were selected for the project. Baseline surveys were conducted in these selected villages prior to dissemination of the developed technology. About 10-15 field surveys were conducted to collect the information for developing socio-economic status of the selected villages. Participatory rural appraisal (PRA) survey was conducted through interaction with the villagers and by filling out questionaries prepared under the project to identify socio-economic profile of the selected villages. Information on community type (SC/ST/OBC etc.), gender, no of households, family size, age group, sources of drinking water, cooking fuel, sanitation, income, occupation/livelihood, education level and land holding in selected villages were collected through the prepared questionnaire.

The surveys were conducted with prior intimation of ward member of the selected villages. The villagers were made aware of the project and its scope during the PRA survey. The project site maps were also collected from the Gram Panchayat Unit (GPU) office from the ward member of the village during field visits. Information on Self Help Groups (SHGs) operating in the villages were also collected during the PRA survey. The data obtained through the baseline survey was used to develop and analyze the socio-economic status of the selected villages.

3.4 Strategic Planning for each activity with time frame

Activities under each objectives were carefully planned to achieve all the targets of the project in time. However, the original time frame and number of field surveys/awareness programs planned could not be followed due to the strict restrictions in inter district/interstate movement during COVID-19 pandemic. Deviations/delay in developing standardized process technologies and processing machineries also occurred due to lockdown of institution during COVID-19 pandemic and seasonal nature of both crops. The time line of Objective wise activities has been outlined below in Table 1.

Table 1: Time frame of project activities

Activities	**Months**																
	3	6	9	12	15	18	21	24	27	30	33	36	39	42	45	48	50
Selection of villages and appointment of staff	■	■															
Literature collection	■	■	■	■													
Baseline survey and determination of socioeconomic status using Participatory rural appraisal approach before dissemination of technology			■	■	■	■	■	■									
Physico-chemical evaluation of cherry pepper and chayote fruits collected from different locations			■	■	■	■	■	■	■	■							
Design, fabrication and performance evaluation of small-scale primary processing machines for cherry pepper and chayote fruits				■	■	■	■	■	■	■	■	■	■	■	■		
Formulation, and evaluation of new value-added products from chayote and cherry pepper				■	■	■	■	■	■	■	■	■	■	■	■		
Optimization of process technology for value added cherry pepper and chayote fruit					■	■	■	■	■	■	■	■	■	■	■	■	

Popularization of technologies through extension activities																	

4 KEY FINDINGS AND RESULTS – ***Appendix 1***

4.1 Major Activities/ Findings

Five major activities were carried out under the project. The key findings of these activities have been discussed below.

4.1.1 Determination of socioeconomic status and benchmark survey using Participatory rural appraisal approach

Chayote and Cherry pepper were the selected crops for the project. A total of ten villages (eight from Sikkim and two from Kalimpong) were selected as project sites. Participatory rural appraisal (PRA) survey was conducted through interaction with the villagers and by filling out questionaries. The data obtained through the baseline survey was used to develop the socio-economic status of the selected villages in terms of land holding, demography, literacy rate, income, and livelihood options. The landholding of maximum number of farmers was < 1 ha. Maximum population in the selected project sites belonged to ST community. Maximum percentage of population are working as daily wage labour other than agriculture and has income of ₹10,000 – ₹15,000 per month.

4.1.2. Physico-chemical evaluation of cherry pepper and chayote fruits

Chayote and cherry pepper samples collected from different locations and analyzed for physical characteristics, proximate composition, pH, Total soluble solids (TSS) content, Vitamin C content and capsaicin content (only for cherry pepper). Unit mass of chayote and cherry pepper samples varied from 247.95 to 331.58g and 2.56g to 3.53g respectively. The effect of location on the proximate composition & chemical properties except fat and protein content of chayote was found to be significant ($p<0.05$). Vitamin C content was in the range of 102.87-123.13 mg/100g for red cherry pepper which was higher compared to chayote. The capsaicin content in the cherry pepper samples ranged from 0.67 -1.51 g/100.

4.1.3 Development of small-scale primary processing machines for cherry pepper and chayote fruits

In the present study, three different peeling methods viz., manual, mechanical abrasive peeling using abrasive peeler and lye peeling were selected for chayote in order to assess their performance. Dependent parameters like peeling percentage, peelability, peel loss, unpeeled percentage were recorded to evaluate these peeling methods. Abrasive peeling at 75% loading capacity and operating time of 4 minutes may be recommended based on highest peelability %, lowest unpeeled percentage, and lower peel loss %. Lye peeling at 12 % NaOH concentration, 90°C temperature and 6 minutes peeling time followed by washing may be recommended as optimized lye peeling condition.

A prototype of hand operated chayote corer was designed, fabricated and assessed for its performance. in terms of kernel yield (%), pulp yield (%), capacity (kg/h), efficiency (%) and pulp loss (%). A combination of plane blade, 28 length of handle and a male operator resulted in highest capacity (111.05 kg/h) and can be recommended. A cherry pepper destemmer prototype was designed, developed and assessed for performance in terms of destemming efficiency and % damage. 1/3rd loading volume with 475 rpm speed operating conditions were found suitable for operation of the machine.

4.1.4 Optimization of process technology for value added cherry pepper and chayote fruit products

Blanching method and conditions were optimized for cherry pepper. Hot water chemical blanching with 1.5 % KMS concentration for blanching time of 2.0 minutes were found to be optimum for cherry pepper. Optimum process technology for three value added products from red cherry pepper viz., red cherry pepper flakes, red cherry pepper powder and red cherry pepper chutney powder and three from chayote viz., chayote-mandarin blended RTS beverage, chayote papad and chayote tuber chips were developed.

4.1.5 Popularization of developed technologies through extension activities

All the developed process technologies and machinery prototype were popularized among 258 beneficiaries through 02 awareness programs, eleven demonstration programs and 04 extension leaflets.

4.2 Key Results

- About 5446 people were surveyed through PRA survey from ten selected villages of Sikkim and Kalimpong.
- Seven out of the ten villages surveyed have more percentage of small and marginal farmers.
- Maximum population (51.82%) belongs to Schedule Tribe (ST) followed by Other backward caste (OBC) which constitute about 38.65%. Lowest population (4.19%) in these villages belong to Schedule Caste (SC).
- Maximum percentage of about 27.92% of studied population lie in the income group of ₹10,000 – ₹15,000 per month. Women family members of the households do not contribute much to the income (< ₹ 4000/- per month).
- The major livelihood option of maximum percentage (36.65%) was daily wage labour other than agriculture.

- The average length, width and thickness of all chayote fruits collected from different locations were in the range of 8.85 – 11.00 cm, 5.42 – 7.21 cm and 4.78 – 6.39 cm respectively. The average length, width and thickness of all red cherry pepper samples collected from different locations were in the range of 19.96 – 23.15 mm, 16.29 – 18.48 mm and 15.99 – 17.82 mm respectively
- Sphericity of the chayote and cherry pepper were in the range of 0.65 to 0.81 and 0.81 to 0.89 respectively. Unit mass of chayote samples varied from 247.95 to 331.58g and 2.56g to 3.53g for cherry pepper. The fruit to tuber ratio of chayote was in the range of 10 - 40.
- pH and TSS content of chayote varied from 6.66 – 7.24 and 5.17 – 5.59 °Bx respectively. The same for cherry pepper were 5.71-6.66 and 10.38-11.22 °Bx respectively.
- Vitamin C content of 102.87-123.13 mg/100g for red cherry pepper makes it a rich source of Ascorbic acid.
- The Scoville Heat Unit fresh red cherry pepper based on capsaicin content ranged from 107200 to 241600.
- Manual peeling of chayote resulted in peeling percentage of 92.08%, peel loss of 2.33%, unpeeled percentage of 2.76 %, and peelability of 97.14%.
- Mechanical abrasive peeling at 75% loading capacity and operating time of 4 minutes showed highest peelability (82%), lowest unpeeled percentage (14%), and lower peel loss (2.95 %).
- Lye peeling at 12 % NaOH concentration, 90°C temperature and 6 minutes peeling time followed by washing may be recommended as optimized lye peeling condition.
- The developed chayote corer prototype showed highest capacity (111.05 kg/h) and moderate efficiency (77.44 %) for optimum combination of plane blade, 28 length of handle and a male operator for fruit with peel whereas optimum combination of serrated blade, 24 mm length of handle and a male operator provided highest capacity (104.41 kg/h) and second highest efficiency (81.01 %) for fruit without peel.
- The optimum conditions for operating the developed cherry pepper destemmer prototype were 1/3rd loading volume with 475 rpm speed showing efficiency of 74.93% and % damage of 1.79%. The capacity of the machine was about 40.2 kg/h.
- The optimum conditions for blanching of red cherry pepper were hot water blanching with 1.5% KMS at 100°C for 2 minutes. At the optimized blanching condition, Vitamin C retention was 89.84% and colour difference was 8.97 with complete inactivation of peroxidase enzyme.
- Hot air drying of cherry pepper coarse paste at 60°C for 14 h were found to be optimum for production of cherry pepper flakes and powder.
- Drying air temperature of 60° C and 4 mm thickness may be recommended for production of red cherry pepper chutney powder with optimized formulation.
- The chayote-mandarin RTS beverage containing 1:1 ratio of chayote juice: mandarin juice, and 10% juice content was found to be optimum.

- 60% chayote paste and 40% black gram flour can be considered as optimum formulation for best quality of chayote papad.
- Frying temperature of 160°C for 130 s and baking temperature of 160°C for 14 minutes were found to be optimum production chayote tuber chips.

4.3 Conclusion of the study

- The socio-economic status of eight villages of Sikkim and two villages of Kalimpong could be successfully developed through PRA survey. The survey also highlighted that the contribution of women in the primary income of the household was minimum. This facilitated selection of women as beneficiaries in the present study.
- A database on physico-chemical properties of chayote and cherry pepper from various locations of Sikkim and Kalimpong could be developed. This database would be useful in developing other processing machines and value added products from these two crops.
- The peeling method for chayote was optimized as lye peeling. This optimized method can be successfully applied for peeling of chayote for developing other value added products viz., chayote flour, osmo-dried chayote slices etc. Abrasion peeling also showed promise for chayote peeling when use of chemicals is not permitted.
- A hand operated chayote corer prototype could be successfully developed and demonstrated in the present study. However, more ergonomical studies are needed to make the corer women/gender friendly. Power/pedal operated corer may be developed to further increase the capacity and reduce drudgery.
- A cherry pepper destemmer prototype was successfully developed and demonstrated. However, the weight of the machine was high due to use of MS rods based on local availability. Further research may be focussed on reducing the load through use of SS wedge wire drum.
- An optimized blanching method and conditions for red cherry pepper was developed which is applicable for general blanching of cherry pepper before developing any other value added product.
- The process technologies developed for red cherry pepper flakes, powder and chutney powder showed promise for livelihood generation. However, initial capital investment of ₹1.0 -1.5 lakhs would be needed for starting an enterprise. Hence, Govt. Schemes providing financial support to individual beneficiaries/SHGs may be popularized.
- The process technologies developed for chayote-mandarin blended beverage, chayote papad and chayote tuber chips were low cost technologies without major additional investment. Chayote papad was found to be the most successful value added product out of all six products which was well received by the beneficiaries.
- Long term Impact analysis of the technologies popularized among the beneficiaries needs to be performed.

5 OVERALL ACHIEVEMENTS – *Appendix 1*

5.1 Achievement on Project Objectives/ Target Deliverables

The socio-economic profile of population of ten villages from Sikkim and Kalimpong (Darjeeling area) has been identified using Participatory rural appraisal approach. A scientific database of physical properties viz., size, sphericity, surface area and unit mass of cherry pepper and chayote fruits collected from selected villages of Sikkim and Kalimpong was created. A database of chemical properties viz., pH, TSS and proximate composition of the selected crops of various locations was generated.

Methods for lye peeling and abrasive peeling of chayote was standardized. However, lye peeling showed better results in performance indicators. A hand operated manual chayote corer prototype with capacity of about 111 kg/h for removing stones/core of chayote was developed. A prototype of cherry pepper destemming machine with capacity of about 40 kg/h for removing tail/stem of cherry pepper was developed. The target of developing 2-3 primary processing machines for chayote and cherry pepper was fully achieved.

Six value added products viz., red cherry pepper flakes, red cherry pepper powder, red cherry pepper chutney powder, chayote papad, chayote-mandarin blended RTS beverage and chayote tuber chips were developed as against six target deliverables.

Six process technologies for developing six value added products were also standardized under the project. In addition, optimized blanching method and parameters were also developed for blanching of red cherry pepper. All quantifiable output were achieved under the project.

Thirteen capacity building/extension activities were conducted to increase awareness and popularize the developed technologies among the selected beneficiaries. Four extension leaflets were also published to distribute the beneficiaries during the demonstration/training programs. About 198 beneficiaries were trained in different technologies developed under the project. Out of 258 beneficiaries, 238 nos. were women belonging to various SHGs of the state. About 150 SC/ST beneficiaries could be reached through project for popularization of the technologies and livelihood generation.

5.2 Interventions

- From the PRA survey, it was found that the participation of women in income generation of the family is very less i.e. < ₹4,000/-. Hence, the first intervention was done by selecting these people as beneficiaries so as to improve their livelihood and generate a source of income.
- The second intervention was to create a scientific database of physico-chemical properties of chayote and cherry pepper from different locations of Sikkim and Kalimpong area which was not available.
- No primary processing machines for coring of chayote and destemming of cherry pepper was available. Both these operations were cumbersome, labour consuming and still performed manually. Hence, the third intervention was to develop these machines for reducing drudgery and improving processing capacity.
- No standardized methods were available for peeling of chayote. The fourth intervention was to develop suitable peeling method for chayote which is again a very laborious operation.
- Blanching is an essential operation prior to processing. However, no study was available on standardized method of blanching of cherry pepper. The fifth intervention was to develop an optimized blanching method suitable for cherry pepper.
- The value addition of chayote was negligible prior to the project. Value addition of cherry pepper was only limited to pickles, brined peppers and sun dried whole cherry pepper. The sun dried peppers were low in quality especially in terms of color. Hence, the sixth intervention was to develop new/novel value added products from chayote and cherry pepper through optimized process technology.
- Seventh intervention was to improve the socio-economic status of people from SC/ST community by developing skills for livelihood generation through capacity building programs.

5.3 On-field Demonstration and Value-addition of Products

- Chayote consumption was only limited to dishes or soups at home scale. Chayote tuber and excess chayote was fed to cattle. In the present study, value addition of chayote and cherry pepper was carried out through development of new products.
- Three value added products viz., red cherry pepper flakes, red cherry pepper powder, red cherry pepper chutney powder were developed through hot air drying. The quality of red cherry pepper flakes and powder produced through the standardized technology was superior in comparison to sun dried flakes and dried whole cherry pepper. The cherry pepper chutney powder was a novel product which can be reconstituted and used readily even during off-season of cherry pepper.
- Three value added products viz., chayote papad, chayote-mandarin blended RTS beverage and chayote tuber chips were developed from chayote. Chayote-mandarin blended RTS beverage is an excellent health drink rich in nutrients of chayote and mandarin juice. Chayote papad developed under the present study can be used as a substitute to the pulse based papad

available in the market. Chayote tuber chips was another novel value added product prepared from chayote roots which otherwise was discarded. The process technology for chayote tuber chips, RTS beverage and papad are simple and were applicable at SHG level especially for women folk.

- Eight on-site demonstration programs were conducted on demonstration and value addition of chayote and cherry pepper value added products and processing machinery. The demonstrations were conducted in the villages and hands on training was provided to the selected beneficiaries. In addition, three skill development trainings were also conducted at the institution for beneficiaries of selected villages.

5.4 Green Skills developed in State/ UT

- Excess chayote and chayote tubers were used as cattle feed or disposed as waste creating environmental pollution. Utilization of chayote and its tuber for developing value added products through low cost less energy intensive processes (green skills) would lead to reduction of wastage in Sikkim and Kalimpong area.

5.5 Addressing Cross-cutting Issues

- Gender inequality was addressed through selection of 238 women beneficiaries out of 258 total beneficiaries. These beneficiaries were trained through various skill development and demonstration programs to create income generation.
- Linkages with about 20-22 women SHG groups of various districts of Sikkim and Kalimpong were developed to promote gender equality and strengthen the SHGs.
- Reduced inequality among various communities were addressed by selection of about 150 SC/ST beneficiaries who were trained in the developed technologies to improve their socio-economical status.
- The project also addressed the issue of responsible consumption and production through development of 06 nos. value added products which aim to reduce post harvest losses through utilization of underrated crops like cherry pepper, chayote and its by-products

6 PROJECT'S IMPACTS IN IHR – *Appendix 1*

6.1 Socio-Economic impact

Out of all the value added products developed under the project, chayote papad was well liked by all beneficiaries and can be regarded as the most novel product of the project. Because of more interest shown in the chayote papad and chayote tuber chips, beneficiaries from cherry pepper villages were also trained in chayote based products. Upon receipt of training, few SHGs have started home scale production for consumption at home level. The beneficiaries were apprehensive of the market of the chayote papad. Though the technology was adopted, the adoption was still in nascent stage. The beneficiaries also expressed desire for future handholding in training and marketing of the these products The socio-economic impact of the developed technologies could not be assessed as the beneficiaries could not start production for sale purpose. Hence, at present, income generation through these technologies could not be achieved. However, assuming adoption of chayote papad at SHG level production, an average increase in income of ₹ 22,500/- per year per beneficiary would be possible. This would help improve the income of 150 SC/ST and 238 women population of Sikkim and Kalimpong. The socio-economic impact need to be studied to assess the adoption rate of these technologies.

6.2 Impact on of Natural Resources/ Environment

- The developed technologies especially for chayote are low cost, simple and needs manual labour. These does not have any adverse effect on the environment/natural resources. Moreover, utilization of chayote and its tuber for developing value added products would lead to reduction of wastage (excess chayote/tuber) in Sikkim and Kalimpong area.

6.3 **Conservation of Biodiversity/ Land Rehabilitation in IHR**: NA

6.4 **Developing Mountain Infrastructures**: NA

6.5 **Strengthening Networking in State/ UT**:

- Linkages with personnels from Department of Agriculture, Sikkim, Department of Horticulture, Sikkim and KVKs were developed by inviting them to Technology Demonstration Mela and extension advisory meetings of the institutes where technologies developed under the projects were showcased for its wide popularization.

- Linkages with ward member/panch (head of GPU) of various villages were established during training/demonstration programs. These programs were conducted in the Gram panchayat offices of selected villages in presence of panch/ward member. The beneficiaries were also trained using the facilities available in gram panchayat offices.

- The processing technologies developed for cherry pepper and chayote has possibility for entrepreneurship/ income generation opportunities for rural youth/women SHGs through Pradhan Mantri Formalisation of Micro food processing Enterprises (PMFME) scheme under the Aatmanirbhar Bharat Abhiyan. Hence, linkages with Commerce and industries department, Govt. of Sikkim responsible for these schemes has been developed.

7 EXIT STRATEGY AND SUSTAINABILITY –.

7.1 Utility of project findings:

- The physico-chemical properties database generated for chayote and cherry pepper would be useful in providing scientific information for design and development of new processing machines and technologies for these crops.

- The small-scale process technologies developed for value added products from chayote can be adopted by already operating Self Help Groups especially women for income generation.
- The primary processing machines developed for chayote and cherry pepper would be suitable for small scale mechanization at rural revel and facilitate drudgery reduction especially for women processors.
- The processing technologies developed for cherry pepper has scope of entrepreneurship/income generation by rural youth with financial support from Govt. Schemes like Pradhan Mantri Formalisation of Micro food processing Enterprises (PMFME) scheme.

7.2 Other Gap Areas:

- Utilization of chayote tuber flour for development of different extruded snack/bakery products may be explored through further research.
- Considerable scope for development of power/pedal operated chayote corer is available to increase the capacity of chayote processing and reduce drudgery.
- A cherry pepper destemmer prototype was successfully developed and demonstrated. However, the weight of the machine was high due to use of MS rods based on local availability. Further research may be focussed on reducing the load through use of SS wedge wire drum.

7.3 Major Recommendations/ Way Forward:

- From the findings of the project, chayote papad was found to be the most sought-after value-added product for adoption by the beneficiaries/women SHGs. Future research may be conducted for developing new formulations for other types of chayote papad.
- The process technologies developed for red cherry pepper flakes, powder and chutney powder showed promise for livelihood generation. However, initial capital investment of ₹1.0 -1.5 lakhs would be needed for starting an enterprise. Hence, Govt. Schemes providing financial support to individual beneficiaries/SHGs may be popularized.
- Based on the feedback from beneficiaries during demonstration of the machinery developed, future refinements/modifications may be taken up in terms of weight reduction, mass production and ergonomic considerations before further transfer of technology.

7.4 Replication/ Upscaling/ Post-Project Sustainability of Interventions:

- Feasibility trials of the developed technologies may be conducted in other IHR states growing these crops to assess its adoption and impact.
- The women SHG groups/beneficiaries who are engaged in the production of the developed value added products needs to be supported for market linkage and FSSAI licensing.

- Continuous monitoring of these groups is essential for assessing the adoption rate and sustainability of the developed technologies.
- Popularization of the developed technologies in other villages of Sikkim through institutional extension activities, KVK and line departments personnel of Sikkim needs to conducted for their wide acceptance.
- Facilitation of rural youth, women SHGs, FPOs for developing entrepreneurship and adopting the technology under Govt. Schemes could be taken up through linkages with Micro Small and Medium Enterprise (MSME) department, Commerce and Industries Department etc. of the state.
- Long term socio-economic impact of the developed technologies may be carried out through involvement of economics/ agri business management scientists/academic professionals.

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APPENDICES

Appendix 1 – Details of Technical Activities

Appendix 2 – Copies of Publications duly Acknowledging the Grant/ Fund Support of NMHS

Appendix 3 – List of Trainings/ Workshops/ Seminars with details of trained resources and dissemination material and Proceedings

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APPENDIX 1

DETAILS OF TECHNICAL ACTIVITIES

1.0 Objective 1: Determination of socioeconomic status and benchmark survey using Participatory rural appraisal approach before and after project work

Chayote and Cherry pepper were the underrated crops selected for the project (Fig. 1 and 2). The project area covers villages from Sikkim and nearby villages from Kalimpong-Darjeeling area of West Bengal state. For selection of villages, information on major chayote and cherry pepper producing villages were sought from the Department of Agriculture, Govt. of Sikkim. Based on the information provided, four villages one from each district out of four districts of Sikkim were selected for chayote and similarly four villages for cherry pepper were selected. Two villages (one each for chayote and cherry pepper) from Kalimpong-Darjeeling hills from neighboring state West Bengal were also selected. A total of ten villages were selected as project sites. Table 1 reports the list of selected villages.

Table 1: Selected villages under the project

Name of district	Name of selected village for cherry pepper	Name of selected village for chayote
East Sikkim	Mamzey	Dalapchand
West Sikkim	Nessa	Arithang-chongrang
North Sikkim	Ringhim-nampatam	Toong-Naaga
South Sikkim	Lamatin Tingmoo	Bikmat
Kalimpong (Darjeeling, West Bengal)	Pakhang	Dabling

Fig. 1. Cherry pepper

Fig. 2. Chayote

Following are the details of the project sites selected for the study. The site maps were collected from the Gram Panchayat Unit (GPU) office during field visits/survey. Figs. 3-12 show the maps of the project sites.

A. Project Site: Dalapchand, East Sikkim
Long. & Lat.: 27.1981°N, 88.6716°E

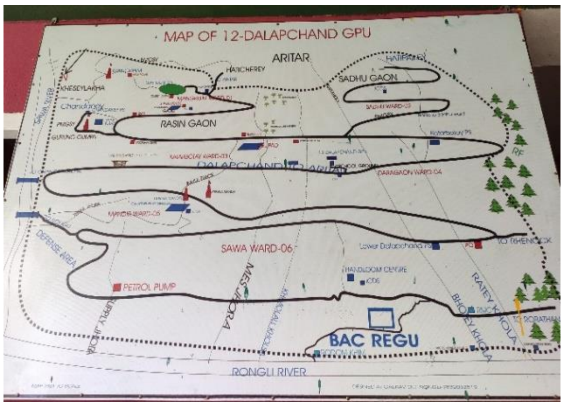


Fig. 3. Site Maps of Dalapchand, East Sikkim

B. Project Site: Bikmat, South Sikkim
Long. & Lat.: 27.1555°N, 88.4351°E

Fig. 4. Site Map of Bikmat, South Sikkim

C. Project Site: Toong Naaga, North Sikkim
Long. & Lat.: 27.7867°N, 88.6039°E

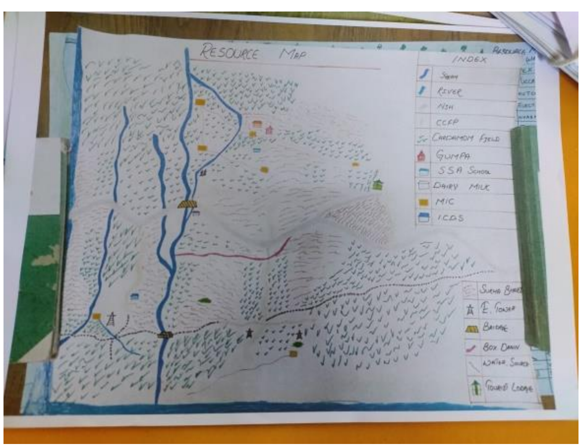


Fig. 5. Site Map of Toong-Naaga, North Sikkim

D. Project Site: Arithang-Chongrang, West Sikkim
Long. & Lat.: 27.34°N, 88.61°E

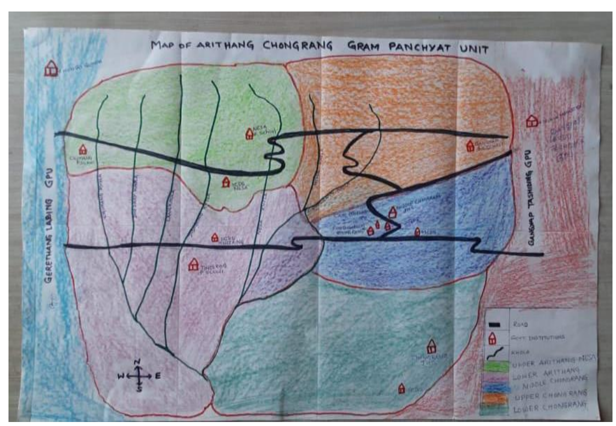


Fig. 6. Site Map of Arithang-Chongrang, West Sikkim

E. Project Site: Dabling, Kalimpong, Darjeeling

Long. & Lat.: 27.05° N 88.596° E'

F. Project Site: Pakhang, Kalimpong, Darjeeling

Long. & Lat.: 27.04°N 88.59°E

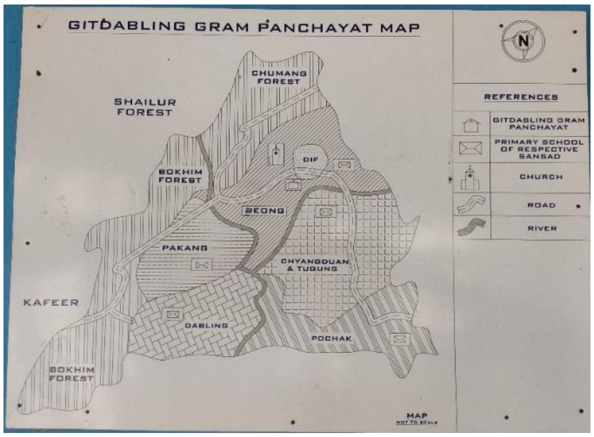


Fig. 7: Site Map of Dabling, Kalimpong

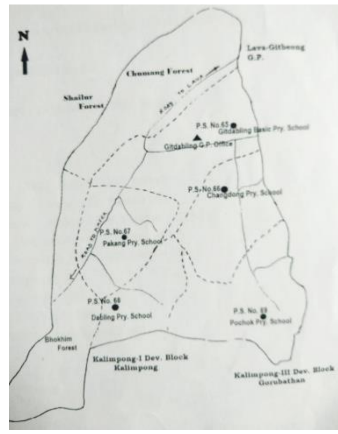


Fig. 8. Site Map of Pakhang, Kalimpong

G. Project Site: Mamzey, East Sikkim

Long. & Lat.: 27.2158°N, 88.5737°E

H. Project Site: LamatinTingmoo, South Sikkim

Long. & Lat.:27.2749°N, 88.3016°E

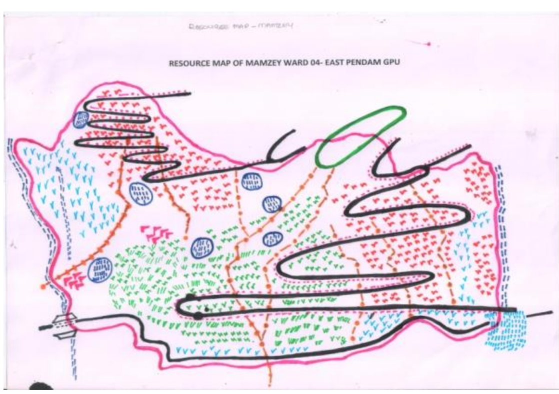


Fig.9. Site Maps of Mamzey, East Sikkim

Fig.10. Site Map of Lamatin Tingmoo, South Sikkim

I. Project Site: Nessa, West Sikkim
Long. & Lat.:27.3882°N, 88.2871°E

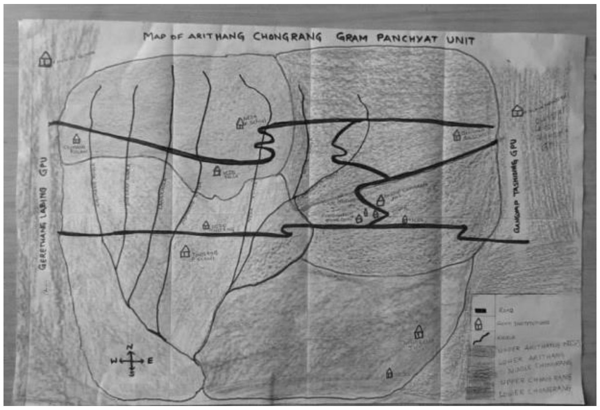


Fig. 11. Site Map of Nessa, West Sikkim

J. Project Site: Ringhim, Mangan, North Sikkim
Long. & Lat.:27.4904°N 88.5388°E

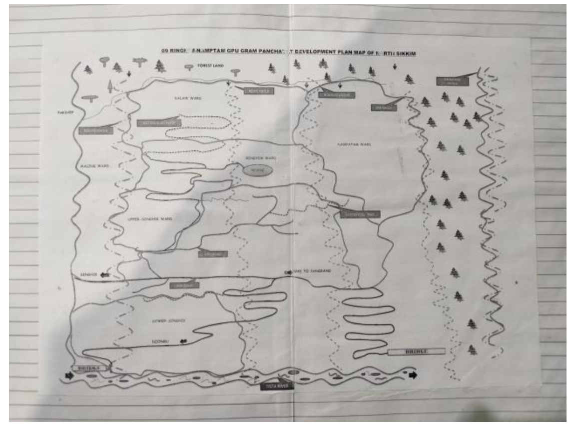


Fig. 12. Site Map of Ringhim, Mangan, North Sikkim

1.1 PRA Survey

Total of ten villages i.e. eight villages from four districts of Sikkim (Mamzey, Dalapchand, Bikmat, lamatin-Tingmoo, Nessa, Arithang-chungrang, Ringhim-naampatam, and Toong-Naaga) and two villages from Kalimpong, Darjeeling hills (Dabling and Pakahng) were surveyed prior to demonstration and other capacity building activities. Several field visits (10-15) were conducted to collect the necessary information for determining the socio-economic status of the selected villages. Participatory rural appraisal (PRA) survey was conducted through interaction with the villagers and by filling out questionaries prepared under the project to identify socio-economic profile of the selected villages. Information on community type (SC/ST/OBC etc.), gender, no of households, family size, age group, sources of drinking water, cooking fuel, sanitation, income, occupation/livelihood, education level and land holding in selected villages were collected through the prepared questionnaire. Fig. 13 shows the glimpses of the field visits for PRA survey during the project. The surveys were conducted with prior intimation of ward member of the selected villages. The villagers were made aware of the project and its scope during the PRA survey. The project site maps were also collected from the Gram Panchayat Unit (GPU) office from the ward member of the village during field visits. Information on Self Help Groups (SHGs) operating in the villages were also collected during the PRA survey.

Fig. 13. Glimpses of PRA survey

1.2 Socio-economic status of the selected villages

In the PRA survey, about 5446 people were surveyed from selected villages. The data obtained through the baseline survey was used to develop and analyze the socio-economic status of the selected villages. Socio-economic status was determined in terms of land holding, demography, literacy rate, income, and livelihood options.

Landholding profile

Fig. 14 highlights the combined landholding profile of the selected villages. From Fig. 14, it can be observed that, maximum number of farmers (about 36.72%) were marginal farmers with landholding of < 1 ha whereas only 4.38 % farmers possess landholding of > 4 ha. Majority of the selected population belong to marginal and small farmers group.

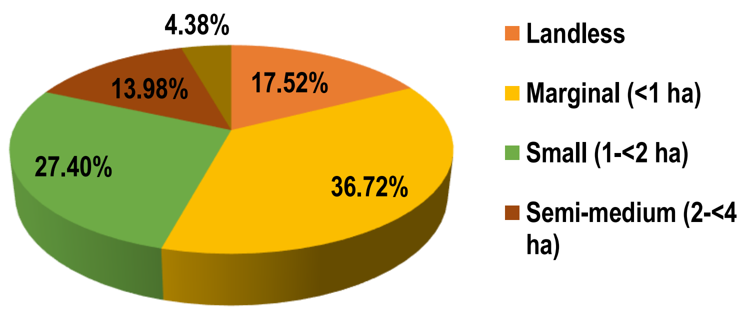
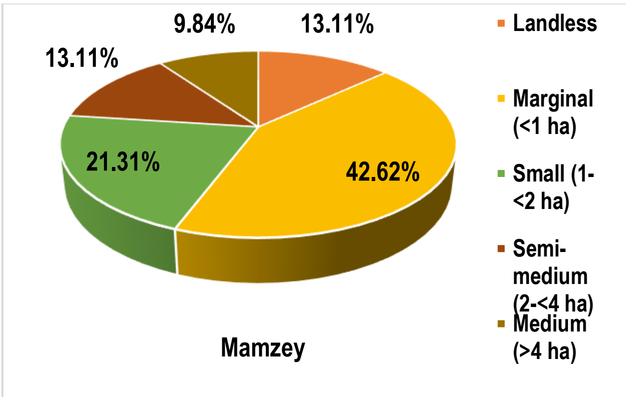
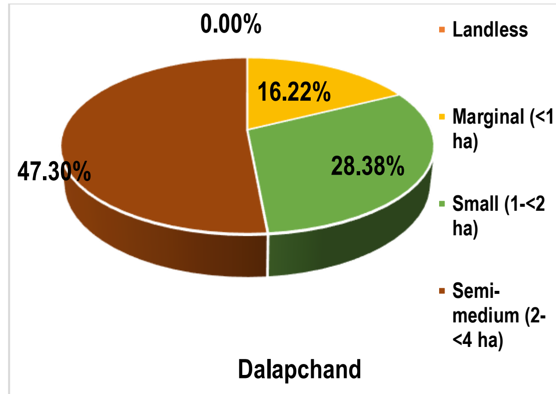
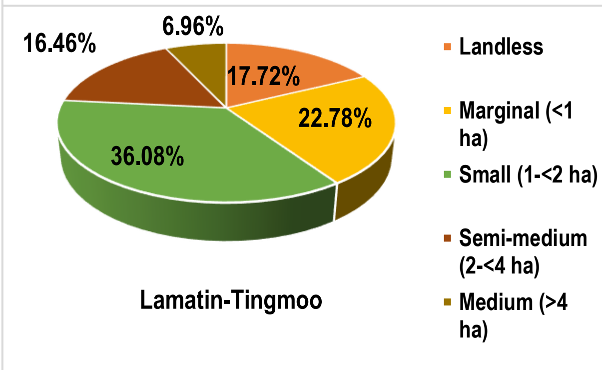


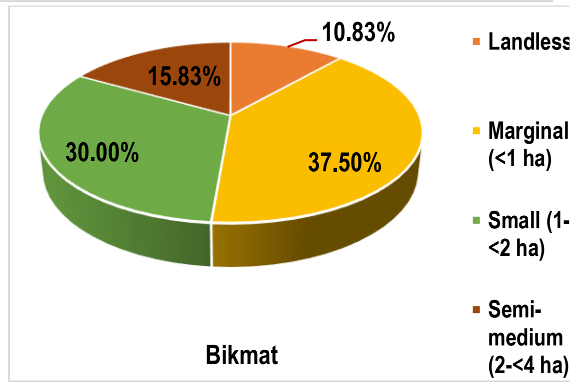
Fig. 14. Landholding profile in selected villages

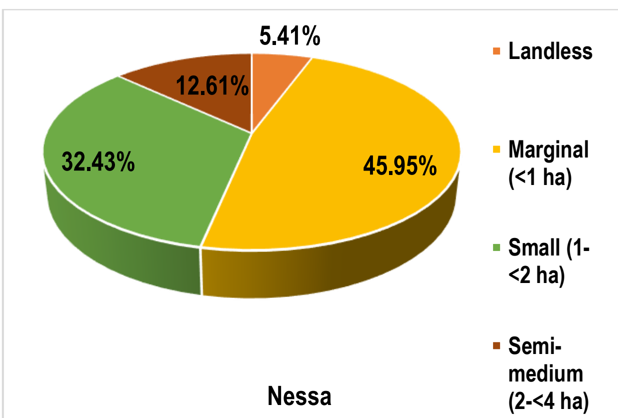
Figs. 15 and 16 show the landholding profile of the selected villages of Sikkim and Kalimpong, West Bengal. From the Figs. 15 and 16, it can be observed that maximum % of small farmers (41.07%) and marginal farmers (51.02%) were in Arithang-chongrang village, West Sikkim and Pakhang village, Kalimpong respectively. Maximum percentage (47.3%) of semi-medium farmers were found to be in Dalapchand village, East Sikkim followed by Toong-Naaga, North Sikkim. Seven out of the ten villages surveyed have more percentage of small and marginal farmers.

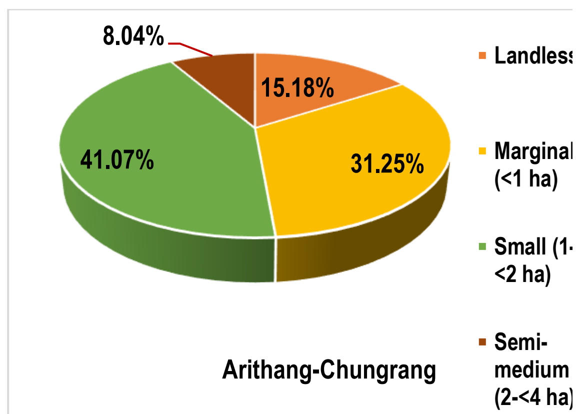

9.84%
13.11%
13.11%
21.31%
42.62%
Landless
Marginal (<1 ha)
Small (1-<2 ha)
Semi-medium (2-<4 ha)
Medium (>4 ha)
Mamzey

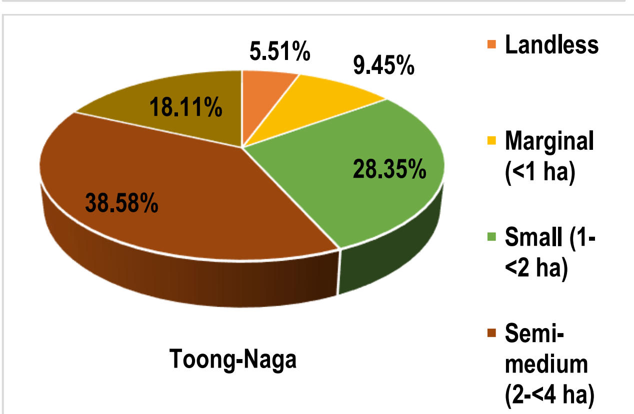

0.00%
16.22%
47.30%
28.38%
Landless
Marginal (<1 ha)
Small (1-<2 ha)
Semi-medium (2-<4 ha)
Dalapchand


16.46%
6.96%
17.72%
22.78%
36.08%
Landless
Marginal (<1 ha)
Small (1-<2 ha)
Semi-medium (2-<4 ha)
Medium (>4 ha)
Lamatin-Tingmoo


10.83%
15.83%
30.00%
37.50%
Landless
Marginal (<1 ha)
Small (1-<2 ha)
Semi-medium (2-<4 ha)
Bikmat


5.41%
12.61%
32.43%
45.95%
Landless
Marginal (<1 ha)
Small (1-<2 ha)
Semi-medium (2-<4 ha)
Nessa


8.04%
15.18%
41.07%
31.25%
Landless
Marginal (<1 ha)
Small (1-<2 ha)
Semi-medium (2-<4 ha)
Arithang-Chungrang


5.51%
9.45%
18.11%
28.35%
38.58%
Landless
Marginal (<1 ha)
Small (1-<2 ha)
Semi-medium (2-<4 ha)
Toong-Naga

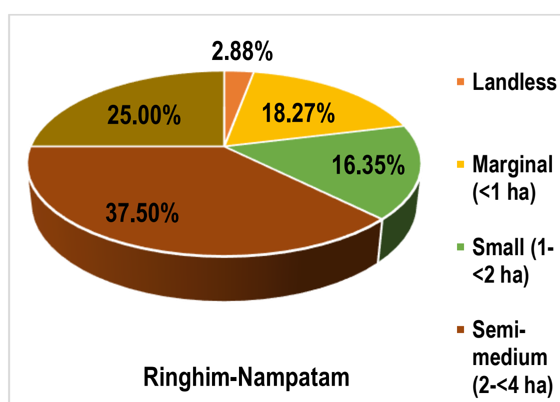
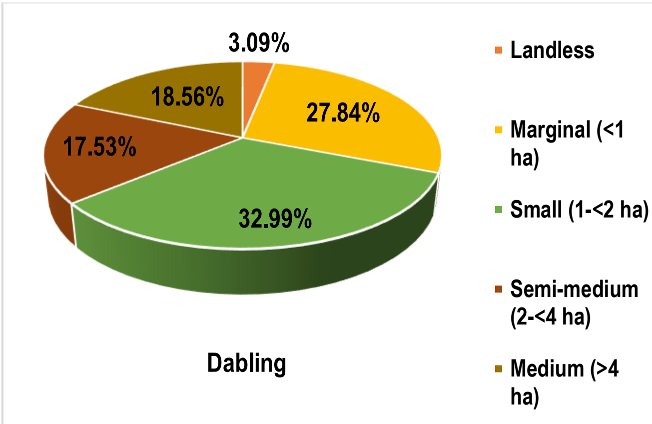

2.88%
25.00%
18.27%
16.35%
37.50%
Landless
Marginal (<1 ha)
Small (1-<2 ha)
Semi-medium (2-<4 ha)
Ringhim-Nampatam

Fig. 15. Landholding Profile of selected villages of Sikkim



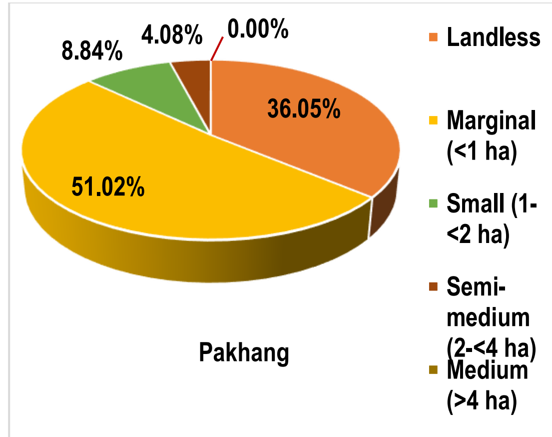


Fig. 16. Landholding Profile of selected villages of Kalimpong

Demography

Fig. 17 shows the combined demographic profile of all the surveyed villages. From the analysis of collected data on demography of the surveyed population (Fig. 17), it was revealed that maximum population (51.82%) belongs to Schedule Tribe (ST) followed by Other backward caste (OBC) which constitute about 38.65%. Lowest population (4.19%) in these villages belong to Schedule Caste (SC) and the % of general population was 5.34%. From the analysis of the population data of individual villages, 100% ST in surveyed population was found to be in Ringhim-Nampatam, North Sikkim.

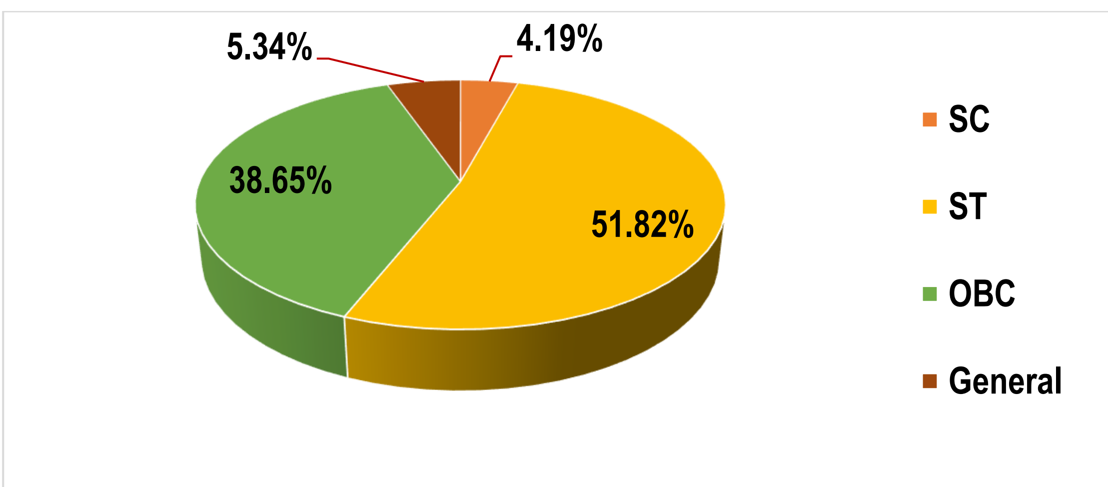


Fig. 17. Demographic profile of surveyed population in selected villages

The gender profile was obtained during the survey of the villages. The gender profile is shown in Fig. 18. From the figure, it can be seen that the ratio of male (50.12%) to female (49.9%) is almost equal.

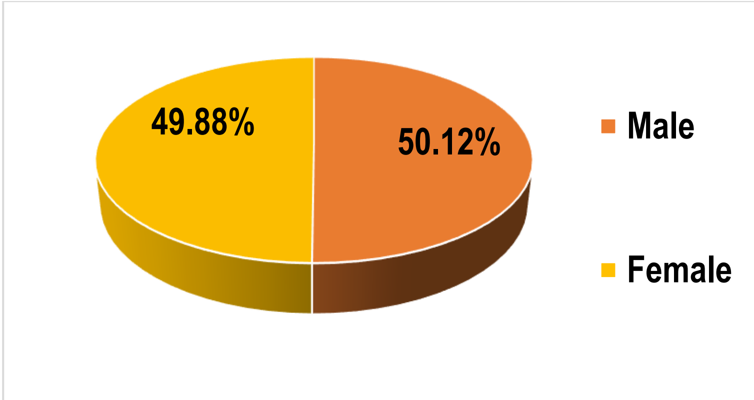


Fig. 18. Gender profile of selected villages

Literacy rate

The collected survey data was used to estimate literacy rate in the selected villages as shown in Fig. 19. From Fig. 19, it can be seen that the literacy rate of the population in the studied project area varied between 60.42% and 89.36%. Highest literacy rate (89.36%) was in Dalapchand, East Sikkim and lowest literacy rate (60.42%) was in Nessa, West Sikkim. The average literacy rate in the surveyed villages was 69.51 ± 9.05%.

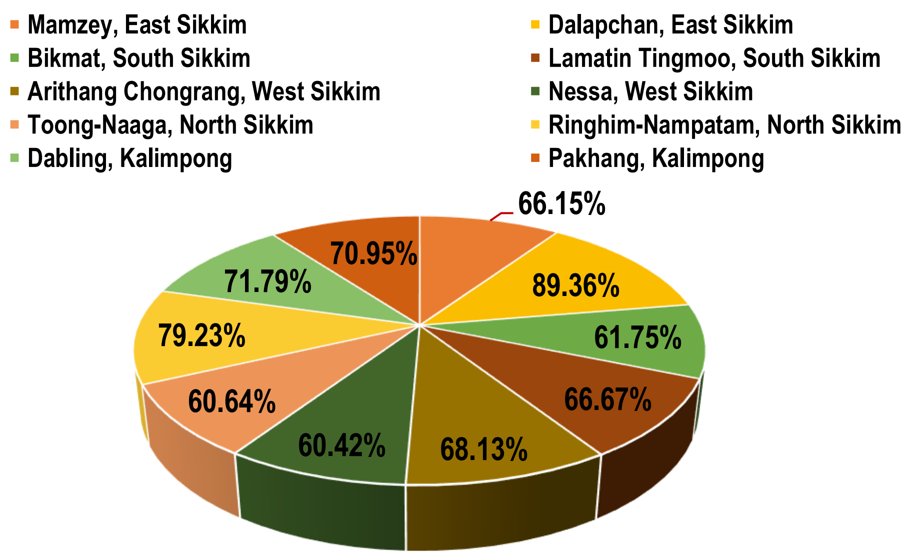


Fig. 19. Literacy profile in selected villages

Income profile

Fig. 20 presents the results of monthly household income profile of surveyed population in selected villages. From the figure, it can be observed that maximum percentage of about 27.92% of studied population lie in the income group of ₹10,000 – ₹15,000 per month followed by income group of ₹15,000- 20,000 per month. Very less number of population (only 4.12%) belong to lowest income group of below ₹5,000 per month. During the survey, it was observed that the most of the women family members of the households do not contribute much to the income (< ₹ 4000/- per month).

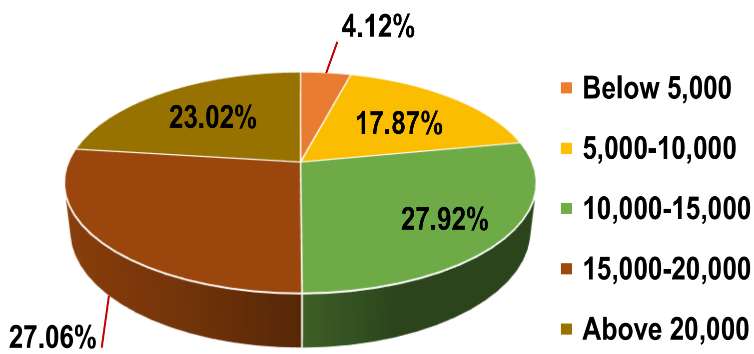


Fig. 20. Household monthly income profile in selected villages

Livelihood options

The livelihood options of the population were collected in the form of cultivation/farming, agricultural wage labour and daily wage/salary labour. Fig. 21 presents the profile of livelihood options of the surveyed population in selected villages. From the figure, it can be observed that maximum percentage of about 36.65% are working as daily wage labour other than agriculture where as lowest population (28.49%) were involved in direct agriculture/cultivation. The percentage of agricultural wage labour was 34.86%. The major livelihood options in the surveyed population were daily wage labour and agricultural wage labour. As observed during survey, women members of the households are helping in cultivation and livestock rearing. It was also observed during the survey that, most of the women members of the household are members of various SHGs and producing different kinds of pickles viz., radish pickle, dalley pickle, bamboo shoot pickle, meat pickle etc.

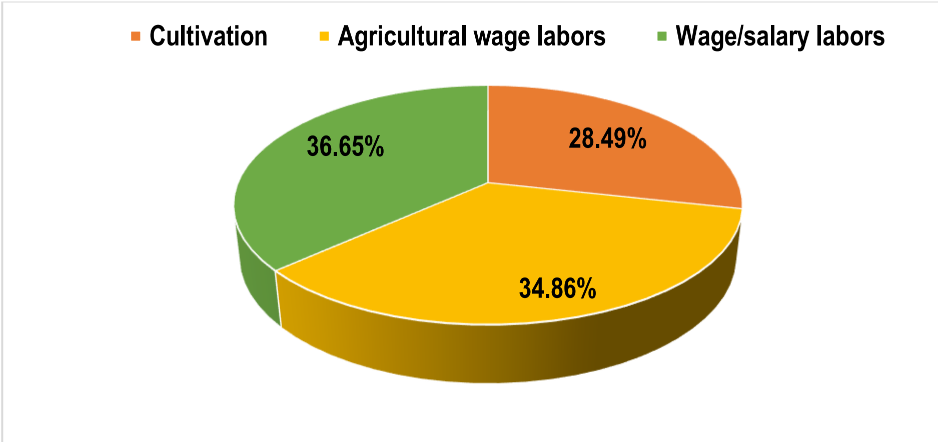


Fig. 21. Livelihood options profile in selected villages

2.0 Objective 2: Physico-chemical evaluation of cherry pepper and chayote fruits from different locations

2.1 Methodology

Chayote and cherry pepper samples were collected from different locations of selected villages, washed using tap water and were analyzed for physical characteristics. Different physical characteristics viz., dimension, arithmetic mean diameter, geometric mean diameter, surface area, sphericity, aspect ratio and unit mass were assessed.

2.1.1 <u>Analysis of physical properties</u>

Dimensions viz., length (*l*), width (*w*) and thickness (*t*) of both chayote and red cherry pepper samples were measured using digital vernier caliper (Fig. 22 and 23).

Fig. 22. Measurement of size of chayote

Fig. 23. Measurement of size of cherry pepper

About 20 numbers of chayote fruits and 50 cherry pepper samples were taken for each location for measurement of physical properties. From the measured values of dimensions, size of the samples was expressed as geometric mean diameter (D_g), and arithmetic mean diameter (D_a) using the following Eq. (1) and (2) respectively. Aspect ratio of the samples were calculated as the ratio of width to length.

$$D_g = (l \times w \times t)^{1/3} \quad \ldots (1)$$

$$D_a = \frac{l+w+t}{3} \quad \ldots (2)$$

Shape of the samples was expressed in terms of sphericity (Φ). Sphericity was estimated using the following formula (Ozturk et. al., 2009) as shown in Eq. (3).

$$\emptyset = {D_g}/{l} \quad \ldots (3)$$

Surface area (S) of the selected mature and raw cherry peppers was computed using the following expression (Eq. 4).

$$S = \left(\pi D_g^{\ 2}\right) \quad \ldots (4)$$

Unit mass of both chayote and red cherry pepper samples was measured using digital weighing balance with accuracy of 0.01 g (Shimatzu, Japan). In case of chayote, the fruit to tuber ratio was calculated by collecting information from the farmers during field visits.

2.1.2 Analysis of Chemical properties

Chayote and red cherry pepper samples collected from various locations of selected villages were analyzed for proximate composition viz., moisture content, fat content, protein content, ash content and carbohydrate content. In addition to proximate composition, pH, Total soluble solids (TSS) content, and Vitamin C content. The capsaicin content of red cherry pepper samples were also analyzed.

Moisture content of samples was measured using standard vacuum oven drying method using vacuum oven at 70°C (Ranganna,1986). The fat content was measured using soxhlet apparatus (Socs plus, Pelican, India) through solvent extraction method (AOAC, 1984). AOAC (1984) procedure was followed for ash content determination using muffle furnace. The protein content of the samples was determined by Kjeldahl procedure using Kjeldahl Nitrogen Analyzer (Pelican, India) as described in AOAC (1984). The carbohydrate content was calculated by subtracting the sum of moisture content, protein content, fat content, and ash content from 100. All measurements were carried out in triplicate. Figs. 24 and 25 depict the protein content and fat content measurement of samples.

Fig. 24. Protein content estimation of samples

Fig. 25 Fat content estimation samples

pH of chayote and cherry pepper samples were measured using digital pH meter (Satorius, India) and TSS content was measured using digital refractometer (ATAGO, Japan).

The Vitamin C content of the fresh red cherry pepper and chayote samples were determined using the method followed by Dinesh et al*.* (2015) and Adebayo (2015) with minor modifications. The reagents required were:

(a) 4% (w/v) Oxalic acid: 40g of oxalic acid were dissolved in 1000 mL of distilled water.

(b) Dye solution: 42 mg of sodium bicarbonate and 52 mg of 2, 6-dichlorophenol indophenol were dissolved in 200 mL of distilled water.

(c) Ascorbic acid stock standard: (1mg/mL): 100mg L-Ascorbic acid was dissolved in 100 mL of 4% oxalic acid.

(d) Ascorbic acid working standard: (100µg/mL): 10 mL of the ascorbic acid stock standard was diluted to 100 mL with 4% oxalic acid.

Sample extraction: The samples were cleaned with distilled water to remove adhering contaminants. 5g of the prepared sample was accurately weighed and ground using mortar and pestle with the addition of 10 mL of 4% oxalic acid. The mixture was further ground and strained through muslin cloth. The final volume of the extract was made up to 200 mL with 4% oxalic acid in a standard flask. The homogenate was then transferred into clean dried centrifuge tubes of 50 ml. The homogenate was centrifuged at 8500 rpm for 10 mins at room temperature. The supernatant was collected into vials while the residue was discarded.

Blank Titration

5ml of working standard solution with addition of 10 mL of 4% oxalic acid in a 100mL conical flask was titrated against the Dye solution till the working standard appears rose pink in colour. The amount of dye consumed is equivalent to the amount of ascorbic acid.

Sample titration

Similarly, 5ml of the supernatant of the centrifuged homogenate sample with addition of 10 mL of 4% oxalic acid in a 100mL conical flask was titrated against the dye solution till the working standard appears rose pink in colour.

The amount of ascorbic acid content in samples were calculated by following formula.

$$Amount\ of\ ascorbic\ acid\ mg/100g\ of\ sample = \frac{0.5}{V_1} * \frac{V_2}{5} * \frac{200}{Weight\ of\ sample} * 100 \quad \ldots (5)$$

Where, 0.5 = mg of standard ascorbic acid taken for titration

V1 = Volume of dye consumed by 0.5mg of standard ascorbic acid (ml)

V2 = Volume of dye consumed by 5 mL of test sample (ml)

200= Corresponds to total volume of the extract (ml)

100 = Ascorbic acid content/100g of the sample

5 = Weight of sample taken for extraction (g)

5 = Volume of the test sample taken for titration (ml)

The capsaicin content of fresh red cherry pepper samples were analyzed at CIPHET, Ludhiana in *HPLC* using C18 column. The capsaicin content in cherry pepper samples was reported in gram of capsaicin per 100g of sample (g /100g). The spicy strength of the fresh cherry pepper samples was calculated in terms of Scoville heat units (SHU) by converting the capsaicin content expressed in grams of capsaicin per gram of pepper. This conversion to Scoville heat units was done by multiplying the capsaicin content in pepper samples in dry weight by the coefficient corresponding to the heat value for pure capsaicin, which is 1.6×10^7 (Othman et al., 2011).

2.2 Results of physical and chemical properties of chayote and cherry pepper

2.2.1. Physical properties

The results of the physical properties of chayote samples are presented in Table 2. From Table 2, the average length, width and thickness of all chayote fruits collected from different locations of Sikkim and Dabling, Kalimpong were in the range of 8.85 – 11.00 cm, 5.42 – 7.21 cm and 4.78 – 6.39 cm respectively. From the comparison of geometric mean diameter of chayote samples, chayote from Dabling and North Sikkim area were found to be highest (7.75 cm) and lowest (6.3cm) respectively. Arithmetic mean diameter of samples varied between 6.62 cm and 8.02 cm. Surface area of chayote samples varied in the range of 124.63 cm^2 -190.17 cm^2. Sphericity of the samples were in the range of 0.65 to 0.81. Unit mass of chayote samples varied from 247.95 to 331.58g. From Table 2, the fruit to tuber ratio of chayote at different locations of project area were in the range of 10 - 40.

Table 2: Physical properties of chayote fruits collected from different locations

Properties	East Sikkim	SD	West Sikkim	SD	South Sikkim	SD	North Sikkim	SD	Dabling	SD
Length, cm	8.85	0.17	9.51	0.69	8.48	0.82	9.65	0.12	11.00	0.53
Width, cm	7.21	0.81	6.84	0.12	6.90	0.73	5.42	0.18	6.96	0.98
Thickness, cm	5.36	0.62	6.39	0.21	5.57	0.03	4.78	0.25	6.10	1.07
Geometric mean diameter, cm	6.98	0.05	7.46	0.22	6.88	0.48	6.30	0.16	7.75	0.94
Arithmetic mean diameter, cm	7.14	0.01	7.58	0.26	6.98	0.53	6.62	0.11	8.02	0.86
Aspect ratio	0.82	0.11	0.72	0.07	0.81	0.01	0.56	0.03	0.63	0.06
Surface area, cm^2	152.89	2.27	174.75	10.18	148.91	20.56	124.63	6.21	190.17	45.95
Sphericity	0.79	0.01	0.79	0.03	0.81	0.02	0.65	0.02	0.70	0.05
Unit mass, g	289.47	2.31	320.12	3.54	247.95	2.94	305.34	3.22	331.58	4.36
Fruit to tuber ratio	16-40		14-25		12-30		15-30		10-30	

SD: Standard Deviation

The results of the physical properties of red cherry pepper samples are presented in Table 3. From Table 3, the average length, width and thickness of all red cherry pepper samples collected from different locations of Sikkim and Pakhang, Kalimpong were in the range of 19.96 – 23.15 mm, 16.29 – 18.48 mm and 15.99 – 17.82 mm respectively. From the comparison of geometric mean diameter of samples, red cherry pepper from East Sikkim area and South Sikkim were found to be highest (19.22 mm) and lowest (17.82 mm) respectively. Arithmetic mean diameter of samples varied between 17.91 mm and 19.08 mm. Surface area of cherry pepper samples varied in the range of 999.42 mm^2 -1160.43 mm^2. Sphericity of the samples were in the range of 0.81 to 0.89. Unit mass of cherry pepper samples varied from 2.56g to 3.53g.

Table 3: Physical properties of red cherry pepper collected from different locations

Properties	East Sikkim	SD	West Sikkim	SD	South Sikkim	SD	North Sikkim	SD	Pakhang	SD
Length, mm	21.73	0.13	23.15	1.15	20.81	0.57	19.96	0.32	23.10	0.33
Width, mm	18.48	0.48	16.29	1.34	17.07	1.66	17.52	1.46	17.31	1.32
Thickness, mm	17.68	0.25	17.82	1.49	15.99	1.70	16.27	1.63	16.77	1.50
Geometric mean diameter, mm	19.22	0.30	18.87	1.36	17.82	1.05	17.84	1.19	18.85	0.95
Arithmetic mean diameter, mm	19.30	0.29	19.08	1.33	17.95	0.93	17.91	1.14	19.06	0.83
Aspect ratio	0.85	0.02	0.70	0.02	0.82	0.10	0.88	0.06	0.75	0.07
Surface area, mm^2	1160.43	36.05	1121.15	161.06	999.42	117.53	1002.23	133.37	1117.22	112.40
Sphericity	0.88	0.01	0.81	0.02	0.86	0.07	0.89	0.05	0.82	0.05
Unit mass, g	3.24	0.61	3.43	0.45	2.96	0.45	2.56	0.28	3.53	0.45

SD: Standard Deviation

2.2.2. Chemical properties

The results of the chemical properties and proximate composition of chayote and cherry pepper collected from different locations is presented in Table 4 and 5 respectively. From Table 4, pH and TSS content of chayote varied in the range of 6.66 – 7.24 and 5.17 – 5.59 °Bx respectively in selected area. From Table 4, the moisture content varied in the range of 88.62 – 94.45% wet basis. The moisture content in chayote samples of North and South Sikkim were higher compared to samples of East and West Sikkim. Moisture content in Kalimpong chayote were found to be the lowest (88.62%). The fat content in chayote samples ranged between 0.57 and 0.68 % where as protein content was in the range of 1.46-2.57%. Ash content ranged from 0.50 to 0.67 % in the samples. From the analysis of proximate composition data, the carbohydrate content in all cherry pepper samples was second highest (2.76-7.60%) after moisture content. The vitamin C content of chayote samples collected varied in the range of 9.38-16.17 mg/100g. Samples from West and North Sikkim were found to be rich in Vitamin C compared to chayote from other villages. From ANOVA, the variation in fat and protein content was found to be non significant where as the variation in all other properties was found to be significant ($p<0.05$).

Table 4: Chemical properties and proximate composition chayote fruits collected from selected villages

Properties	East Sikkim	North Sikkim	South Sikkim	West Sikkim	Dabling
pH	6.66±0.04	7.24±0.1	7.18±0.13	6.61±0.39	7.16±1.12
TSS, °Bx	5.59±0.13	5.17±0.56	5.26±0.16	5.59±0.13	5.27±0.10
Vitamin C, mg/100g	9.38±2.5	12.72±3.42	14.92±1.47	16.17±1.01	10.60±0.73
Fat content, %	0.68±0.07	0.60±0.07	0.57±0.15	0.59±0.03	0.58±0.04
Protein content, %	1.51±0.11	1.46±0.1	1.71±0.87	1.56±0.59	2.57±0.27
Moisture content, %	89.59±0.98	94.26±0.95	94.45±1.1	91.41±2.35	88.62±2.39
Ash content, %	0.67± 0.08	0.5± 0.06	0.51± 0.05	0.53± 0.06	0.63± 0.04
Carbohydrate content, %	7.55±0.91	3.19±0.86	2.76±0.81	5.90±1.81	7.60±2.59

From Table 5, the pH and TSS content of red cherry pepper varied in the range of 5.71-6.66 and 10.38-11.22 °Bx respectively. From proximate analysis, the red cherry pepper samples were found to be higher in carbohydrate content (9.8-10.82%) and lower in fat content (1.83-2.34%). The moisture content in the samples varied in the range of 84.64 – 85.28% wet basis. The ash content in cherry pepper samples varied in the range of 0.71 – 0.81%. Vitamin C content was in the range of 102.87-123.13 mg/100g for red cherry pepper collected from selected villages indicating it to be a rich source of Ascorbic acid. From ANOVA, significant variation in pH of samples were observed whereas the variation in all other properties were found to be nonsignificant. The capsaicin content in the cherry pepper samples collected from various locations ranged from 0.67 -1.51 g/100. The SHU of fresh red cherry pepper samples collected from different locations as calculated from capsaicin content ranged from 107200 to 241600 respectively. All the red cherry pepper samples collected from various locations can be classified as very highly pungent as the Scoville Heat Unit (SHU) values exceed 80,000 (Nwokem et al., 2010).

Table 5: Chemical properties and proximate composition Red Cherry pepper collected from selected villages

Properties	East Sikkim	North Sikkim	South Sikkim	West Sikkim	Pakhang
pH	5.71±0.5	6.13±0.01	6.63±0.13	6.66±0.28	6.4±0.1
TSS, °Bx	10.67±0.48	11.07±0.06	10.89±0.3	11.22±0.3	10.38±0.64
Vitamin C, mg/100g	105.52±6.45	123.13±6.1	110.65±10.32	114.51±14.66	102.87±4.83
Fat content, %	2.21±0.28	2.34±0.71	1.92±0.29	1.83±0.26	2.03±0.07
Protein content, %	2.45±0.08	2.4±0.07	2.03±0.39	2.0±0.18	2.4±0.07
Moisture content, %	84.68±0.51	84.71±0.44	85.28±1.05	84.64±2.28	85.17±1.89
Ash content, %	0.81±0.04	0.74±0.04	0.72±0.06	0.71±0.03	0.76±0.09
Carbohydrate content, %	9.85±0.19	9.8±0.99	10.06±1.69	10.82±2.22	9.91±1.98
Capsaicin content, g/100g	1.0	1.2	1.51	1.5	0.67

3.0 Objective 3: Development of small-scale primary processing machines for cherry pepper and chayote fruits

Primary processing of chayote consists of washing, peeling, decoring and cutting. Peeling and decoring (removal of central hard core/stone) from chayote are two cumbersome operations in its primary processing. Focus was given on these unit operations for chayote in the present study. During processing of cherry pepper, the tail/stem of the pepper needs to be removed especially before converting it to value added products. In the present study, the detailing/desteming operation of the cherry pepper has been taken into consideration for development of suitable machine.

3.1 Peeling of chayote

During peeling of chayote, a gummy, irritative substance is released from the surface below the skin which is termed as sap. In addition, it is tough skinned vegetable hence difficult to peel off. Traditionally, house women, make a cut over the surface of chayote and dip in the water (perpendicular) to ooze out the chemical present in it. The only problem when peeling is the sap, a transparent substance that the chayote produces. When peeling it, the sap sticks to the hands creating an uncomfortable feeling of irritation and numbness accompanied with loosening of outer skin from palm. Hence, developing suitable machine/method for peeling of chayote is needed. However, instead of developing new machines, existing peeling machines and methods used for other similar crops were evaluated for chayote in the present study to test its efficacy.

3.1.1 Performance evaluation of different peeling methods for chayote

In the present study, three different peeling methods viz., manual, mechanical abrasive peeling using abrasive peeler and lye peeling were selected for chayote in order to assess their performance.

Peeling experiments

Fresh, mature and tender fruits of chayote were procured from selected villages. The chayote fruits were washed thoroughly in water. Manual peeling was performed by using knives and used as a control. Abrasive peeler of 10 kg capacity was used for mechanical abrasive peeling of chayote (Fig. 26). Experiments were conducted for different peeling time (4, 6, and 8 minutes) and at different loading capacity (50% and 75% loading capacity).

The sodium hydroxide (NaOH)/lye solution was prepared in different concentrations. In lye peeling, three independent parameters viz., NaOH solution (8-12% concentration), lye solution temperature (70-90°C) and peeling time (4-8 min) were taken. Dependent parameters like peeling percentage, peelability, peel loss, unpeeled percentage were recorded to evaluate these peeling methods. The experiment was designed using Taguchi orthogonal array design (L27). Figs. 27 – 30 show a comparison of chayote samples peeled through different peeling methods. The optimization of independent parameters was done based on the desirable responses.

Fig. 26. Abrasive peeling of chayote

Fig. 27. Raw chayote

Fig. 28. Manually peeled chayote

Fig. 29. Mechanical peeled chayote

Fig. 30. Lye peeled chayote

The peeling percentage was calculated as the ratio of the weight of fully peeled chayote to the total weight of chayote processed in that batch expressed as %. Peel loss was calculated from the weight of pulp adhering to the peeled skin after peeling. The ratio of pulp lost during peeling to the initial weight of chayote was expressed as peel loss %. The total amount of skin that was not removed and adhered to the parent chayote was calculated by USDA standardized grid square method (inspection AID 30B, USDA AMS). According to this method, the remaining peel or skin of fruit after peeling was manually removed and the removed skin was kept on the 1mm^2 grids for the measurement of surface area. The ratio of surface area of these unpeeled sking to initial total surface area of chayote was expressed as unpeeled percentage (Pan et al., 2009). Peelability % was calculated by taking the ratio of the surface area of the peeled skin to the surface area of unpeeled skin (Li et al., 2014).

Evaluation of different peeling methods

Manual peeling of chayote resulted in peeling percentage of 92.08%, peel loss of 2.33%, unpeeled percentage of 2.76 %, and peelability of 97.14%. Table 6 shows the results of mechanical abrasive peeling at different experimental conditions. From Table 6, highest peeling percentage of 80.65% was observed for 8 min at 50% capacity, however the peeling loss of 11.89 % was also highest at the same condition. The peelability % was higher in case of 75% capacity operated for 4 minutes. The study revealed that peelability % reduced (from 82% to 60.47%) with increase in peeling time at 75% loading capacity and opposite trend was observed in case of 50% loading capacity (Table 6). However, the peel loss % was higher when peeling was done at 50% capacity of peeler. This indicates that the time and capacity both were crucial factors affecting peeling. The increased capacity assisted the abrasion as friction between the chayote samples increased. More the time of peeling, more would be the contact between abrasive surface and samples resulted in excessive peeling of surface i.e. more peeling loss. From Table 6, mechanical abrasive peeling at 75% loading capacity and operating time of 4 minutes may be recommended based on highest peelability %, lowest unpeeled percentage, and lower peel loss %. The performance of abrasive peeler could be considered as better if capacity was the only performance indicator.

Table 6: Performance of mechanical peeling of chayote using abrasive peeler

Time of operation, min	Loading Capacity, %	Peeling Percentage, %	Peel loss, %	Unpeeled percentage (%)	Peelability (%)
4	50	57.08	7.21	35.21	64.79
6	50	68.47	8.56	31.85	68.15
8	50	80.65	11.89	19.12	70.87
4	75	76.35	2.95	14.00	82.00
6	75	79.41	3.43	20.25	75.75
8	75	79.45	2.91	29.53	60.47

For lye peeling, total of 27 experiments were carried out for lye peeling. During experimentation, nine experiments (Table 7) were repeated in triplicates to make up for 27 experiments. Table 7 shows the results of lye peeling at different experimental conditions. From Table 7, peeling %

varied in the range of 81.48 – 93.44%, peel loss varied in the range of 3.46 – 6.3%, unpeeled % varied in the range of 5.78% - 19.62% and peelability % were in the range of 80.38 – 91.42%. ANOVA was carried out using Minitab software to study the effect of independent variables on the responses. From the ANOVA, the response variables were found to be significantly ($p<0.05$) affected by the treatment combinations. However, washing under tap water was essential after peeling to remove peels.

For optimization of lye peeling conditions, highest peeling %, highest peelability, lowest unpeeled % and lowest peel loss % was taken as the desirable criteria. From the observation of Table 7, lye peeling conditions of 12 % NaOH concentration, 90°C temperature and 6 minutes peeling time resulted in highest peeling percentage of 93.44 %, highest peelability of 84.22%, lowest unpeeled percentage of 5.78%, and peel loss of 4.20%. Though peel loss % was not lowest at this condition, the difference between the lowest and this value was not much. Hence, lye peeling at 12 % NaOH concentration, 90°C temperature and 6 minutes peeling time followed by washing may be recommended as optimized lye peeling condition. The peeling %, peel loss %, unpeeled % at this treatment was higher and peelability % was lower compared to manual peeling.

Table 7: Performance of Lye peeling of chayote

Lye Concentration, %	Lye Temperature, °C	Peeling time, min	Peeling %	Peel loss, %	Unpeeled percentage (%)	Peelability (%)
8	70	4	92.46	4.56	11.87	88.13
10	80	6	85.56	3.86	12.80	87.47
12	90	8	86.59	5.84	10.92	89.08
8	70	4	87.40	6.30	8.58	91.42
10	80	6	81.48	5.07	11.68	88.32
12	90	8	89.15	6.07	9.45	90.55
8	70	4	88.91	3.46	19.62	80.38
10	80	6	87.28	3.53	10.13	93.20
12	90	8	93.44	4.20	5.78	94.22

Fig. 31 shows the comparison of different peeling methods. The comparison was done on the basis of recommended peeling conditions for lye and abrasive peeling. From the figure, it can be observed that the peeling performance parameters in case of lye peeling is close to manual peeling. Mechanical abrasive peeling showed poor results compared to other peeling methods. Manual peeling capacity was about 17.5 kg/h. However, capacity in abrasive peeling method at the recommended conditions was about 112.5 kg/h. Lye peeling capacity would be higher than both manual and abrasive peeling depending on the capacity of the tank used for lye treatment. Based on the comparison of all these peeling methods, lye peeling at 12 % NaOH concentration, 90°C temperature and 6 minutes peeling time followed by washing may be recommended for peeling of chayote.

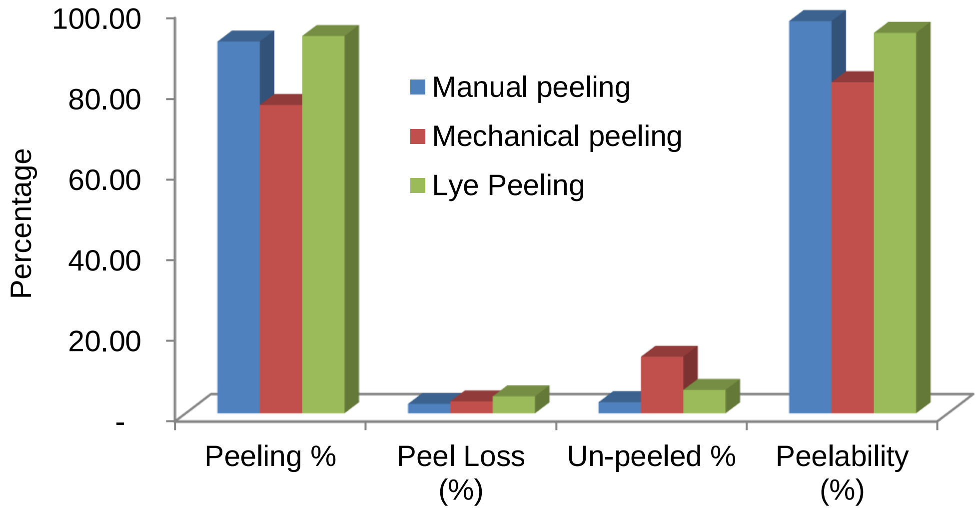


Fig. 31. Comparison of different peeling methods of chayote

3.2 Design and development of chayote corer

The conventional method of coring chayote involves cutting the fruit in half lengthwise with a knife. Therefore, cutting and core removal of a chayote fruit is not only difficult but is also a time-consuming affair and hence the value addition like minimal processing, pickling, etc. are not yet done commercially. It takes about one min per fruit depending on the skills of a person cutting the fruit and the maturity of fruit. The fruit is firm and thin layered however the seed/kernel is hard and fibrous similar to mango kernel for which the knife must be ensured of sharped edged. However, the stem end is small and other end is broad resulted in loss during seed removal. Further, there is a possibility for the operator to be subjected to injury. Inadequate or improper core removal of chayote may cause problems in other processing stages such as pulping or juice extraction. It is therefore, important to cut chayote properly in order to facilitate the removal of core from fruit with minimum loss. As the traditional cutting method is very slow and time consuming, the quantity of fruits, a farmer can process is limited (Onyemelukwe 1991). The foregoing scenario demands the invention of a mechanical tool or machine capable of coring entire chayote with increased cutting speed and capacity. A chayote has irregular and variable shapes and sizes; therefore, sharpness of the cutter is to be designed in a way such that it is able to cut fruits of all sizes with minimum loss. Considering the constraints, in the present study a prototype for hand operated chayote corer was developed.

3.2.1 Design and fabrication of a hand operated chayote corer prototype

For the development of a hand operated chayote corer prototype, the following factors were considered.

a) Suitability of machine for core/seed removal for different size and shape of the fruit.
b) Ease of operation
c) Less labour requirement
d) Simplicity, low cost of fabrication, durability, availability of material at the time of fabrication.
e) Physical and textural properties of chayote fruit and kernel

Physical and textural properties of chayote fruit and kernel were measured prior to the design of the prototype. The physical properties (dimensions and radius of curvature) of both chayote fruit and kernel were measured using digital vernier caliper. The radius of curvature of kernel is important for deciding curvature in the blade so that the pulp can be removed cleanly with minimum losses. It was calculated using the given equation (Burubai et al., 2007).

$$R = \frac{b^2 + a^2/4}{2b} \qquad \ldots(6)$$

Where, R= radius of curvature (mm)

a= length of seed (mm)

b= width of seed (mm)

In textural properties, the cutting strength of chayote fruit was measured using texture analyzer (Stable micro systems) through cutting test. The pre-speed of the test was set at 3 mm/sec and post test speed was 10 mm/sec. The force-deformation plots were used to determine the cutting strength of chayote fruits.

The design of the prototype was done using CATIA. Based on these data of physical properties of chayote fruit and kernel, and the conceptual design, the dimensions of cutter and its components were decided. The prototype of hand operated chayote corer consists of a) Platform, b) core cutting assembly (cutting blade, shaft, spring, PVC solid bar and supporting rod), c) Fruit holder, d) Handle and frame. The conceptual design drawing (3 D) along with dimensions is presented in Fig. 32. The design and fabrication of individual parts are given in following sections.

A) Platform, fruit holder and handle: The platform is a component of the corer prototype on which whole assembly was fitted. The platform was made in form of a rectangular box using SS square pipe and MS sheet iron. Fruit holder (Fig. 33) has the purpose of holding the fruit during the operation and when the cutting blade is moved upwards after separating the core part. During operation, fruit is positioned in the fruit holder fixed on the platform and force is applied to the cutting blade through handle. Additionally, PVC board of dimension 450 mm × 300 mm × 10 mm was fixed above SS platform in order to avoid scratches and slip of fruit during cutting. A handle (lever) is attached to the core cutter which is made up of a mild steel rod/pipe. To facilitate the ease of operation, comfort and mobility, the handle length was varied at three different lengths as 28 cm, 24 cm and 20 cm for testing. The handle was made from the round pipe which was fixed to SS flat.

B) Core cutting assembly: The cutting blade is the major component of core cutting assembly (Fig. 34) of the prototype. It is designed to remove central core i.e., seed from the pulp/ flesh of the fruit. Two types of blades (serrated and plane) were taken for the purpose. Each blade unit consists of two curved blades joined to form oval shape which is cross sectional shape of seed. The curved shape was selected for efficient cutting of pulp from seed. The blades were connected to the shafts from both ends (round pipe) which moves up and down when handle is moved. The spring were used on the shaft to easily move assembly upward on release of handle.

The design of the blade was based on the average radius of curvature of a chayote kernel i.e 33.19 mm. A factor of safety of 25% for the blade was taken as to avoid kernel damage. The length of the blade was calculated by the following Eq. (7) (Kumar et al. 2018): The length of blade was calculated to be 60.77 mm i.e 61 mm.

$$L_B= L_c+S_b+S_w \quad \ldots (7)$$

Where, L_B = Length of blade

L_c = intermediate dimension of the chayote seed

S_b = clearance between cutting blade and chayote resting seat

S_w = space of welding in head cylinder

After the conceptual design, the machine was fabricated locally and Fig. 35 shows the pictorial view of the developed prototype.

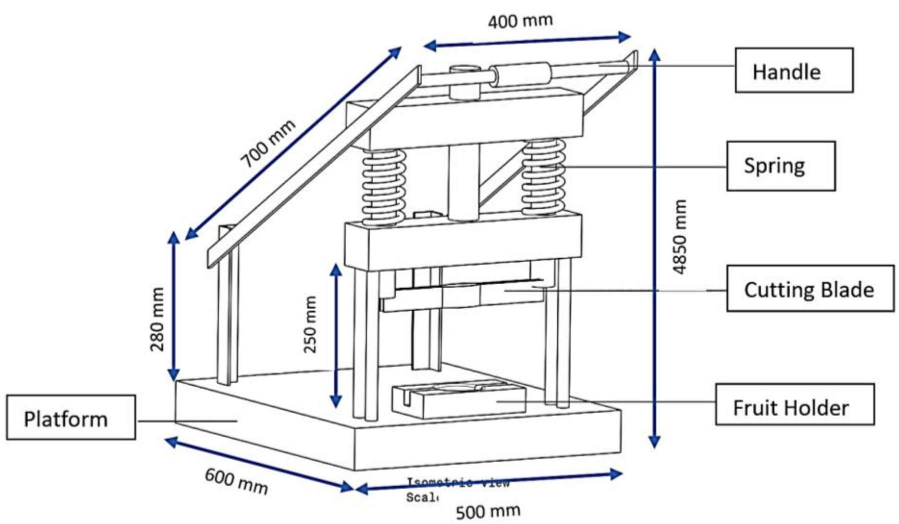


Fig. 32. 3D drawing of the designed hand operated chayote corer

Fig. 33. Fruit holder

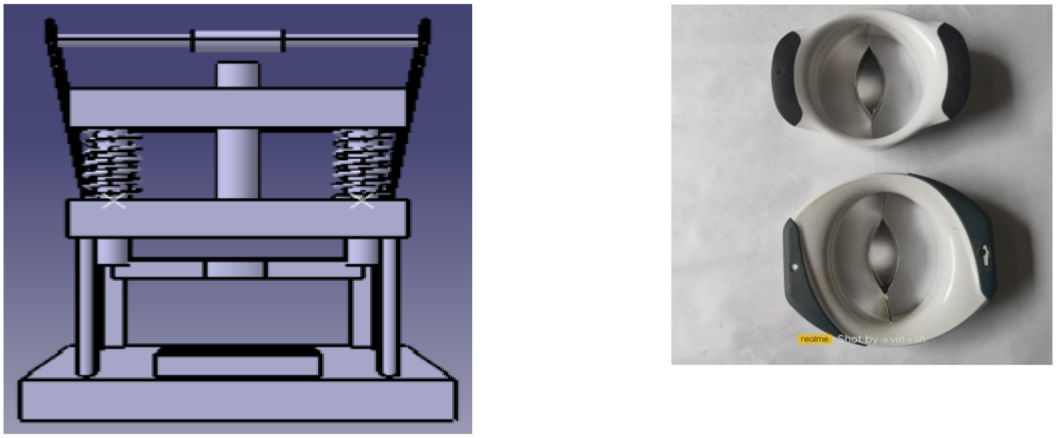


Fig. 34. Core cutting assembly

Fig. 35. Pictorial view of the developed chayote corer prototype

3.2.2 <u>Performance evaluation of prototype of hand operated chayote Corer</u>

After the design and fabrication of the prototype, experimental trials were carried out for evaluating its performance. The testing was done for following independent variables:

a) Type of blade: Plane and serrated
b) Length of handle: 20 cm, 24 cm and 28 cm
c) Type of gender: Male and Female
d) Fruit type: with peel and without peel

A full factorial design with three replications were followed for the performance trials. Table 8 shows the experimental design for chayote fruit with peel. Same design was replicated for chayote without peel. The performance was evaluated in terms of kernel yield (%), pulp yield (%), capacity (kg/h), efficiency (%) and pulp loss (%) (Nayak and Rayaguru, 2017). The kernel yield (%) was calculated from the ratio of mass of kernel to the overall mass of fruit and was expressed in the percentage. The pulp yield was determined from the ratio of mass of pulp extracted to the overall mass fruit and was expressed in the percentage. The corer efficiency was measured as the ratio of the weight of flesh and sum of weight of flesh and weight of flesh on kernel and was expressed in %. The capacity (kg/h) of the machine was determined by measuring the mass of fruits processed and the time of operation. The pulp loss (%) was measured by the ratio of the weight of flesh on kernel and sum of weight of flesh and weight of flesh on kernel. Traditional method of core removal was also performed for comparison. The average reading of three replications were considered.

Table 8: Experimental design for performance evaluation of corer to remove core from fruit with peel

Sl. No.	Type of blade	Length of handle:	Type of gender	Treatment code
1.	Plane	20	Male	PL1M
2.	Plane	20	Female	PL1F
3.	Plane	24	Male	PL2M
4.	Plane	24	Female	PL2F
5.	Plane	28	Male	PL3M
6.	Plane	28	Female	PL3F
7.	Serrated	20	Male	SL1M
8.	Serrated	20	Female	SL1F
9.	Serrated	24	Male	SL2M
10.	Serrated	24	Female	SL2F
11.	Serrated	28	Male	SL3M
12.	Serrated	28	Female	SL3F

Results of performance evaluation of chayote corer

The results of the performance evaluation of the chayote corer have been shown in Table 9 and 10 respectively for chayote fruit with peel and without peel respectively. The traditional method of core removal showed 100% efficiency with 90% pulp yield and 10 % kernel yield. However, the capacity was only 13.85 kg of fruits per hour.

Table 9: Performance evaluation of developed prototype for chayote core removal (with peel)

Treatment	Kernel yield (%)	Pulp yield (%)	Capacity (kg/h)	Efficiency (%)	Pulp loss (%)
PL1M	13.65	66.58	71.81	77.13	22.87
PL1F	11.87	46.22	80.64	52.27	47.73
PL2M	12.48	66.72	80.82	76.35	23.65
PL2F	14.51	69.83	86.33	81.68	18.32
PL3M	10.00	69.65	111.05	77.44	22.56
PL3F	9.86	44.74	59.79	50.24	49.76
SL1M	12.48	72.08	81.39	82.40	17.60
SL1F	11.09	21.54	33.87	23.95	76.05
SL2M	10.45	74.18	62.98	82.91	17.09
SL2F	7.92	46.45	45.89	50.16	49.84
SL3M	10.89	74.21	64.10	83.28	16.72
SL3F	9.01	21.85	68.37	24.32	75.68
Significance	NS	NS	S	NS	NS
CD @ 5%	29.00	42.78	38.17	47.61	47.61
CV	5.50	44.97	31.93	44.27	77.05

Table 10: Performance evaluation of developed prototype for chayote core removal (without peel)

Treatment	Kernel yield (%)	Pulp yield (%)	Capacity (kg/h)	Efficiency (%)	Pulp loss (%)
PL1M	15.43	66.60	71.94	78.79	21.21
PL1F	11.16	38.32	53.03	43.63	56.37
PL2M	18.09	65.14	82.65	79.54	20.46
PL2F	13.19	64.25	79.17	73.99	26.01
PL3M	13.86	38.69	44.87	46.47	53.53
PL3F	10.04	42.40	57.87	47.56	52.44
SL1M	11.56	72.29	71.20	81.71	18.29
SL1F	11.60	48.82	68.75	56.49	43.51
SL2M	8.65	73.99	104.41	81.01	18.99
SL2F	14.23	67.53	74.12	78.75	21.25
SL3M	12.51	70.07	75.22	80.11	19.89
SL3F	14.22	66.59	73.31	77.74	22.26
Significance	NS	NS	S	NS	NS
CD@5%	4.98	34.89	42.40	34.92	40.70
CV	22.83	35.19	35.08	40.70	77.07

***Kernel Yield** %*

From Table 9, the highest kernel yield % (14.51%) from chayote fruit with peel was obtained for PL2F i.e. plane blade, 24 mm length of handle and operated by female gender; whereas lowest (7.92 %) was observed for SL2F i.e. serrated blade, 24 mm length of handle and operated by female. The highest kernel recovery (18.09 %) from chayote fruit without peel was observed for PL2M i.e., plane blade, 24 mm length of handle and operated by male gender, whereas lowest (8.65 %) was observed for SL2M i.e. serrated blade, 24 mm length and operated by male (Table 10). From ANOVA, the interaction effect of independent variables did not have significant effect on the kernel yield but the individual variable was having significant effect on the kernel yield. Figs 36 and 37 show the effect of independent variables on the kernel yield (%) for chayote with peel and without peel respectively. It showed that the kernel yield was higher when the prototype was operated by male for core removing for all types of fruit and blades.

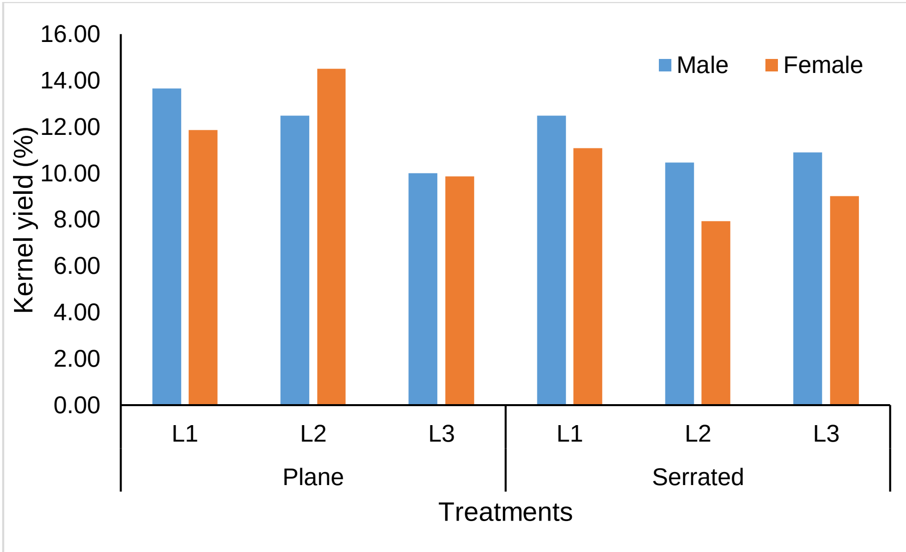


Figure 36. Effect of treatments on kernel yield % (with peel)

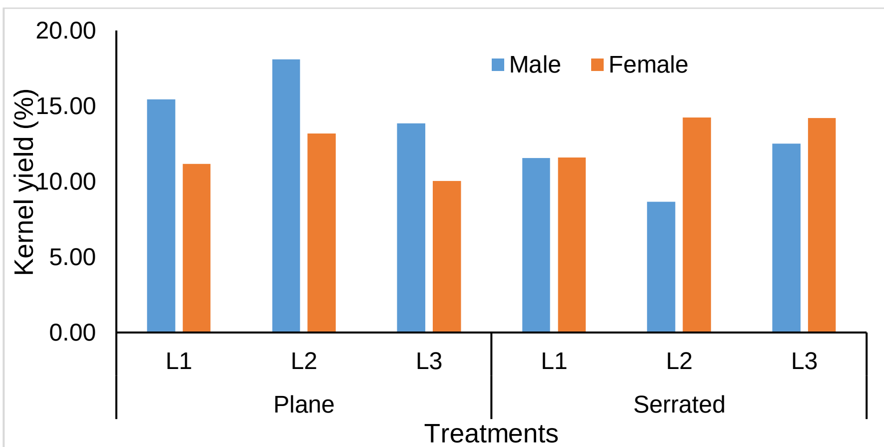


Figure 37. Effect of treatments on kernel yield % (without peel)

Pulp Yield %

From Table 9, the highest pulp recovery (74.21%) from chayote fruit with peel was obtained for SL3M i.e., serrated blade, 28 mm length of handle and operated by male; whereas, the lowest pulp recovery (21.54%) from chayote fruit with peel was observed for SL1F i.e., serrated blade, 24 mm length of handle and operated by female. The highest pulp recovery (73.99%) from the fruit without peel was observed for SL2M i.e., serrated blade, 24 mm length of handle and operated by male gender; whereas the lowest pulp yield (38.32 %) was observed for PL1F i.e. plane blade, 20 mm length of handle and operated by female gender (Table 10). The statistical analysis using ANOVA showed that there was no significant effect of combination of independent variable on pulp yield but the individual variable has significant effect on the pulp yield. It may be due to variable thickness of pulp or flesh on the kernel. The size of fruit was highly variable than the kernel resulted in the yield of different quantities of pulp when it was separated using the prototype. The maturity of the fruit and variety also has role in the pulp yield which is need to be studied in the future. The graphical representation of the effect of treatments on the pulp yield has been given in the Fig. 38 and 39 for chayote with peel and without peel respectively. It was observed that the pulp yield was more when the prototype was operated by the male gender for fruits with and without peel. Moreover, the serrated blade has more pulp yield that the plane blade for both fruits with and without peel.

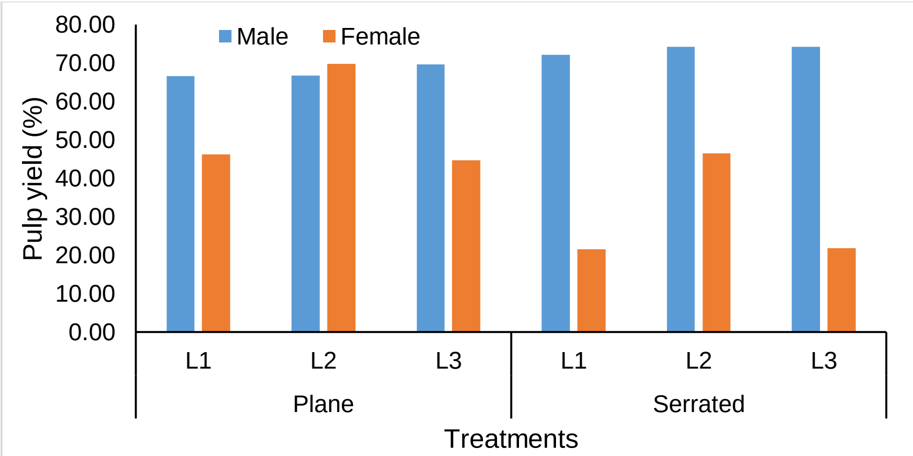


Figure 38. Effect of treatments on pulp yield (with peel)

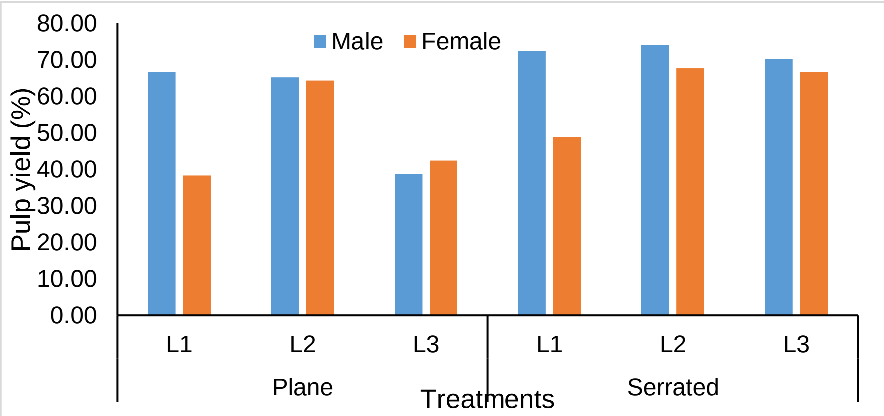


Figure 39. Effect of treatments on pulp yield (without peel)

Capacity

The highest capacity of the developed prototype for removing kernel from the fruit with peel was found to be 111.05 kg/h for PL3M i.e., plane blade, 28 mm length of handle and operated by the male (Table 9). The lowest capacity for removing kernel from fruit with peel was found to be 33.87 kg/h for SL1F i.e., serrated blade, 20 mm length of handle and operated by the female. In case of fruits without peel, the capacity of core removing varied from 104.41 kg/h (SL2M) to 44.87 kg/h (PL3M) (Table 10). The statistical analysis using ANOVA showed that the combination of independent variable was having significant effect on the capacity of the developed prototype for removal of chayote kernel. Highest capacity was observed for removing kernel from the fruit with peel. It may be due to textural properties of peel resulting in sharp, uniform and quick cut. From Figs. 40 and 41, plane blade showed more capacity than serrated blades. But the serrated blade showed positive results when operated by the female gender.

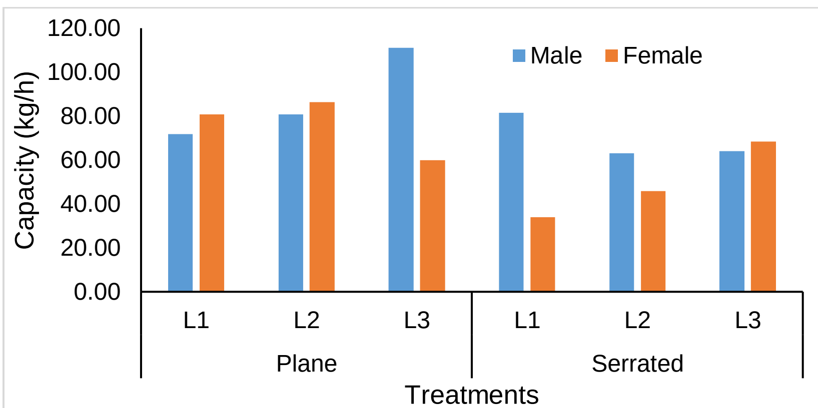


Figure 40. Effect of treatments on capacity (with peel)

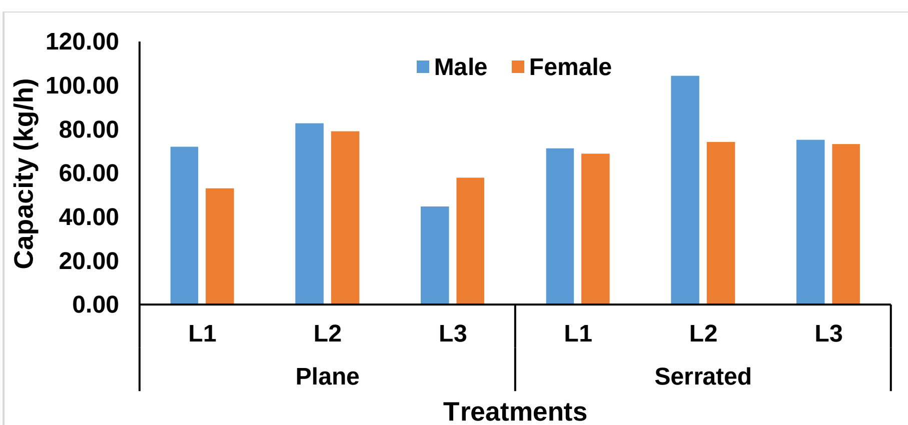


Figure 41. Effect of treatments on capacity (without peel)

Efficiency

Maximum efficiency of the developed corer prototype was found to be 83.28% for removing kernel from fruit with peel and for treatment combination of SL3M i.e., serrated blade, 28 mm length of handle and operated by male gender as observed form Table 9. The lowest results for removal of kernel from fruit with peel was 23.95 % for SL1F i.e., serrated blade, 20 mm length of handle and when operated by female. In case of fruits without peel, the efficiency of core removal was varied from 81.71 % (SL1M) to 43.63 % (PL1F). The analysis of variance showed that the treatments did not have significant effect on the efficiency of core removal from fruit with peel and without peel. From Table 9 and 10, the serrated blade operation was giving better efficiency when operated by the male gender for both fruit with peel and without peel.

Pulp Losses

Pulp loss occurs due to inadequate penetration blade or smaller size of kernel. Smaller size of kernel left more clearance between kernel and the blade which resulted in the loss. The minimum losses of 16.72 % and 18.29 % were observed for separation of kernel from fruit with and without peel, respectively (Table 9 and 10). However, the treatments were having non-significant effect on the pulp loss when it was analyzed using ANOVA and 95% level of significance. As observed from Table 9 and 10, less pulp losses occurred when operated by the male gender for removing kernel from fruit both without peel and with peel.

Optimization of process variables for chayote corer

Developed hand operated chayote corer prototype aimed to reduce labour requirement, time and ease of the operation. Thus, during optimization of the prototype capacity was given importance followed by the efficiency. So, treatment with highest capacity and efficiency was selected as optimum and recommended for utilization. Based on this criteria, combination of plane blade, 28 length of handle and a male operator resulted in highest capacity (111.05 kg/h) and moderate efficiency (77.44 %) for fruit with peel whereas combination of serrated blade, 24 mm length of handle and a male operator provided highest capacity (104.41 kg/h) and second highest efficiency (81.01 %) for fruit without peel. Hence, the above two combinations may be recommended during operation of the prototype for fruit with and without peel. Though developed prototype could be operated by both genders, better results were obtained for male gender. Hence, suitable ergonomic modifications may be made through future research to make the prototype gender friendly.

3.3 Design and development of a cherry pepper destemmer prototype

Cherry pepper processing involves removal of stem/tail prior to further conversion into any value added products. Presently, the tail is being removed manually by hand. This leads to burning of all contact skin parts due to the high pungency of the chilli. In addition, the manual method is laborious and time-consuming which limits the capacity of processing cherry pepper. Hence, the present study was undertaken to design and develop a prototype of cherry pepper destemmer.

3.3.1 <u>Design and fabrication of a cherry pepper destemmer prototype</u>

For the development of a cherry pepper destemmer prototype, the following factors were considered.

a) Simplicity, low cost of fabrication, availability of material at the time of fabrication.
b) Ease of operation
c) Suitability of machine for processing different size of cherry pepper.
d) Less labour requirement
e) Physical properties of cherry pepper and its stem

The data on size (physical property) of cherry pepper was collected from the results of physico-chemical evaluation of cherry pepper as discussed in Section 2.0. The length and diameter of cherry pepper stem were measured using digital vernier calliper prior to the design of the prototype. Bulk density of cherry pepper was also measured through standard methods. For the design of the prototype 10 kg/batch of cherry pepper was considered. Based on the data of physical properties of cherry pepper and its stem, the conceptual design of the prototype was developed using CATIA.

The main components of the designed cherry pepper destemmer were a) Base Frame b) Rotating drum/cage c) Stem cutting mechanism d) Outer cover e) Discharge tray. The design and fabrication of individual parts are given in following sections.

A) Base Frame: The base frame supports the rotating drum and the outer cover of the drum during operation. It was made from mild steel angle iron of 35 x 35 X 5 mm. The frame dimensions were 530 mm X 420 mm X 405 mm. All other parts of the machine were fixed using bolts and nuts for easy maintenance.

B) Rotating drum/cage: The rotating drum/cage was a cylindrical drum in which cherry pepper was loaded during operation. It was assumed that the drum would be operated maximum ½ filled loading capacity i.e. volume of the drum for free movement of cherry pepper during operation. The cylindrical drum/cage should be enough to hold 10 kg of cherry pepper at ½ loading capacity. Using the measured cherry pepper bulk density value of 650 kg/m^3, the volume of the drum was calculated as 0.015 m^3. Actual volume of the drum was taken as double this value i.e. 0.030 m^3. Assuming the diameter of the drum to be 300 mm, the length of the rotating cage was calculated to be 435 mm. The rotating drum was fabricated in the form of wedge wire drum using MS iron rods bent into circular rings and attached through MS iron flats. The gap between two consecutive rings was kept as 12 mm which was lower than the thickness (lowest dimension) of cherry pepper. Both ends of the drum were closed using circular MS iron sheet. A chute/opening was provided in one of the end sheets for loading/unloading of cherry pepper which was closed with a shutter during operation. Fig. 42 shows the isometric view of the designed rotating drum. The rotating drum was mounted on a 20 mm ϕ MS shaft.

Fig. 42. Isometric view of the rotating drum

C) Steam cutting mechanism: A cutting blade made up of high carbon steel with a sharp edge was used for cutting of the cherry pepper stems protruding out of the drum during its rotation. The blade was fixed on the frame at an angle of 45° with the horizontal. The length of the cutting blade was equal to the length of the drum.

D) Outer cover and discharge tray: An outer protecting cover made up of MS sheet was provided to cover the rotating drum during operation. A discharge tray was fixed below the rotating drum to for collection of destemmed cherry pepper.

The developed cherry pepper destemmer prototype with all components is shown in Fig. 43. The prototype was powered by a single phase 1 HP motor and power was transmitted to the rotating drum through belt and pulley transmission system. The overall dimensions of the developed prototype was 535 mm X 445 mm X 760 mm.

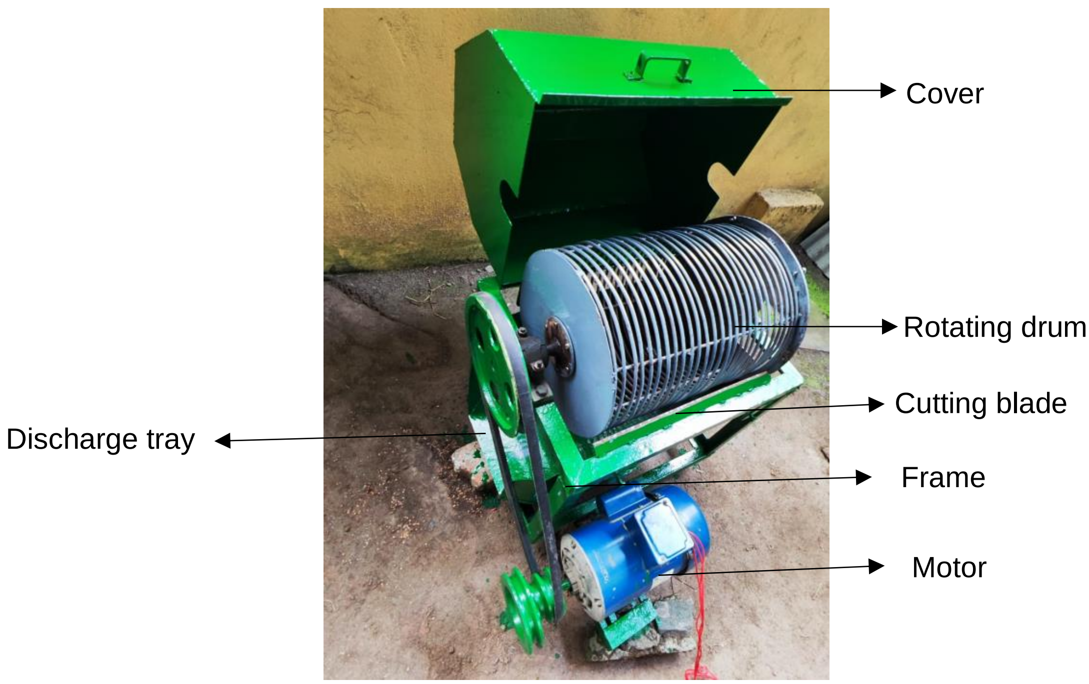


Fig. 42. Cherry pepper destemmer prototype

3.3.2 <u>Performance evaluation of cherry pepper destemmer prototype</u>

After the design and fabrication of the prototype, experimental trials were conducted for evaluating its performance. During operation, the speed of the rotating drum was kept above the critical speed of the drum to facilitate centrifuging action of the cherry pepper. Due to centrifuging, the stem of the cherry pepper would stick to the walls and protrude through the gaps provided in the drum resulting in its removal by the cutting blade. Experiments were conducted at two loading volumes (1/4th, 1/3rd and ½ loading capacity) and two operating speeds (475 rpm and 792 rpm). to assess the performance. The machine was operated for about 02 minutes for each batch of processing based on preliminary trials. The total time of processing (loading, unloading, destemming) was about 10 minutes per batch. Total six batches could be processed in one hour. A full factorial design with three replications were followed for the performance trials. The performance was evaluated in terms of destemmed cherry pepper, capacity (kg/h), destemming efficiency (%), and damage %. The machine was operated for about 02 minutes for each batch of processing based on preliminary trials. The total time of processing (loading, unloading, destemming) was about 10 minutes per batch. Capacity was determined as the weight of cherry pepper processed in one hour. The destemming efficiency was calculated as the ratio of weight of destemmed cherry pepper to weight of fresh cherry pepper expressed as %. The damage % was calculated as the ratio of weight of damaged/cut cherry pepper to weight of destemmed cherry pepper expressed as %. Manual method of stem removal was also performed for comparison. The average reading of three replications were considered.

Results of performance evaluation of cherry pepper destemmer prototype

The results of the performance evaluation of the cherry pepper destemmer prototype have been shown in Table 11. In manual method, the destemming efficiency was 100% and damage % was nil. The capacity of manual cherry pepper destemming was 5.4 – 6 kg/h. From Table 11, highest destemming efficiency (76.42%) was found at1/3rd loading volume and 790 rpm and lowest efficiency (68.3) was at ½ loading volume and 475 rpm. The efficiency increased as loading volume decreased and speed increased. The capacity ranged between 30-60 kg/h. The damage percentage varied in the range of 1.16 – 3.97%. Higher speed and high loading volume contributed to more damage to the cherry pepper. From ANOVA, the effect of both speed and loading volume on destemming efficiency was found to be significant at 95% significance level. The effect of these parameters on % damage was not significant ($p>0.05$). From the analysis of the results of Table 11, it can be seen that 1/3rd loading volume with 475 rpm speed showed second lowest efficiency (74.93%) and lower % damage (1.79%). This may be taken as the most suitable operating conditions for the machine which had a capacity of about 40.2 kg/h.

Table 11: Performance evaluation of developed prototype for cherry pepper destemmer

Loading capacity	Operating Speed, rpm	Destemming efficiency (%)	Capacity (kg/h)	Damage (%)
½ filled	792	70.60	60	3.97
½ filled	475	68.30	60	1.76
1/3rd filled	792	76.42	40.2	3.52
1/3rd filled	475	74.93	40.2	1.79
1/4th filled	792	74.60	30	1.88
1/4th filled	475	72.20	30	1.16

4.0. Objective 4: Optimization of process technology for value added cherry pepper and chayote fruit products

4.1 Optimization of blanching process for red cherry pepper

For development of value added products from cherry pepper, blanching studies of cherry pepper were carried out for optimizing the blanching parameters. Blanching of red cherry pepper helps in better retention of color in the product. Hence, fresh red cherry pepper was evaluated under different blanching conditions viz., hot water blanching (100°C), chemical blanching using hot water with potassium meta bisulfite (KMS) at various concentration levels 0.5%, 1% and 1.5% and steam blanching. The blanching time was varied from 0.5 to 3 minutes (0.5min, 1min, 1.5min, 2min, 2.5 min and 3 min). The blanched cherry pepper samples were assessed via peroxidase enzymatic activity, color difference (between fresh and blanched samples) and vitamin C content retention in blanched cherry peppers.

Peroxidase enzyme activity was assessed as per the method prescribed by Mercer (2018). The color difference was calculated from color values L*, a*, and b* of fresh and blanched samples as measured using chromameter. Full factorial design was followed with three replications. Vitamin C content was measured as per the method described in Section 2.0. Vitamin C retention % was calculated as the ratio of Vitamin C content in blanched sample to the Vitamin C content in fresh unblanched samples and was expressed in %.

The results of the blanching experiments have been shown graphically in Figs. 43 to 45 for peroxidase enzyme activity, color difference and vitamin C retention %. peroxidase enzyme activity has been shown as numerical values of 0, 0.5 and 1.0 in Fig. 43. In Fig.43, 0 refers to complete inactivation of enzyme, 0.5 refers to partial inactivation and 1.0 refers to active enzyme presence in blanched cherry pepper. From Fig. 43, it can be seen that peroxidase enzyme activity decreases with increase in blanching time for all blanching methods. No difference in peroxidase activity was observed between hot water and steam blanching method. Hot water chemical blanching with 1.5% KMS showed complete inactivation of peroxidase enzyme activity at blanching time of 2.0 minutes (Fig. 43).

Fig. 44 shows the variation of color difference in various blanching treatments. From the figure, it can be observed that highest color difference (33.65) in cherry pepper was in case of hot water blanching for 2.5 minutes where as lowest color difference (5.812) was at steam blanching for 2.5 minutes. From ANOVA, the effect of both blanching method and blanching time on color difference was found to be non-significant (p>0.05).

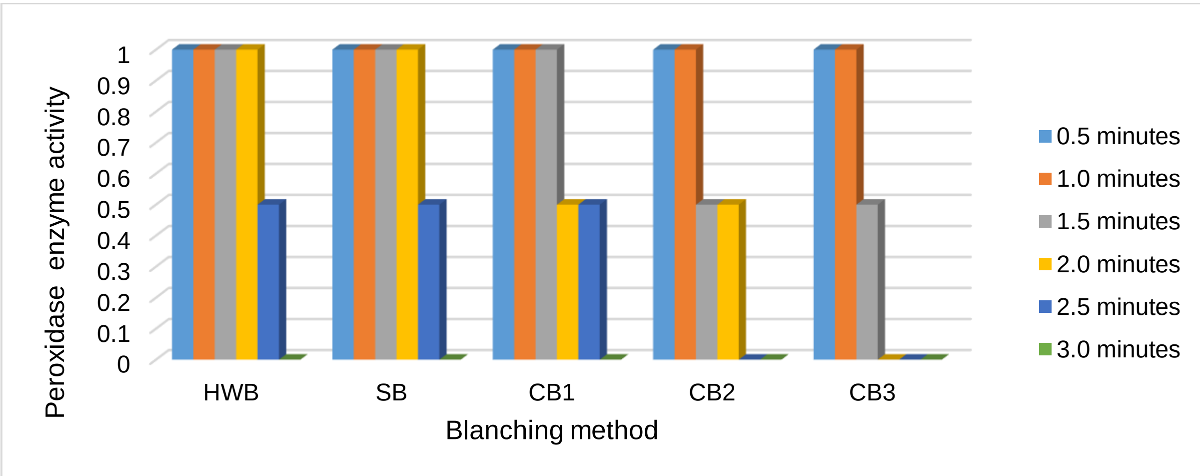


Fig. 43. Comparison of various blanching methods for PPO enzyme activity

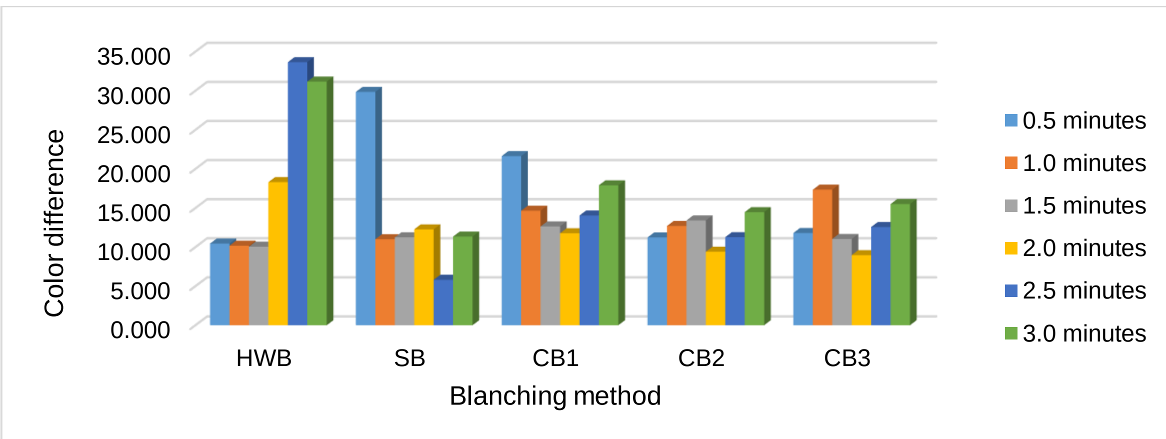


Fig. 44. Comparison of various blanching methods for color difference

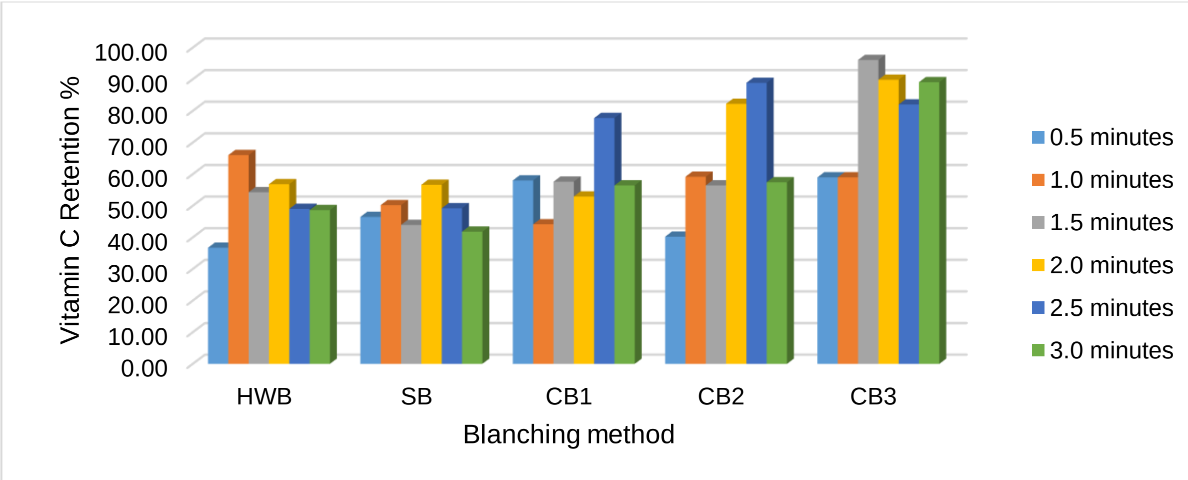


Fig. 45. Comparison of various blanching methods for vitamin C retention %

HWB: Hot water blanching; SB: Steam blanching; CB1: Hot water Chemical blanching with 0.5 % KMS

CB2: Hot water chemical blanching with 1 % KMS; CB3: Hot water chemical blanching with 1.5 % KMS

Fig. 45 shows the variation of vitamin C retention in various blanching treatments. From the figure, it can be observed that highest vitamin C retention (96.09%) in blanched cherry pepper was in case of hot water chemical blanching with 1.5 % KMS for 2.0 minutes where as lowest vitamin C retention (36.72%) was at hot water blanching for 0.5 minutes. From ANOVA, blanching method had significant effect ($p<0.05$) on vitamin C retention where as the effect of blanching time on vitamin C retention was found to be non-significant.

For recommendation of optimum blanching treatment for cherry pepper, the desired responses were complete inactivation of PPO enzyme, minimum color difference and maximum vitamin C retention. From the analysis of results and Figs. 43 to 45, all these desirable criteria were met by hot water chemical blanching with 1.5 % concentration for blanching time of 2.0 minutes. Hence, the optimum conditions for blanching of red cherry pepper can be recommended to be 2 minutes by hot water blanching with 1.5% KMS at 100°C. At the optimized blanching condition, Vitamin C retention was 89.84% and colour difference was 8.97 with complete inactivation of PPO enzyme.

4.2 Process technology for value added products from red cherry pepper

In the present study, three value added products from red cherry pepper was developed. These value added products include hot air dried red cherry pepper flakes, red cherry pepper powder and red cherry pepper chutney powder. The process technology for these products have been discussed below.

4.2.1 <u>Red cherry pepper flakes</u>

Chilli flakes has considerable demand especially as toppings in various snack products to increase the pungency/spiciness. Being a highly pungent chili, red cherry pepper/Dalley khorsani is most suitable for production of dried flakes. In the present study, the process for production of red cherry pepper flakes through hot air tray drying was standardized.

For the study, fresh mature cherry pepper samples were collected, washed, manually destemmed and blanched at optimum blanching conditions of 2 minutes in hot water blanching with 1.5% KMS at 100°C as described in Section 4.1. The blanched samples are then ground into coarse paste using kitchen grinder prior to drying. Based on preliminary trials, the grinding time was kept about 8 seconds at low speed for getting flakes. The coarse paste was dried in a hot air dryer by uniformly spreading in SS drying trays in 8 mm thin layers. The drying experiments were conducted at various temperatures 50, 60 and 70˚C at a fixed air velocity of 1.7 ± 0.1 m/s. Drying was continued till the moisture content of cherry pepper flakes reduced to less than 10% dry basis which is safe for storage. Drying time at all temperatures were noted down. All experiments were done in triplicate. The dried flakes were analyzed for moisture content, total color difference, and vitamin C retention %. The method of estimation of these properties were similar to as explained in earlier sections.

Results

The average time required to dry cherry pepper flakes from an initial moisture content of 85.26 % w.b. to a moisture content of around < 10 % (dry basis) during hot air drying at 50, 60, and 70°C was 18 h, 14 h and 11.5 h. respectively. Lowest drying time was observed at highest temperature due to increased drying rate. The final moisture content in the dried cherry pepper flakes varied in the range of 7.88 – 9.21 % db. The total color difference in dried cherry pepper flakes varied as 25.73, 29.51 and 38.95 for hot air drying at 50, 60, and 70°C respectively. Highest color difference was observed at higher temperature which may be due to higher loss of color pigments at higher temperature. Vitamin C content retention % in dried cherry pepper flakes were 10.28%, 14.55% and 11.67% at 50, 60, and 70°C respectively. Vitamin C retention decreased with increase in temperature and drying time. From the analysis of quality of dried cherry pepper flakes, 60°C temperature was found to be most suitable on the basis of highest vitamin C retention and medium color change. The dried cherry pepper flakes (Fig. 46) produced through the above standardized conditions are packed in aluminium foil laminated pouches during storage. The product yield of dried cherry pepper flakes was about 16.38%. The optimized process flow chart for production of dried cherry pepper flakes is given in Fig. 47.

Fig. 46. Red cherry pepper flakes

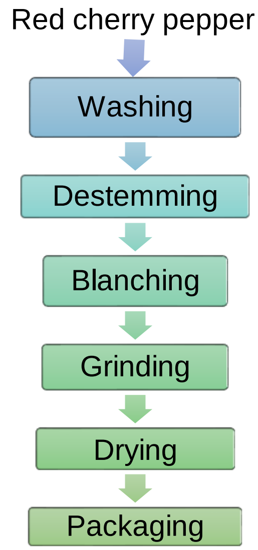


Fig. 47. Process Flow chart for production of red cherry pepper flakes

4.2.2 Red cherry pepper powder

The process for production of red cherry pepper powder through hot air tray drying was standardized. Fresh mature cherry pepper samples were collected, washed, destemmed and blanched at optimum blanching conditions of 2 minutes in hot water blanching with 1.5% KMS at 100°C. For powder production, optimized process for cherry powder flakes was followed. The dried flakes were sieved through a 400 mm wire mesh screen to remove seeds. After removal of seeds the dried flakes were ground to less than 500µ using a hammer mill to produce red cherry pepper powder. Separation of seeds (Fig. 48a) prior to grinding helped retain the red color of the powder. Grinding of flakes along with seeds led to light red/brown color of the cherry pepper powder. The red cherry pepper powder (Fig. 48b) produced retained good red color. The moisture content of the powder was about 7.86 – 8.37 % wb which conforms to FSSAI standards of < 20% wb moisture content for dry fruit powder. The developed powder (Fig. 47) was packed in laminated pouches for storage. The process flowchart for production of red cherry pepper powder is given as Fig. 49.

Fig. 48. Red cherry pepper Seeds (a) and powder (b)

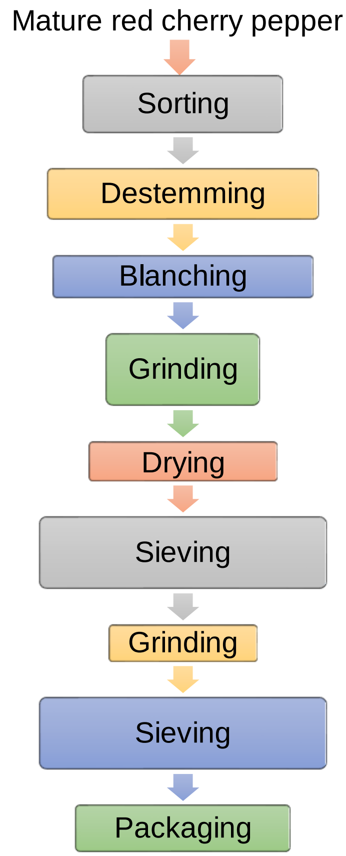


Fig. 49. Process Flow chart for production of red cherry pepper powder

4.2.3 Red cherry pepper chutney powder

Red cherry pepper chutney is a delicacy which is enjoyed with *momos* and other snacks in various parts of Sikkim. Though extremely popular, availability of the chutney in off season period is very limited. Moreover, the shelf life of this chutney is only 2-3 days. Hence, producing a new value added product through standardization of composition and in the form of dried chutney powder would facilitate ready availability of the product which can be reconstituted and consumed at any time.

Optimization of red cherry pepper chutney formulation

Red cherry pepper chutney powder was developed using fresh mature red cherry pepper, tomatoes, ginger, white sesame seeds and salt. The materials were procured from local market. The raw cherry pepper, tomato and ginger were washed thoroughly in running tap water. The cherry pepper was destemmed manually and ginger was peeled. The tomatoes were blanched in boiling water for 2-3 minutes to facilitate peeling. Sesame seeds were dry roasted separately for

1 minute for development of flavour. All the ingredients of the chutney viz., red cherry pepper, raw ginger, peeled tomatoes, roasted sesame and salt were ground in a kitchen grinder to prepare coarse cherry pepper chutney. The range of ingredients have been given in Table 12. For optimization of formulation of chutney, 50 formulations of chutney were prepared by varying different composition of all ingredients (Table 13). A central composite design was followed for the experiment. The prepared chutney was assessed through sensory evaluation on the basis of appearance/color, aroma, taste, consistency and overall acceptance. Sensory evaluation was done using 9-point hedonic scale where each product was coded with three-digit number and was tested by 50 semi-trained panelists.

Table 12. Range of ingredients for red cherry pepper chutney

Ingredients:	**Range, %**
Red cherry pepper	10-20
Tomato	40-60
Ginger	5-10
Sesame	10-20
Salt	5-10

The result of the sensory evaluation is shown in Table 13. From the analysis of sensory scores, chutney sample with 15% sesame, 20% cherry pepper, 7.5% ginger, 50% tomato and 7.5 % salt scored highest in appearance (8.0), aroma (7.87), taste (7.58) and overall acceptability (7.48). It scored second highest score (7.37) in consistency. Based on these scores, the above formulation was considered as optimum formulation for production of red cherry pepper chutney and further drying experiments.

Table 13. Sensory evaluation scores for red cherry pepper chutney

Sample No.	Sesame, %	Cherry pepper, %	Ginger, %	Tomato, %	Salt, %	Appearance	Aroma	Taste	Consistency	Overall Acceptability
1.	15.0	15.0	7.5	50.0	7.5	6.98	6.90	6.53	6.66	6.94
2.	12.9	12.9	6.4	54.2	8.6	7.03	6.94	6.94	6.58	7.00
3.	12.9	17.1	6.4	45.8	8.6	7.42	7.73	6.82	6.85	7.06
4.	17.1	17.1	8.6	45.8	8.6	7.26	6.98	7.15	6.79	7.09
5.	15.0	15.0	7.5	40.0	7.5	7.34	7.39	6.95	6.69	6.69
6.	17.1	12.9	6.4	54.2	8.6	7.40	7.21	7.23	5.77	6.65
7.	17.1	17.1	8.6	45.8	6.4	7.13	6.45	6.45	5.94	6.87
8.	12.9	12.9	8.6	45.8	6.4	6.90	6.35	6.61	6.58	6.92
9.	17.1	12.9	8.6	54.2	8.6	6.65	6.87	6.60	6.42	6.81
10.	10.0	15.0	7.5	50.0	7.5	6.97	6.73	6.40	6.69	6.68
11.	17.1	17.1	6.4	54.2	8.6	7.26	7.19	6.55	6.68	7.10
12.	17.1	12.9	6.4	45.8	8.6	7.42	6.77	6.42	6.74	7.00
13.	15.0	20.0	7.5	50.0	7.5	8.00	7.87	7.58	7.37	7.48
14.	17.1	12.9	8.6	45.8	6.4	7.81	7.23	7.10	7.15	7.35
15.	12.9	12.9	8.6	54.2	8.6	7.81	7.39	6.97	6.68	7.16
16.	17.1	17.1	6.4	54.2	6.4	7.77	7.26	7.21	6.97	7.17
17.	12.9	12.9	8.6	54.2	6.4	7.42	7.68	7.18	7.45	7.16
18.	12.9	17.1	6.4	54.2	8.6	6.92	7.29	7.32	7.16	7.26
19.	15.0	15.0	7.5	60.0	7.5	6.53	7.15	5.95	6.47	6.89
20.	17.1	17.1	6.4	45.8	6.4	7.45	7.23	7.34	6.97	7.39
21.	12.9	17.1	6.4	54.2	6.4	7.23	7.10	6.74	6.94	7.23
22.	17.1	17.1	8.6	54.2	8.6	7.21	6.84	6.87	6.98	6.81
23.	17.1	12.9	6.4	45.8	6.4	6.87	6.68	6.32	6.27	6.66
24.	15.0	15.0	7.5	50.0	7.5	7.10	7.00	6.55	6.74	6.94

25.	12.9	12.9	6.4	45.8	6.4	6.77	6.68	6.45	6.63	6.79
26.	12.9	17.1	8.6	54.2	6.4	7.23	6.76	6.65	6.90	7.16
27.	15.0	15.0	7.5	50.0	7.5	7.40	7.42	6.42	7.00	7.00
28.	15.0	15.0	5.0	50.0	7.5	7.32	7.23	7.29	6.77	7.19
29.	20.0	15.0	7.5	50.0	7.5	7.24	7.08	6.81	6.74	7.02
30.	12.9	12.9	6.4	45.8	8.6	7.60	7.52	7.11	7.16	7.35
31.	15.0	15.0	7.5	50.0	7.5	7.19	6.77	6.48	7.45	6.89
32.	15.0	15.0	7.5	50.0	10.0	7.32	6.58	7.45	7.00	6.81
33.	17.1	12.9	8.6	45.8	8.6	7.19	6.85	6.45	6.55	6.44
34.	15.0	15.0	7.5	50.0	5.0	7.68	7.06	7.16	7.19	7.35
35.	15.0	15.0	7.5	50.0	7.5	7.26	7.37	7.15	6.69	6.77
36.	15.0	15.0	10.0	50.0	7.5	7.74	7.19	7.19	7.29	7.18
37.	15.0	15.0	7.5	50.0	7.5	7.10	6.15	7.26	7.12	6.81
38.	17.1	12.9	6.4	54.2	6.4	7.58	7.03	6.68	7.03	6.97
39.	15.0	15.0	7.5	50.0	7.5	7.06	6.92	6.73	6.95	6.84
40.	12.9	17.1	8.6	45.8	8.6	6.97	7.00	6.68	6.68	6.81
41.	12.9	17.1	8.6	45.8	6.4	7.29	7.05	6.61	7.05	6.84
42.	15.0	10.0	7.5	50.0	7.5	7.81	7.37	6.87	6.98	6.94
43.	17.1	17.1	8.6	54.2	6.4	7.81	7.39	7.23	7.08	7.08
44.	17.1	17.1	6.4	45.8	8.6	7.29	7.39	6.58	6.45	6.81
45.	12.9	12.9	6.4	54.2	6.4	7.13	6.75	6.80	6.38	6.62
46.	17.1	12.9	8.6	54.2	6.4	7.23	7.27	6.62	6.88	7.03
47.	12.9	12.9	8.6	45.8	8.6	7.03	7.28	6.63	6.92	6.67
48.	15.0	15.0	7.5	50.0	7.5	6.90	7.12	6.45	6.85	6.23
49.	12.9	17.1	8.6	54.2	8.6	6.93	6.72	6.35	6.40	6.03
50.	12.9	17.1	6.4	45.8	6.4	7.67	7.47	6.99	6.82	6.70

Production of red cherry pepper chutney powder

For preparation of chutney powder, red pepper chutney was prepared using optimum formulation and was dried using a hot air tray dryer at different temperatures (*T*) of 50°C, 60°C and 70°C at different thickness of 2mm, 3mm and 4mm till moisture content reduced to 10%db. The air velocity during drying was 1.6-1.8 m/s. A full factorial design with three replications was followed. The dried chutney sheet was ground using kitchen grinder to less than 500µ powder to produce cherry pepper chutney powder (Fig. 50). All the dried samples were ground and stored in self-sealing pouches for analysis. Fig. 16 shows the process flowchart for production of red cherry pepper chutney powder. The chutney powder was analyzed for moisture content, colour, and sensory characteristics. Moisture content was analyzed using digital moisture analyzer (Mettler Toledo). Color was analyzed using chromameter. Total color difference (ΔE) between fresh chutney and reconstituted chutney was calculated using color values of L*, a* and b*. Sensory evaluation was done for reconstituted chutney. Sensory evaluation was done using 9-point hedonic scale based on the sensory parameters like appearance/colour, taste, aroma, texture, spiciness, and overall acceptability. 30 semi-trained panelists were used for sensory evaluation.

Results

The results of the drying experiments of red pepper chutney powder have been shown in Table 14. The moisture content of fresh cherry pepper chutney was found to be 69.75% wb. The final moisture content of dried chutney powder at various experimental conditions varied from 1.33% wb to 8.93% wb. The total drying time varied in the range of 5.17 h to 9 h for different drying conditions. It was observed that drying time reduced with increase in drying air temperature and decreased with decrease in sample thickness.

From Table 14, the total color difference between the fresh red cherry pepper chutney and reconstituted chutney powder ranged between 8.17 and 14.89. The color difference was found to be highest (14.89) at the lowest temperature of 50°C and 4 mm thickness. This may be due to longer drying time resulting in loss of color pigments. Color difference decreased with increase in drying temperature and decrease in sample thickness. Lowest color difference of 8.17 was observed at temperature of 70°C and 2 mm thickness which may be due to lowest drying time. However, at higher thickness the total color difference again increased at higher temperature. This may be due to combined effect of high temperature and longer drying time leading to color loss. From ANOVA, the effect of temperature and thickness on color difference was found to be non-significant. Hence, optimization was done based on sensory evaluation.

Table 14. Color difference and sensory parameters for red cherry pepper chutney powder

T, ℃	Thickness, mm	*ΔE*	% Sensory indices					
			Flavour	Color	Consistency	Smell	Spiciness	Overall acceptability
50	2	13.64	36.30	35.56	32.59	35.56	33.83	35.80
50	3	9.53	33.58	35.31	33.33	35.31	35.06	35.31
50	4	14.89	38.27	38.02	36.54	38.77	37.28	39.51
60	2	8.22	34.81	35.80	32.84	35.80	35.31	33.58
60	3	10.85	34.57	37.04	38.02	33.33	36.54	37.53
60	4	12.85	38.52	39.01	36.75	40.00	36.79	40.49
70	2	8.17	32.84	35.80	37.04	35.56	34.57	34.57
70	3	9.74	31.85	33.09	34.32	34.57	35.06	35.31
70	4	13.66	33.33	33.58	35.06	34.81	35.06	35.06
	Fresh		32.59	33.55	34.32	35.56	36.05	36.05

The sensory scores for all the six sensory parameters viz., flavour, colour, consistency, smell, spiciness and overall acceptability were converted to sensory indices using the following Eq. (8) Sensory index was calculated in percentage with the help of total sensory score and the total sensory scale (Madhu, 1999). Table 14 shows all the sensory indices of developed chutney samples.

$$\text{Sensory index} = \frac{Total\ Sensory\ score}{Total\ Sensory\ scale} \times 100 \qquad \dots (8)$$

$$= \frac{\{(\mathbf{9} \times \boldsymbol{X_1})+(\mathbf{8}\times\boldsymbol{X_2})+(\mathbf{7}\times\boldsymbol{X_3})+(\mathbf{6}\times\boldsymbol{X_4})+(\mathbf{5}\times\boldsymbol{X_5})+(\mathbf{4}\times\boldsymbol{X_6})+(\mathbf{3}\times\boldsymbol{X_7})+(\mathbf{2}\times\boldsymbol{X_8})+(\mathbf{1}\times\boldsymbol{X_9})\}\times\mathbf{100}}{(\mathbf{9+8+7+6+5+4+3+2+1})\times\mathbf{9}}$$

Where, X_n = Number of judges

From Table 14, the taste index ranged from 31.85 to 38.52, colour index from 33.09 to 39.01, consistency index from 32.59 to 38.02, aroma index from 33.33 to 40.0, spiciness index from

33.83 to 37.28 and overall acceptability index from 33.58 to 40.49. ANOVA analysis was performed to determine the effect of drying parameters viz., drying air temperature and sample thickness on the sensory indices. It was found to be significant with $p<0.05$ for taste index and was found to be non-significant for all other the indices of reconstituted red cherry pepper chutney powder. From the sensory analysis, red cherry pepper chutney powder prepared at 60°C, 4 mm thickness scored highest in four sensory indices (taste, color, aroma and overall acceptability) out of six sensory parameters. Based on these criteria, Drying air temperature of 60° C and 4 mm thickness may be recommended for production of red cherry pepper chutney powder. The final moisture content of this powder was 6.68% wb which conforms to FSSAI standards for fruit powder which cites moisture content of dry powder must be less than 20%. The chutney powder recovery was about 25-30%. Fig. 51 depicts the process flowchart for production of red cherry pepper chutney powder.

Fig. 50. Red cherry pepper chutney powder

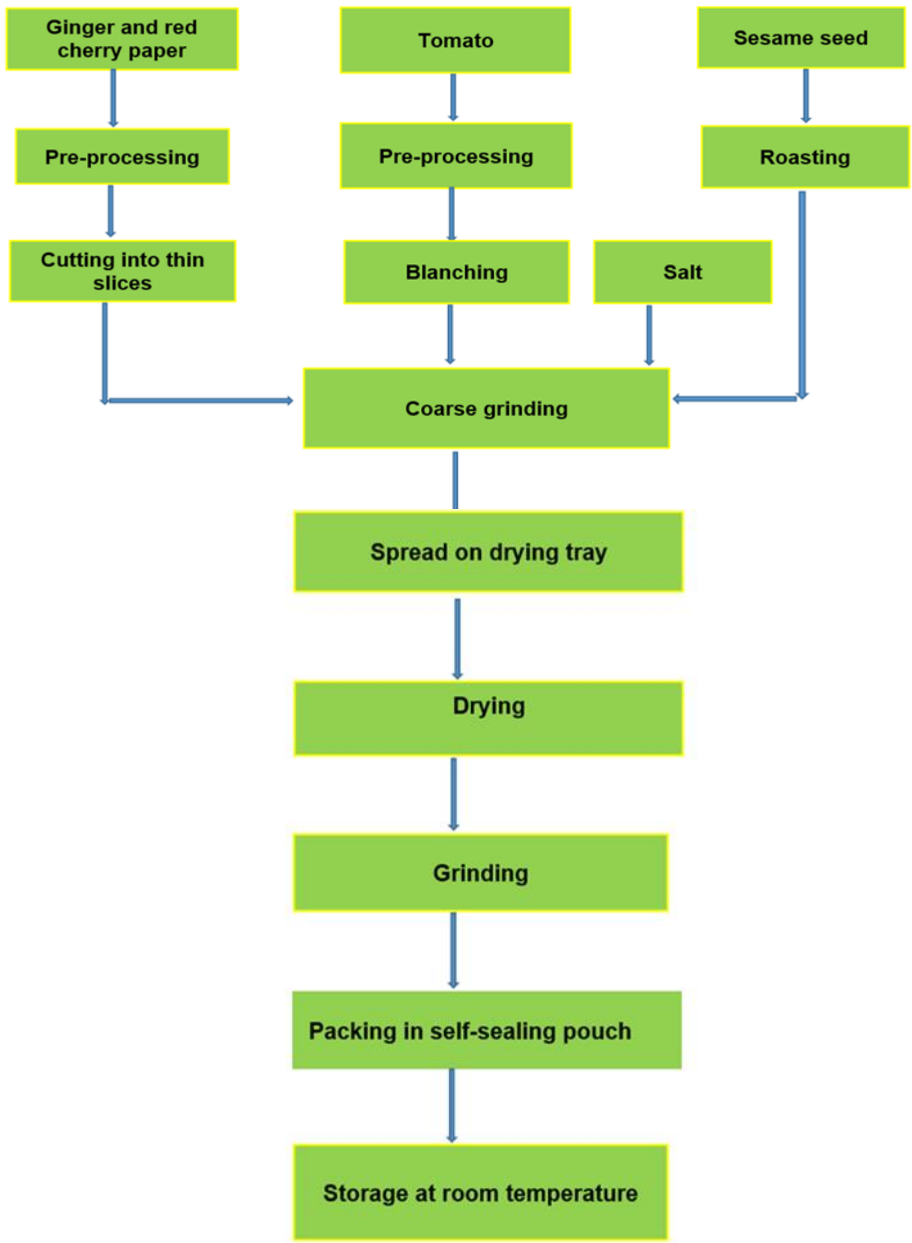


Fig. 51. Process flow chart for production of red cherry pepper chutney powder

4.3 Process technology for value added products from chayote

Three value added products viz., chayote-mandarin blended RTS beverage, chayote papad and chayote tuber chips were developed from chayote fruit and chayote tuber/root. The details of the process technology have been discussed in the following sections.

4.3.1 <u>Chayote-mandarin blended Ready to Serve (RTS) beverage</u>

Chayote fruit juice is very rich in nutrients viz., calcium, phosphorus, potassium, and vitamin C. However, the taste of the juice is very bland due to which it is not preferred by consumers. Fruits which are rich in nutrients but are not accepted due to high acidity or poor taste and flavour like chayote can be blended with other fruits to improve their acceptability and make use of available nutrients (Khan et al., 1988). Therefore, blending of fruit juices for the preparation of ready to serve (RTS) beverages with/without the addition of spice extracts/drops as health drinks are thought to be convenient alternative for its utilization in order to have some value-added drinks which are of high quality in respect of both sensory and nutritional aspects (Bidyut and Sethi, 2001). Mandarin (*Citrus reticulata Blanco*) is most popular citrus fruit having attractive colour, pleasing taste, and flavour. Sikkim is the largest producer of Sikkim mandarin and contributes 2% share in north-eastern mandarin production. Its juice is refreshing and nutritious due to its ascorbic acid content, has sweet acid taste and appealing colour. The fruits have been used extensively in the form of juice due to its therapeutic potential. Due to their availability and quality considerations, this fruit juice was selected to be blended with chayote juice for development of RTS beverages.

Methodology

For preparation of RTS beverages, well matured chayote fruits were selected, washed, and then peeled with the help of stainless-steel knife and core was removed using corer. Good quality mandarins were also washed and peeled. The juice was extracted using a juice extractor (USHA cold press juicer, CPJ-3625, India) separately. Both the juices were filtered through double layered muslin cloth to avoid any solids to enter into extract. Blended RTS beverages were prepared using different quantities of the extracted chayote and mandarin juice. Sugar syrup was prepared by manual mixing of sugar and water in desired quantities calculated through solid balance. The mixture was then blended using blender for proper mixing of all ingredients. The prepared blended RTS beverage (Fig. 52) was pasteurized and filled into the pre-sterilized glass bottles. The heat treatments (sterilization) were done in autoclave (Indo Scientific & Surgicals, India) for 15 minutes at 15 PSI. The filled bottles were sealed airtight using caps and capping was done manually. During the study, the fruit juice content of blended beverages were varied as 10, 12, 14, 16 and 18% and the ratio of chayote juice to mandarin juice was varied as 2:3, 1:1 and 3:2. A full factorial design with total fifteen experiments were designed and performed, and each experiment was replicated thrice to minimize experimental error. The RTS beverages were analyzed for TSS, Titratable acidity, pH, ascorbic acid content, and sensory evaluation. TSS was measured using digital refractometer (ATAGO, India). pH was determined with the help of electronic pH meter (EUTECH). Total titratable acidity was determined by titrating the juice against N/10 NaOH using phenolphthalein as indicator and expressed in percentage as per the method described in Ranganna (2001). The vitamin C content was measured using the method followed by Dinesh et al. (2015) and Adebayo (2015) with minor modifications. The sensory evaluation of developed RTS beverages was carried out by using 9-point hedonic scale by 30 semi-trained panelists. The assessment included the beverage quality attributes: color, taste, aroma, mouthfeel, consistency and overall acceptability. The sensory scores obtained were converted to sensory indices using Eq. (8) as explained in section 4.2.3. The process flow chart for the developed RTS beverage is given in Fig. 53.

Fig. 52. Chayote-mandarin blended RTS beverage

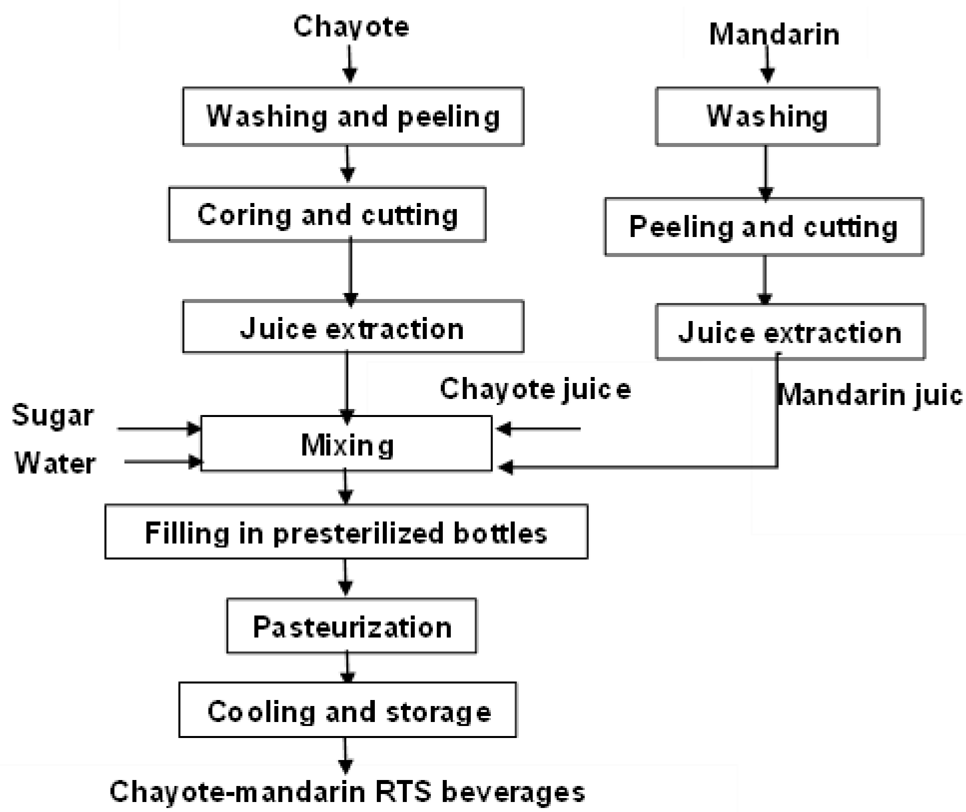


Fig. 53. Process flow chart for production of chayote-mandarin blended RTS beverage

Results

The average TSS of chayote juice was 3.80±0.5ºBx, whereas it was 11.06±0.3ºBx for mandarin juice. The average pH of chayote juice was 6.57±0.04 and that of mandarin juice was 3.90±0.26. The average acidity of chayote juice was 0.96±0.04, whereas 1.04±0.10 for mandarin juice. The results of quality evaluation of chayote-mandarin blended RTS beverages have been presented in Table 15. From Table 15, the TSS values were in the range of 11.67 to 16.27° Bx. The TSS values were within the acceptable quality standards for RTS beverages (not less than 10 °Bx) according to FSSAI. The TSS was the highest (16.27 ºBx) when the juice content (%) was 12% for chayote: mandarin ratio of 3:2. Both ANOVA and DMRT result showed that the treatments and their interaction had significant effect on total soluble solids. From The Table 15, pH varied between 3.8 and 4.3 for different treatments. It can be observed that pH of the RTS beverages decreased with decrease in chayote to mandarin juice ratio This is due to the increased mandarin juice content in the beverages which has lower pH values. The ANOVA results showed that the independent variables have significant effect on pH. As observed from the Table 15, titratable acidity varied between 0.44 and 1.08% citric acid for different treatments. It can be observed from ANOVA that titratable acidity of the blended beverages significantly increased with decrease in chayote to mandarin juice ratio. However, the titratable acidity of the developed blended beverages Slightly above the maximum acceptable limits (0.2-0.3) for RTS beverages as per FSSAI standards. The developed beverages had ascorbic acid content in the range from 8.84 to 14.91 mg/100g. It can be observed that the ascorbic acid content increased with juice content up to 14% for blending of 2:3 and 3:2 chayote and mandarin juice, but it showed decline with further increase in the juice content.

Table 15. Chemical Quality of chayote-mandarin blended RTS beverages

Juice content (%)	Ratio of Chayote juice to Mandarin juice	TSS, °Brix	pH	Titratable Acidity, %	Ascorbic Acid, mg/100g
10	3:2	12.47^{de}	4.37^{h}	0.64^{d}	11.62^{bc}
10	1:1	12.73^{f}	4.23^{f}	0.74^{ef}	11.73^{cde}
10	2:3	12.23^{bc}	4.23^{f}	0.70^{e}	8.91^{a}
12	3:2	16.27^{j}	4.40^{h}	0.44^{a}	8.84^{a}
12	1:1	15.40^{i}	4.18^{ef}	0.51^{b}	11.72^{cde}
12	2:3	14.63^{h}	4.03^{c}	0.55^{c}	11.68^{cd}
14	3:2	13.93^{g}	4.23f	0.62^{cd}	14.70^{g}
14	1:1	12.50^{de}	4.10^{d}	0.75^{ef}	11.82^{e}
14	2:3	12.33^{cd}	4.00^{c}	0.71^{e}	14.91^{h}
16	3:2	11.67^{a}	4.13^{de}	0.75^{ef}	11.76^{de}
16	1:1	12.30^{bcd}	3.90^{b}	0.83^{f}	14.81^{h}
16	2:3	12.60^{ef}	3.80^{a}	1.08^{h}	11.93^{f}
18	3:2	12.10^{b}	4.30^{g}	0.63^{cd}	11.71^{cde}
18	1:1	12.77^{f}	4.10^{d}	0.83^{f}	11.66^{cd}
18	2:3	12.20^{bc}	3.93^{b}	0.95^{g}	11.55^{b}

Same letters indicate non significance between treatments whereas different letters indicate significant effect

Table 16 records the sensory indices for different sensory parameters of the developed RTS beverages. From Table 16, it can be observed that no treatment showed highest scores for all sensory attributes. However, the treatment with 1:1 ratio of chayote to mandarin juice with 10% juice content had 3rd or 4th highest for all attributes and had consistent rating as well. Thus, this treatment may be considered as optimum subjected to minimum requirement of quality as per FSSAI. The chayote-mandarin RTS beverage containing 1:1 ratio of chayote juice: mandarin juice, and 10% juice content had TSS of 12.73°Brix, pH of 4.23, titratable acidity of 0.74% and high ascorbic acid content of 11.73mg/100g which conform to FSSAI standards for RTS beverages.

Table 16. Sensory Quality of chayote-mandarin blended RTS beverages

Juice content (%)	Ratio of Chayote juice to Mandarin juice	Sensory analysis index (%)					
		Taste	Color	Mouthfeel	Aroma	Consistency	Overall Acceptability
10	3:2	74.07	75.19	74.44	75.56	76.30	80.37
10	1:1	78.52	79.26	79.26	75.56	78.52	80.74
10	2:3	76.30	73.33	76.67	72.96	78.89	84.44
12	3:2	75.93	75.19	74.44	72.22	76.67	77.04
12	1:1	80.00	78.52	82.96	77.78	75.19	77.78
12	2:3	78.15	81.48	77.04	83.70	69.63	82.22
14	3:2	77.41	75.56	73.70	67.41	78.89	75.19
14	1:1	69.63	76.30	82.22	71.11	77.04	74.07
14	2:3	71.48	79.26	74.44	75.19	75.93	71.11
16	3:2	78.15	81.11	81.48	72.22	72.96	71.11
16	1:1	74.07	77.41	80.00	71.11	77.41	77.78
16	2:3	75.19	75.19	74.44	81.48	77.04	82.22
18	3:2	82.96	75.93	77.04	68.52	73.70	74.44
18	1:1	80.37	79.63	76.30	75.56	74.44	75.19
18	2:3	77.04	83.33	76.67	80.74	83.33	78.89

4.3.2 Chayote papad

Papads are generally made from dough of cereal/pulse flour separately or in blends along with salt, spices (Asafoetida and pepper), edible oil and an alkaline additive (popularly known as papadkhar), which is chemically a combination of carbonate, bicarbonates, sulfates and chlorides.

Cereals/pulses- based papads can be enriched by incorporating nutritious substances. Vegetables such as chayote can be incorporated, in papads for value addition which would remarkably improve the vitamin, mineral and fibre content. They are cheap, easily available and cooked quickly and hence a perfect source of the micronutrients for snacks deficient in such nutrients.

Methodology

For preparation of chayote papad, fresh mature chayote fruits and other ingredients viz., black gram (urad dhal), salt, black pepper powder, chilli/cherry pepper powder, papad khar, asafoetida (hing) and vegetable oil, which were purchased from the local market of Ranipool, Sikkim. Split urad dal (without seed cover) were converted to flour using a kitchen grinder (Bajaj, REX 500, India). This flour was used for preparation of chayote papad. The chayote fruits were washed with portable water before further processing. The chayote fruits were peeled, cored and cut with a stainless-steel knife. The cut pieces of chayote were steamed. The steamed chayote pieces were cooled and ground into a paste using a kitchen grinder. All other dry ingredients were weighed and mixed first uniformly and then added to chayote paste followed by mixing. The mixed ingredients were kneaded to form a dough. The prepared papad dough was divided into smaller pieces and formed into small balls of dough. The dough balls were rolled into thin round papad of about 15 cm diameter with the help of wooden rolling pin. The freshly prepared chayote papads (Fig. 54) were dried using a hot air oven at 40°C or sun dried to reduce its moisture content below 10% wb. The dried papad (Fig. 55) samples were packed in LDPE pouches till further analysis.

For standardization of formulation for chayote papad, papad dough was prepared using various combinations of cooked chayote paste and black gram flour. Chayote paste and black gram flour were the base ingredients of the papad dough. The maximum and minimum levels of these base ingredients were determined based on preliminary trials as no reported literature was available. The other levels/combinations of chayote paste and black gram flour were estimated using D-optimal mixture design as given in Table 17. Total of five combinations/treatments were used which were marked as T1, T2, T3, T4 and T5. Pure black gram papad was treated as control sample and was designated as T6. The formulation of standard ingredients used in chayote papad were: viz., black pepper powder (1.67g), chilli powder (0.67g), asafoetida (Hing) (0.67g), papad khar (0.67g) and salt as per taste. All these standardized ingredients were kept constant throughout all treatments. Black gram papad was prepared from 100% black gram flour and was used as control.

Table 17. Combinations of base ingredients used for preparation of chayote papad dough

Treatment	Cooked chayote paste (g per 100 g dough)	Black gram flour (g per 100 g dough)
T1	52.5	47.5
T2	60	40
T3	50	50
T4	57.5	42.5
T5	55	45
T6	0	100

All dried papads were analyzed for weight, moisture content, and colour. Weight was measured using digital weighing balance (Satorius, India). Moisture content was analyzed using hot air oven at 103°C for 24h. Color was measured using chromameter. Sensory evaluation of developed papad was carried out after converting the dried papads into edible form. This was done through frying and roasting. Both fried and roasted papads were compared based on the sensory evaluation. Sensory evaluation for different attributes viz., colour, taste, mouthfeel, texture/crispiness, smell/aroma, after taste and overall acceptability of both fried and roasted papads was carried out by 30 untrained panellists (of the age group 20-45) from both genders. The sensory scores were converted to sensory indices as explain in earlier sections. The frying quality of fried papads were also analyzed in terms of expansion ratio and oil uptake. The expansion % of papad on frying was calculated as the ratio of difference in diameter of papad after and before frying to diameter before frying expressed as % (Jagadeesh et al., 2009). Oil uptake % was calculated as the ratio of difference in weight of papad after and before frying to weight before frying expressed as % (Jagadeesh et al., 2009). Fig. 56 show the pictures of fried chayote papad.

Fig. 54. Fresh chayote papad

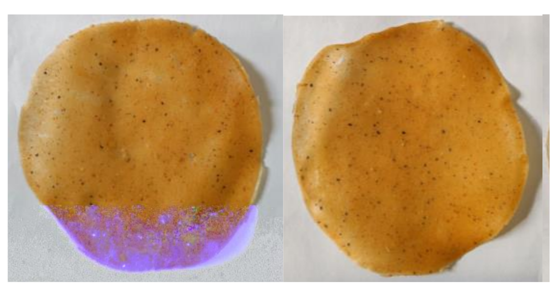


Fig. 55. Dried chayote papad

Fig. 56. Fried chayote papad

Results

The weight of the dried chayote papads ranged from 16.38 to 16.52 g. A moisture content of 13–14% wb is required for papad to make it pliable at the time of packaging (Kulkarni et al. 1996). Papads become brittle and break if the moisture content is very low, and prone for spoilage if moisture is more than the desired level. In the present study, moisture content of prepared dried chayote papads varied in the range of 11.22 to 14.28%. According to FSSAI standards, the moisture content of pulse based papads should not be more than 14% wb (FSSAI, 2011). The moisture content of all chayote papads were within the desired moisture content level. Black gram flour papad and Market Lijjat papad showed moisture content of 9.67% and 9.52% wb respectively. Chayote papads were found to have higher moisture content compared to black gram papad and market sample due to the higher water holding capacity of the chayote paste. From 1 kg of chayote fruit, 2.5 kg of dried papads were developed. The papad recovery was 250%.

The colour difference (ΔE) of the raw papads with respect to control papad (Black gram flour papad) and market papad (Green gram flour papad) were also determined as shown in Table 18. As shown in Table 18, with respect to control papad (Black gram flour papad), the treatment, T2 having 60% chayote paste and 40% black gram flour has the highest colour difference and the treatment, T3 having 50% chayote paste and 50% black gram flour recorded the least colour difference. With respect to Market Lijjat papad (Green gram papad), the treatment, T3 having 50% chayote paste and 50% black gram flour recorded the highest colour difference while the treatment, T2 having 60% chayote paste and 40% black gram flour has the least colour difference.

Table 18. Colour difference of prepared dried chayote papads with respect to control and market papad

Treatments	∆E (with respect to Control papad)	∆E (with respect to Market papad)
T1	7.871	14.526
T2	9.109	15.039
T3	3.946	18.151
T4	2.624	18.668
T5	3.48	20.883

The diametrical expansion of papads is an important frying characteristic and was found to influence crispness and taste (Kamaraddi and Naik, 2002). From the fried papad quality analysis, the expansion ratio % of fried chayote papads varied from 1.55% for T2 having 60% chayote paste and 40% black gram flour to 3.98% for T3 having 50% chayote paste and 50% blackgram flour. Fig. 57 shows the variation in Expansion ratio % among the developed chayote papad samples, control and market samples. From Fig. 57, it can be observed that, black gram flour papad (control) showed expansion ratio of 4.44% and the Market Lijjat papad showed the highest expansion ratio of 11.06%. It can also be observed that the expansion ratio % increased with the increase incorporation of black gram flour used in papad preparation. From single factor ANOVA, the increase in expansion ratio % with increase in black gram flour was found to be highly significant ($p<0.05$).

From the results, the treatment, T2 (60% chayote paste and 40% black gram flour) was found to have least minimum oil uptake % (11.87%), while treatment, T3 (50% chayote paste and 50% blackgram flour) had absorbed higher oil in the papads among the chayote papad treatments (28.07%). Fig. 58 shows the variation of oil uptake % in various treatments. From Fig. 58, it can be observed that, black gram flour papad (control) showed oil uptake of 30.75 % and the Market Lijjat papad showed the highest oil uptake of 35.54 %. Incorporation of black gram flour in the papad positively influenced the oil uptake as shown in Fig. 58. This effect was found to be significant ($p<0.05$) from ANOVA.

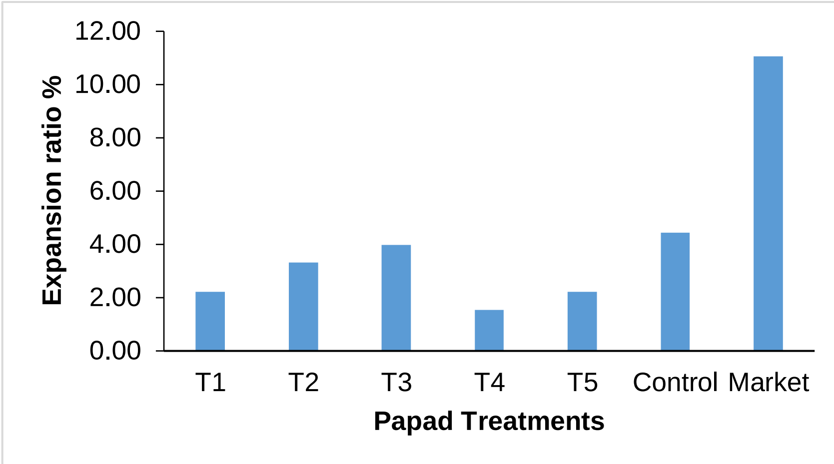


Fig. 57. Variation of Expansion Ratio % of fried papad treatments

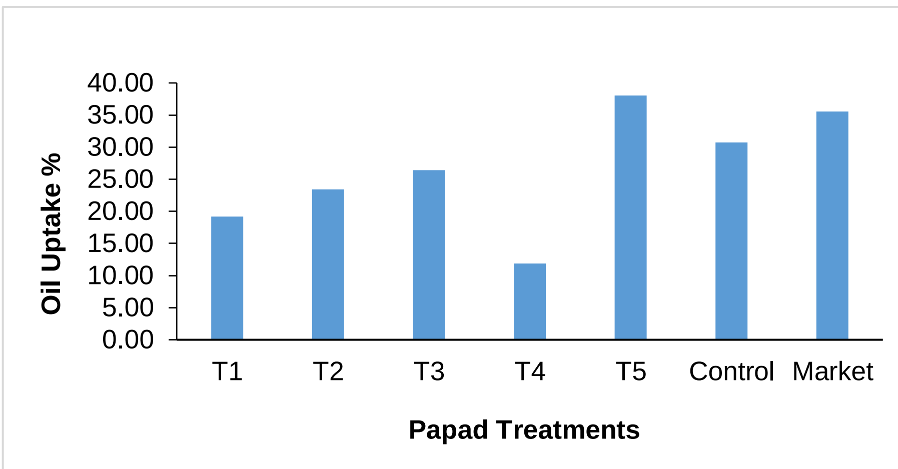


Fig. 58. Variation of oil uptake % of fried papad treatments

Sensory index scores for appearance, taste, mouthfeel, crispiness, aroma, after taste and overall acceptability for fried (F) and roasted (R) papad are presented below in Table 19. From Table 19, fried papad samples showed higher taste, mouthfeel, aroma, after taste and overall accpetibilty scores compared to roasted papads. The effect of method of cooking on taste index was found to be significant from ANOVA where as the effect of the treatments and method of cooking (frying or roasting) on the color, taste, mouthfeel, crispiness, aroma, after taste and overall acceptibity of papad was found to be non-significant. Roasted roasted papad samples showed higher crispiness index than fried samples. From the Table 19, it can be observed that the treatment T2 showed consistent scores in five out of seven attributes for fried papads where as among roasted papad samples, both T2 &T3 showed consistent scores three out of seven sensory attributes. Based on these observations, the papad treatment T2 having 60% chayote paste and 40% black gram flour can be considered as optimum formulation for best quality of chayote papad both under frying and roasting conditions. The quality of the papad with optimized formulation were: moisture content of 11.53% wb , 1.55 % expansion ratio % and 11.87% oil uptake %. The process flow chart for production of chayote papad is shown in Fig. 59.

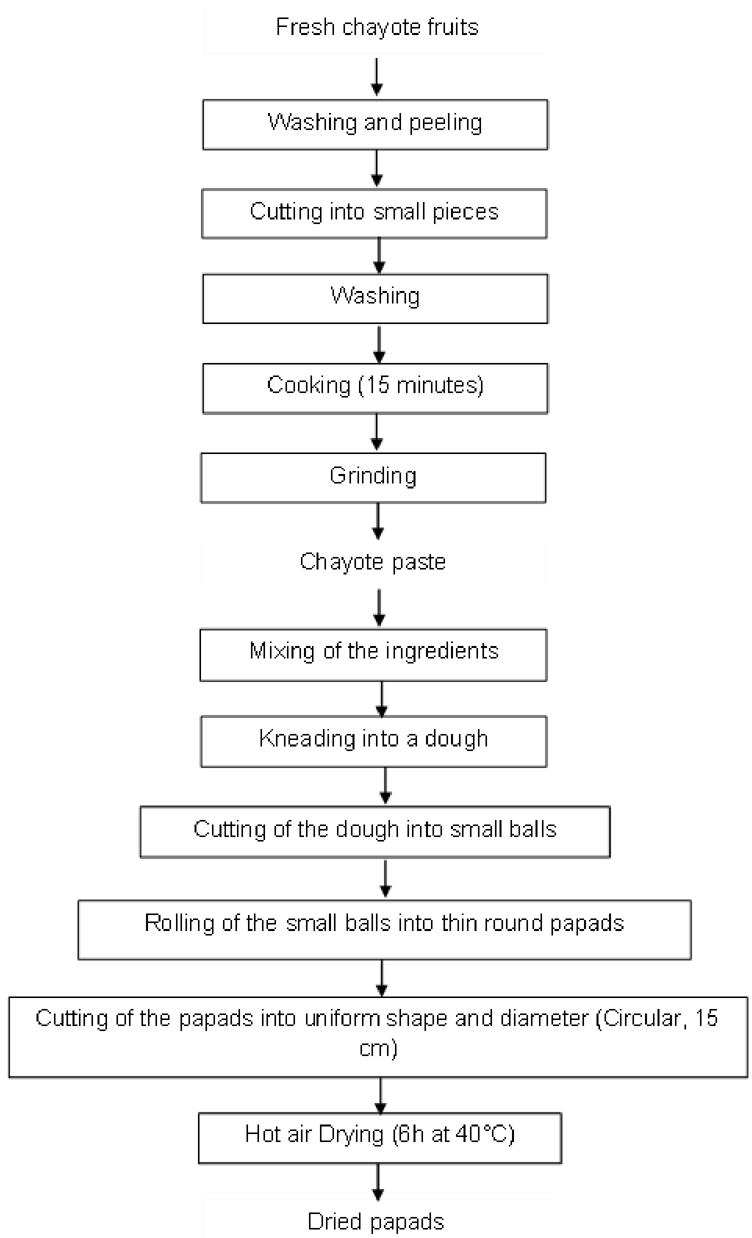


Fig. 59. Process flow chart for chayote papad

Table 19. Sensory evaluation scores for papads

Treatments	Color		Taste		Mouthfeel		Crispiness		Aroma		After Taste		Overall Acceptability	
	F	R	F	R	F	R	F	R	F	R	F	R	F	R
T1	52.35	51.36	51.11	45.93	49.63	48.64	52.59	48.64	58.02	48.15	50.86	46.67	54.57	49.88
T2	56.54	49.14	50.62	48.89	54.32	49.14	51.85	45.43	55.80	51.11	54.32	51.11	55.06	51.36
T3	50.37	49.14	53.83	52.10	55.31	49.63	47.90	50.12	52.59	49.14	49.14	52.10	52.35	51.85
T4	50.86	49.14	54.07	47.90	45.93	50.37	49.63	47.16	51.36	46.91	53.58	49.38	50.37	46.42
T5	49.38	46.67	52.35	47.16	53.09	44.94	49.14	52.35	48.15	50.37	52.84	47.65	48.89	50.86
T6	56.05	53.09	58.02	50.12	59.01	47.16	60.74	57.04	55.31	53.58	58.52	55.56	59.75	53.33
T7	61.98	55.80	61.98	52.10	62.47	53.58	44.20	60.25	60.74	58.27	60.74	59.51	62.47	56.54

4.3.3 Chayote tuber chips

Chips, also known as crisp, is a popular food in Indian diet which is crispy, wafer like, usually thin in size, circular or triangle in shape and prepared from fruits and vegetables. Chips are commonly served as a snack, side dish, or appetizer. It can be consumed either as fried or baked. Chayote roots, which possess a white color and taste like potatoes after cooking, are highly appreciated throughout all Latin American countries (Shiga *et al.,* 2015). However, chayote tuber/root is one of the most underutilized part of the chayote plant in India. It is mostly used as cattle feed in Sikkim and near by region. Hence, in the present study a new value added product i.e. chayote tuber chips was developed from chayote tubers.

Methodology

For preparation of chayote tuber chips, fresh matured chayote tuber roots and other ingredients (Fig 3.1), such as salt and vegetable oil, were purchased at the Ranipool, Sikkim, local market. The chayote tuber roots were washed before any further processing. The chayote tuber roots were peeled manually, washed and sliced using a vegetable slicer up to a thickness of 1.2 to 1.5mm. The chayote tuber slices were blanched at 100°C ± 2°C for 3 minutes in boiling water, drained, and dried at room temperature for 30 minutes (Juvvi et al., 2020). In the present study, chayote tuber chips were prepared through two methods viz., frying and baking. Different time and temperature combinations for both frying and baking experiments were selected to standardize the baking and frying parameters.

For frying experiments, the prepared slices were fried in refined oil in an electric fryer (Fuzion 6L TRS). The fried chayote tuber chips were packed in self-sealing pouches after draining excess oil for further analysis. Frying experiments were conducted at different levels of frying oil temperature (160-180°C) and frying time (90-150s) based on preliminary trials. For baking experiments, prepared chayote tuber slices were baked in a baking oven (USHA 3760RCSS, India). Baking was done at various time (6-14 minutes) and temperature (160-180°C) combinations selected based on preliminary trials. The baked chayote tuber chips were packed in self-sealing pouches till further analysis. A full factorial design with three replications was followed for both frying and baking experiments (Table 20).

Table 20. Experimental design for chayote tuber chips

Independent variables		Treatment	Dependent variable
Frying temperature	**Frying Time**		Moisture content
160°C	130 s	T1	Hardness
	140 s	T2	
	150 s	T3	
170°C	90 s	T4	Color
	100 s	T5	
	110 s	T6	
180°C	70 s	T7	Acid insoluble ash
	80 s	T8	
	90 s	T9	
Baking temperature	**Time**		Fat
160°C	10 min	B1	Acid value
	12 min	B2	
	14 min	B3	
170°C	8 min	B4	Peroxide value
	12 min	B5	
	14 min	B6	
180°C	6 min	B7	Sensory analysis
	8 min	B8	
	10 min	B9	

The physical quality of fried and baked chayote tuber chips were analyzed in terms of moisture content, hardness, and color. The moisture content of chayote tuber chips samples were determined according to the method given by BIS (12569:1989) by using halogen moisture analyser (HC 103, Mettler Toledo) at 105°C. The hardness of the sample was evaluated by compression test using texture analyzer (TA-HD plus 5153, Stable Micro systems) with a 30 kg load cell. Color of the chips samples were measured using a Chroma meter (CR-410, Konica Minolta, Japan). The browning index (BI) of all samples were estimated using the L*, a* and b* color values as per Eq. (9). Browning index indicates the degree of browning in the developed chips. The product yield/recovery was determined as the ratio of the weight of fried/baked chips to the weight of fresh chayote tuber and expressed as %.

$$BI = 100 \times \left(\frac{X - 0.31}{0.17}\right) \quad \ldots (9)$$

where,

$$X = \frac{(a + 1.75L^*)}{(5.645L^* + a^* - 3.012b^*)}$$

The fried and baked chips were also analyzed for chemical properties viz., acid insoluble ash, fat content, acid value, and peroxide value. The acid insoluble ash content of the chayote tuber chip samples was determined using muffle furnace (USHA ITC 901M) according to the method described by BIS (12569:1989). The fat content of the chayote tuber chip samples was determined using soxhlet extraction apparatus (SOCS PLUS SCS 3) according to the method described by BIS (12569:1989). The acid value of the chayote tuber chip samples was determined according to the method describe by BIS (12569:1989). The peroxide value of the chayote tuber chip samples was determined according to the method described by Ranganna (2001). Sensory evaluation for different attributes viz., color, taste, odour crispiness, and overall acceptability of both fried chips was carried out by 60 untrained panellists and 20 panelists for baked chips (of the age group 20-45) from both genders. Sensory scores were converted to sensory indices for analysis as described in earlier sections.

Results

According to BIS standard, a moisture content of 2% db is required for fried and baked chips (BIS 12575, 2010). Chayote tuber chips become soft and sticky if the moisture content is very high, and prone to spoilage if moisture is more than the desired level. In the present study, moisture content of prepared fried chayote tuber chips varied in the range of 1.21 to 3.01% db for different treatments. Highest moisture content of 3.01% was found for Treatment, T7 (160°C for 130s) whereas lowest moisture content of 1.21% was observed for Treatment, T3 (180°C for 90 s). The moisture content of prepared baked chayote tuber chips varied in the range of 0.98 to 1.94% db for different treatments. Highest moisture content of 1.94% was found for Treatment, B2 (160°C for 12min) whereas lowest moisture content of 0.98% was observed for Treatment, B9 (180°C for 10min). From ANOVA, the moisture content of chayote tuber chips after frying and baking decreased ($p<0.05$) with the increase in temperature and time. These results were in agreement with those reported earlier by Quasem et al. (2009) and Bouaziz et al. (2016a).

The hardness values of fried and baked chips have been shown in Table 21. Table 21 shows that the hardness values ranged from 2.28 N to 7.67 N of fried chayote chips and from 4.75 N to 8.56 N for baked chips. From ANOVA, the effect of temperature and time on hardness of both fried and baked chips was found to be non-significant. Similar observations have been reported by Raleng et. al. (2022) for fried chayote fruit chips. No significant difference in hardness between fried and baked chips was observed. chayote tuber chips recovery was about 20-20.5%.

Table 21. Hardness and browning index of fried and baked chayote tuber chips

Frying Treatments	Hardness, N	Browning Index	Baking treatments	Hardness, N	Browning Index
T1	7.67	41.20	B1	4.75	109.33
T2	2.28	41.35	B2	4.38	114.99
T3	6.54	45.05	B3	5.52	92.18
T4	3.34	33.50	B4	2.48	109.83
T5	3.05	41.17	B5	6.69	122.74
T6	3.81	51.45	B6	8.56	128.10
T7	4.59	50.78	B7	5.68	109.26
T8	4.65	71.45	B8	7.54	100.36
T9	5.85	72.80	B9	4.12	81.35

The color of fried and baked chips were assessed in terms of browning index. The browning index increased from 41.20 to 72.80 for fried and 81.35 to 128.10 for baked chips as the frying and baking time & temperature increased (Table 21). Increase in browning index with increase in temperature and time of frying and baking may be attributed to Maillard reactions taking place at high temperatures. The browning index in case of baked chips were higher than fried chips which may be due to longer time of baking. Figs. 60 and 61 show the comparison of fried and baked chayote tuber chips.

Fig. 60. Fried chayote tuber chips

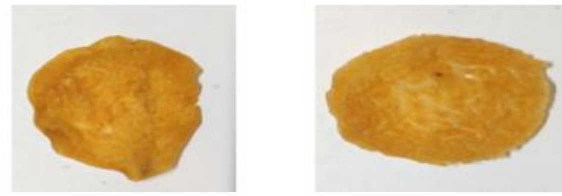


Fig. 61. Baked chayote tuber chips

In chemical properties, acid insoluble ash content was in the range of 0.01 to 0.06% (on dry basis) for fried chips samples and in the range of 0.02 to 0.10% (on dry basis) for baked chips. According to BIS standards, the acid insoluble ash of fried potato chips should not be more than 0.15% wet basis. From the comparison of data, the acid insoluble ash content decreased with increase in frying and baking temperature and frying/baking time. From ANOVA, these effects were not significant.

Table 22 shows the chemical properties data of fried and baked chayote tuber chips. Fat is an important component of chayote tuber chips that affect its taste and texture. The fat content of fried chayote tuber chips was found to be in the range of 11.95 - 23.77% and in the range of 2.48 – 12.05% for baked chips (Table 22). All the values were below 30% as recommended by BIS standards for fried potato chips. From ANOVA, the effect of frying/baking time on fat content was not significant ($p > 0.05$). The fat content in baked chips were significantly lower than fried chips.

Free fatty acids (FFA) value of oil is a key parameter regarding the fried product. The fatty acid composition is typically used for the assessment of oxidative stability and quality of the oil. The acid value of fried and baked chayote tuber chips ranged from 1.5-3.23% and 1.9-2.13% respectively as reported in Table 22. From Table 22, the peroxide values ranged from 5.97-13.84 meq O_2/kg of oil for fried and 7.32-12.65 meq O_2/kg of oil for baked chips. According to BIS standards, acid value should not be more than 2% and peroxide value should not be more than 10 meq O_2/kg of oil. Higher values of FFA and PV indicate the possibility of poor stability and susceptibility of the oil for oxidation. From Table 22, most treatments conform to the BIS standards of acid value and peroxide value. From ANOVA, effect of frying/baking time on acid value was not significant where as effect of frying time on peroxide value was highly significant ($p < 0.05$).

Table 22. Chemical properties of fried and baked chayote tuber chips

Frying Treatments	Fat content, %	Acid value, %	Peroxide value, meq O_2/kg of oil	Baking treatments	Fat content, %	Acid value, %	Peroxide value, meq O_2/ kg of oil
T1	18.11	1.97	5.98	B1	9.53	2.13	11.98
T2	23.77	2.14	7.96	B2	8.92	1.94	7.32
T3	18.17	3.23	9.95	B3	9.73	1.94	7.99
T4	11.95	2.6	13.84	B4	12.05	1.96	7.98
T5	14.73	1.96	7.97	B5	9.39	1.99	12.65
T6	23.03	1.89	5.98	B6	9.56	2	7.32
T7	14.43	2.05	5.97	B7	5.94	2.01	9.31
T8	21.20	1.5	7.99	B8	6.74	1.99	9.32
T9	16.08	1.94	8.95	B9	2.48	1.9	10.64

Table 23 shows the sensory evaluation scores in terms of sensory indices of color, taste, odour, crispiness and overall acceptability. Table 23, shows that maximum appearance index (90.00%) was found in the treatment T3 (Frying at 160°C 150 s) in case of fried chayote tuber chips and (15.00%) in the treatment T2 (Baking at 160°C 12 min) in case of baked chayote tuber chips (Fig 4.15). The least appearance score was recorded in treatment T9 (180°C 90 s and 10 min) both in the cases of (74.44%) fried and (11.11%) baked chayote tuber chips. The effect of the treatments on the appearance was significant ($P < 0.05$) for fried chips but not significant in baked chips as observed from ANOVA. From Table 23, it can be observed that the taste index varied from 77.2 to 89.26% in fried chips and from 11.11 to 12.78% in baked chayote tuber chips. The effect of temperature and time on the taste was significant ($P < 0.05$) for fried chips but not significant for baked chips as observed from ANOVA. The crispiness index varied from 79.63 – 88.7% and 11.44 -16.11% for fried and baked chips respectively. The effect of temperature and time on the crispiness was significant ($P < 0.05$) for fried chips but not significant for baked chips as observed from ANOVA. No significant effect of temperature and time on odour index was observed in both fried and baked chips. The range of overall acceptability index was 77.41 – 90.19% and 11.11-16.11% for fried and baked chips respectively. The effect of temperature and time of fried chips overall quality score was significant; but not significant in baked chips.

Table 23. Sensory Quality of chayote tuber chips

Treatments	Color		Taste		Odour		Crispiness		Overall Acceptability	
	Fried	Baked	Fried	Baked	Fried	Baked	Fried	Baked	Fried	Baked
T1/BI	89.63	14.44	88.89	12.22	81.11	13.89	88.70	14.64	90.19	18.33
T2/B2	88.70	15.00	89.26	11.67	79.81	13.33	87.41	12.22	89.44	15.56
T3/B3	90.00	12.78	86.30	12.78	76.85	12.78	86.48	16.11	86.11	16.11
T4/B4	86.48	13.33	84.63	11.67	76.85	11.67	83.70	15.78	85.19	15.00
T5/B5	85.19	12.78	79.44	12.22	75.93	12.22	83.15	12.78	81.67	15.56
T6/B6	79.44	12.78	77.22	11.66	73.15	11.67	82.59	14.44	90.00	13.33
T7/B7	76.67	13.33	81.48	12.78	75.19	11.11	82.59	15.54	80.74	12.22
T8/B8	76.48	11.67	82.41	11.11	76.11	11.11	79.63	13.33	81.48	11.67
T9/B9	74.44	11.11	77.96	11.11	72.78	11.11	83.89	11.44	77.41	11.11

For optimization of frying and baking conditions, sensory evaluation scores of chayote tuber chips were considered. From the analysis of sensory data as in Table 23, Treatment T1 (frying temperature of 160°C for 130 s) showed consistent scores in four out of five sensory attributes. Hence, it can be considered as optimum treatment for frying of chayote tuber chips. In case of baked chips, treatment B3 showed consistent scores in three out of five attributes and has peroxide value within 10 mEq/kg of oil. Hence, B3 treatment (baking temperature of 160° for 14 minutes) can be treated as optimum. Table 24 shows the quality of optimized fried and baked chayote tuber chips which conforms to BIS standards for fried potato chips. Fig. 62 shows the process flowchart for production of fried/baked chayote tuber chips.

Table 24. Quality parameters of fried and baked chayote tuber chips at optimized process conditions

Parameters	**T1**	**B3**	**BIS standard**
Moisture content, %db	1.99	1.86	2
Ash content, %	0.06	0.10	0.15
Hardness, N	7.67	5.52	-
Peroxide value, mEq/kg of oil	5.98	7.99	10
Fat, %	18.12	9.73	35
Acid value, %	1.97	1.94	2

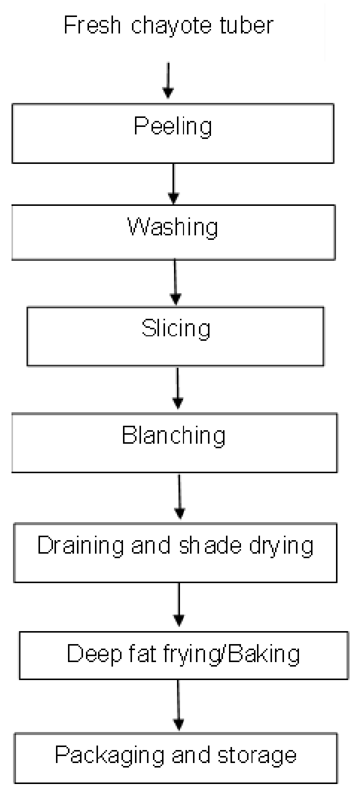


Fig. 62. Process flow chart for chayote tuber chips

5.0 Objective 5: Popularization of developed technologies through extension activities

Two primary processing machineries and six value added products were developed from chayote and cherry pepper under the present project. The process technologies for these products were also optimized. These technologies and machinery were popularized through various awareness, demonstration and skill development training programs and extension leaflets. Four leaflets viz., Dalle Khorsani, Chayote, Chayote-mandarin RTS beverage and red cherry pepper powder were published.

In addition to creation of awareness during field survey/visits, one awareness program and one technology demonstration mela was organized. One day awareness program on "Processing and value addition of chayote and dalley" was conducted in Mamzey village, East Sikkim on 05/01/22. About twenty two number of farmers participated in the program. The farmers were made aware about the different value added products from Dalley and chayote viz., chayote juice and other beverages, chayote papad, dalley powder, chutney etc. Samples of chayote papad were distributed to farmers which were well liked by the farmers.

Fig. 63. Glimpses of the awareness program conducted at Mamzey, East Sikkim

One technology demonstration mela was conducted at the institution on 25th January 2023, to showcase different products/machinery developed under the project. About 132 farmers participated in the mela. In addition to farmers of selected villages, farmers from other villages also participated. Leaflets developed under the project were distributed to the farmers to increase awareness about the chayote and cherry pepper processed products. Fig. 64 shows the glimpses of the Technology Mela conducted.

Fig. 64. Technology demonstration mela 2023

Eight on-field demonstration/training programs were organized to give hands on training on developed products to selected beneficiaries. Eight on-field one day demonstration programs on "Processing and value addition of chayote and dalley" was conducted in Dalapchen, East Sikkim on 13/03/22 & 10/03/23, Bikmat, South Sikkim on 24/05/22 & 06/03/23, Toong Naga village, North Sikkim on 21/09/22, Nessa & Arithang Chugrang, West Sikkim on 24/09/22, Lamantin Tigmoo, South Sikkim on 18/03/23 and Dabling, Kalimpong on 21/03/23. Total 147 beneficiaries were given hands on training on chayote and cherry pepper value added products and machinery. Fig. 65 and 66 show glimpses of various on-field demonstration programs conducted.

Fig. 65. Glimpses of various on-field demonstration programs

Fig. 66. Various glimpses of on-field demonstrations conducted

Three on campus one day skill development training program on "Processing and value addition of chayote and dalley" was organized at CAEPHT, Ranipool. were conducted at the institute for beneficiaries of selected villages. Total 51 beneficiaries from Ringhim, North Sikkim, Pakhang, Kalimpong, Nessa & Arithang-chungrang, West Sikkim were trained on 23/03/23, 27/03/23 and 28/03/23. Most of the trainees were women. The women were given hands on training on different value added products from Dalley and chayote viz., chayote papad, chayote tuber chips, dalley powder, dalley chutney powder etc. Different processing machines on chayote and dalley were also demonstrated to the trainees. Figs. 67 and 68 show glimpses of the skill development programs conducted at the institute.

Fig. 67. Hands on training for beneficiaries at CAEPHT, Ranipool

Fig. 68. Hands on training for selected beneficiaries at CAEPHT, Ranipool

For selection of beneficiaries, mostly Women Self Help Groups (SHGs) were selected. Most of the beneficiaries were selected from twenty women SHG groups operating in the selected villages. About 258 beneficiaries were selected from various villages of Sikkim and Kalimpong. About 198 beneficiaries were directly trained on various products and machineries developed under the project. Other beneficiaries were trained through the lead member of the SHG. Out of all the products demonstrated, chayote papad and chayote tuber chips were well received by all beneficiaries. These two products could be prepared using household appliances available in most of the SHGs without any additional investment. Out of all cherry pepper value added products, cherry pepper chutney powder was especially liked by many beneficiaries. However, production of cherry pepper products needed ₹ 1-1.5 lakhs as capital investment for mechanical hot air dryer. Hence, most of the beneficiaries were reluctant to adopt the technology. However, some beneficiaries were interested to adopt the technology with the support from State/Central Govt..

The two protoypes/machine developed were also appreciated by the beneficiaries. However, few modifications are needed in terms of ergonomical considerations, weigh reduction and durability before adoption by the beneficiaries.

Because of more interest shown in the chayote papad and chayote tuber chips, beneficiaries from cherry pepper villages were also trained in chayote based products. Few SHGs have started home scale production. Hence, at present, income generation through these technologies could not be achieved. The beneficiaries also expressed desire for future handholding in training and marketing of the products.

Since, the adoption of the technology was only in initiation stage, assessment of increase in income of the selected beneficiaries could not be done. However, assuming chayote papad to be the star novel product of the project, a probable increase in the income of the selected beneficiaries has been presented in Table 25. From Table 25, an average increase in income of ₹ 22,500/- per beneficiary would be possible if only chayote papad is taken for production. The amount would increase if chayote tuber chips is also taken for consideration. From the calculations presented in Table 25, it may be inferred that production of chayote papad can successfully be taken up as a livelihood generation option for 238 women and 150 SC/ST beneficiaries. The increase in income per beneficiary would help improve the overall socio-economical status of the whole household. Assuming four persons per household, the overall improvement in livelihood/socio-economic status of 600 SC/ST people would be possible only through one product developed under the project.

Table 25: Expected increase in livelihood/income of beneficiaries

		Existing average yearly income/ beneficiary, ₹	Expected yearly income/ beneficiary, ₹	Expected increase in yearly income/ beneficiary, ₹	Total increase in yearly income, ₹
Total No of Beneficiary	258	40,500/-	62,500/-	22,500/-	58,05,000/-
No. of women beneficiary	238				53,55,000/-
No. of SC/ST beneficiary	150				33,75,000/-

Basis of Analysis:

1. No land and equipment cost assuming all facilities to be available at SHG/home
2. Production days: 100 days per year based on seasonal availability
3. Production capacity: 2.5 kg chayote papad/day
4. Cost of production: ₹ 50/ kg papad
5. Selling price: ₹ 250/kg papad (at par with existing market price of regular papad)

Popularization of the developed process technologies needs to be continued for increasing the adoption rate of these technologies. Long term impact analysis in terms of actual increase in income and adoption rate of the technologies needs to be conducted for assessing the sustainability of these technologies.

APPENDIX 2

List of publications and Scientific manpower developed

Sl. No.	Type of publication	Details
1.	Extension leaflet	Dalle Khorsani
2.	Extension leaflet	Chayote mandarin blended beverage
3.	Extension leaflet	Red cherry pepper powder
4.	Extension leaflet	Chayote
	Technical report	
5.	B. Tech. project report	Development of chayote papad
6.	B. Tech. project report	Development of chayote kernel remover
7.	B. Tech. project report	Optimization of chayote-mandarin blended beverage
8.	B. Tech. project report	Study on the effect of hot air drying parameters on physical and sensory quality of red cherry pepper chutney powder
9.	B. Tech. project report	Development of a standardized process for chayote tuber chips
10.	B. Tech. project report	Performance evaluation of different peeling methods of chayote
11.	B. Tech. project report	Ergonomic evaluation of a prototype of chayote kernel remover
12.	B. Tech. project report	Shelf life estimation of chayote mandarin blended beverage
13.	B. Tech. project report	Study on the effect of blanching methods on the textural characteristics of red cherry pepper
14.	Conference/seminar souvenir	Said P.P., Jena, S., Majumder, K. and Subba, R (2022). Optimization of Chayote-Mandarin Blended Beverage. Published in the Souvenir of 56th Annual Convention of Indian Society of Agricultural Engineers (ISAE) & International Symposium on “India@2047: Agricultural Engineering Perspective”. 09.11.22-11.11.22, pp: ISAE-2022/PDFE/ DJRF – 042, TNAU, India.
15.	Scientific manpower developed	• 02 JPF • 15 nos. B. Tech (Agricultural Engg./Food Tech.) students

EXTENSION LEAFLETS

Dried Whole Dalle khorsani

Dried whole dalle khorsani has longer shelf life compared to fresh chilli. For production of whole dried dalle khorsani, fresh mature chillies are washed, destemmed, blanched followed by hot air drying at 60°C. Traditionaly, the chillies are sundried in an open area.

Ingredients: Dalle Khorsani

Dalle khorsani powder and flakes

Dried red cherry pepper flakes and powder belong to its high value processed products segment. In addition to the high value, these also have longer shelf life leading to lower spoilage and post-harvest losses. For production, fresh mature chillies are washed, destemmed, blanched followed by hot air/vacuum drying at 60°C. For production of flakes, the whole dalle chilli can be either cut into two halves or coarsely ground before drying. For production of powder, the dried chilli is ground in a spice grinder to a size < 500μ. The dried flakes and powder can be packed in aluminium foil lainated LDPE packets.

Ingredients: Dalle khorsani

Dalle khorsani chutney powder

Chutney is a thick paste prepared either from vegetables, fruits or nuts. Dalle khorsai chutney is a popular product to be used as a side dish with momos. It is prepared by grinding blanched and peeled tomatoes, fresh peeled ginger, destemmed dalle khorsani, roasted sesame seeds, and salt. The prepared chutney can be dried in a hot air dryer at 60°C and ground in to powder to be used as a ready to reconstitute product. This powder has a moisture content of 6-7% and can be packed in aluminium foil lainated LDPE packets.

Ingredients: Dalle khorsani, tomato, ginger, sesame seeds, and salt

Dried Dalle khorsani whole, flakes and powder

Dalle khorsani chutney powder

Dalle khorsani paste

Dalle khorsani vinegar pickle

Dalle khorsani oil pickle

Acknowledgement: NMHS for financial support through project entitled "Enhancing livelihood of farmers in Sikkim Darjeeling Himalayan belt through possible intervention in processing and value addition of underrated horticultural and spice crops"

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Dalle Khorsani

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Dalle khorsani/red cherry pepper is botanically known as Capsicum annuum var. cerasiforme. It belongs to the family Solanaceae and genus Capsicum. Red cherry pepper/Dalle Khorsani is a special variety of chilly grown in Sikkim, the Darjeeling hills and the Himalayas of Nepal. Cherry Bomb pepper or Red Cherry pepper is named as such for its resemblance in size and shape to fruits that share the same name, cherries and cherry tomatoes. They are small, round shaped, fleshy and heavily seeded. They are green in colour in early stage of fruiting and turn to red when fully matured. The local varieties of red cherry pepper include Nagey, Sanu dalley, and Thullo dalley.

Red cherry peppers have small, uniform pods, averaging 2 to 7 centimetres in both diameter and length, and are round to slightly ovate in shape attached to dark green, fibrous stems. It is well known for its unique flavor and high pungency. Scarlet red in colour, it is one of the hottest chillies in the world with a Scoville rating of 100,000 to 350,000 SHU. The area under red cherry pepper is about 248 hectares in Sikkim. Sikkim's Dalle has earned its Geographical Indication (GI) tag from the Department for Promotion of Industry and Internal Trade in 2020.

Nutritive value of Dalle Khorsani

Fresh cherry pepper contains about 84-88% wb moisture content. It is an excellent source of vitamin A and C, which are important antioxidants. It also has significant amounts of vitamin B, iron, thiamine, niacin, magnesium and riboflavin. It is cholesterol-free, saturated fat-free, low in calories, low in sodium and high in fiber. The amount of capsaicin in hot peppers varies very significantly between varieties.

Composition of Dalley khorsani

Components	Quantity
Water, %	84.64-85.28
Protein, %	2.0-2.45
Ash, %	0.71-0.81
Carbohydrates, %	9.8-10.82
Fat, %	1.83-2.24
Vitamin C, mg/100g	105.52-114.51
TSS, °Bx	10.89-11.07
pH	5.71-6.66

Pre Harvest Management

Dalle can be grown in open or under green house conditions. Its plant grows up to 100-130 cm height in an open field and 150-180 cm height in green house condition. Water stagnation in the field should be avoided to prevent damage to the crop.

Harvesting and Yield

Index of maturity and harvesting: The chill should be harvested when the pods are well ripened and the plant is partially withered. At this condition, the pods would have superior pungency and colour retention properties. Dalle khorsani is susceptible to water loss, and heat damage. Dalle khorsani starts flowering after 70-80 days of planting. The plant bears fruits for 2-3 years. Each plant produce 2.5 to 3.0 kg fruits with about 500 to 1000 pods. About 8-10 pickings are done per year. Care should be taken to gently pick the pods from the plants without causing any mechanical damage to the stem.

Fresh Dalle khorsani

Post Harvest Management

The freshly harvested chilli must be pre-cooled in cold room or through forced air cooling. It should be packed in corrugated fibre board boxes with cushioning materials. The packed chilli should be stored at a temperature of 7-10°C under high relative humidity (90 to 95 %) to maintain the freshness. Chilling injury may occur at lower temperatures. The symptoms of chilling injury are softening, pitting, and an increased susceptibility to decay.

Value addition

Cherry pepper is of ideal size for pickling or brining, and they also make for an excellent garnish on a dish. Green cherry pepper is mostly consumed as fresh. Very addictive, this chilli/pepper is a favourite side-dish with the usual 'daal-bhaat' in the Nepal-Sikkim belt. Red cherry pepper is crunchy and juicy and it is used for making pickle, brined dalle, sauce, and chutneys along with momos. It can be converted into dry chilli, paste, flakes, powder and chutney powder to add value.

Dalle khorsani pickle

Dalle pickle is very popular product. Both vinegar and oil based Dalle pickle can be produced. For pickiling, the dalle is first destemmed manually and washed. It is dipped in 5% brine (common salt) solution for 2-3 days. The soaked and drained dalle is then filled in pre-cleaned dry PET/glass bottles or jars with vinegar @ 2-5%, capped and stored. In case of oil pickle, the soaked and drained chilli is mixed with spices, oil and little vinegar followed by filling into bottles for storage.

Indredients: Dalle khorsani, oil, salt, vinegar and spices

Dalle khorsani paste

Chilli paste is a perishable semi-convenient food commodity which is much loved by the consumers. For is production, fresh red Dalle khorsani is destemmed, washed and ground to a smooth paste. It is mixed with salt, spices and acids/vinegar for improving the taste and shelf life.

Ingredients: Dalle khorsani, salt, spices, vinegar/acid

Chayote –Mandarin RTS Beverage

Chayote – mandarin RTS beverage has a fresh and sweet taste which is liked by the consumers. Though the shape of a chayote has been likened to a fist, its flavor doesn't exactly pack a punch. It has a fruit juice content of 10% and Total soluble solids of 12-13°Bx.

Ingredients: Chayote juice, mandarin juice, sugar, water and spices (optional).

Mixing of Juices

Prepared RTS

Acknowledgement: NMHS for financial support through project entitled "Enhancing livelihood of farmers in Sikkim Darjeeling Himalayan belt through possible intervention in processing and value addition of underrated horticultural and spice crops"

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Chayote-mandarin blended RTS beverage

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Blended RTS beverage-

Blended beverage improves the nutritional quality of traditional products. Compare to the raw materials, mixing of two or more kinds of fruits produced more vitamins and minerals and different sensory and flavor characteristics is obtained.

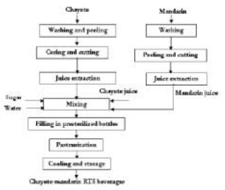
Fruits base beverage are liked and appreciated by all ages because of their being rich in essential minerals, vitamins and other nutritive factors and they accepted in all occasion.

Because of the lack of cold storage facilities and lack of awareness amidst the cultivator about preservation, many of the fruits' quality are spoiled before reaching the customer. Preparation of RTS from the chayote and mandarin thus preserved their taste and nutrients and also increased the shelf life.

Equipment:

Juice extractor

Process flow chart for production of chayote-mandarin RTS beverage-



Procedure

Preparation of chayote juice-

- Wash and peel the mature chayote
- Remove the core of the chayote
- Cut into medium size pieces and fed into the fruit juice extractor
- Filter the juice through double layered muslin cloth

Preparation of Sikkim mandarin juice

- Wash and peel the Sikkim mandarin
- Extract the juice using fruit juice extractor
- Filtered the juice through double layered muslin cloth

Preparation of RTS beverage

- Mix required quantity of sugar and water to prepare sugar syrup
- Add the sugar syrup to a mixture of chayote juice and Sikkim mandarin juice
- Mix thoroughly
- Fill the prepared RTS beverage in clean glass bottles.
- Sterilize the filled and capped bottles in boiling water for 15 minutes.
- Col and store

Composition of the RTS per litre

Components	Quantity
Chayote juice , ml	50
Sikkim mandarin juice, ml	50
Sugar, g	130
Water, ml	770
TSS, °Bx	12-13

Red cherry pepper powder

For production of red cherry pepper fresh mature cherry pepper samples are collected, washed, destemmed and blanched in hot boiling water for 2 minutes in hot water blanching with 1.5% KMS. The blanched samples can be cut into two halves or dried as whole in a tray dryer at 60°C for 14-15 hours or sun dried. For powder, the seeds are separated before grinding in a hammer mill/grinder to less than 500μ. The red cherry pepper powder produced retained good red colour. The moisture content of the powder is about 8-10 % db. The red cherry pepper powder can be packed in laminated pouches for storage. The process flowchart for production of red cherry pepper powder.

Materials required-

- Red cherry pepper
- Hot air tray dryer
- 1.5% KMS
- Grinder

Blanched and cut red cherry pepper

Dried Red cherry pepper seeds

Red cherry pepper flakes

Red cherry pepper powder

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Red cherry pepper powder

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Sorting
Sorting is a separation based on a individual physical properties of raw materials such as weight, size, shape, density, photometric property, etc.

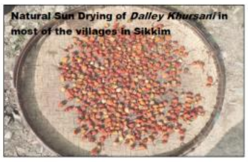
Destemming
Removing the stem or tips or tails of the cherry pepper.

Blanching
Blanching is scalding vegetables in boiling water or steam for a short time. It is typically followed by quick, thorough cooling in very cold or ice water. It deactivates the enzymatic activities.

Drying
It is the process of removing water.

Grinding
Reducing the dried red cherry pepper into powder.

Packaging
Packaging helps in keeping the products safe from external damages and also increases the shelf life.



Natural Sun Drying of *Dalley Khursani* in most of the villages in Sikkim

Red cherry pepper powder before packaging

Process Flow chart for production of red cherry pepper powder

Equipment for red cherry pepper powder

Hot air dryer

Solar tunnel dryer

Grinder

Hand sealer

Chayote –Mandarin RTS Beverage

Chayote – mandarin RTS is has a fresh and sweet taste which is liked by the consumers. Though the shape of a chayote has been likened to a fist, its flavor doesn't exactly pack a punch. Hence, blending of chayote juice with mandarin juice are excellent way to have high quality beverage.

Ingredients: Chayote juice, madarin juice, sugar, water and spices (optional)

Chayote Petha

An apealing sweet, "Petha" can be prepared using chayote fruit. The Intermediate mosisture food has better nutritional properties and acceptability by the consumers. Natural sweetner, honey, can be used to replace sugar.

Indredients: Chayote cubes, sugar/honey syrup, flavours and colours (optional)

Chayote tuber chips

The chyote tube is a potential source of carbohydrate. It can be dried into thin wafers/ chips and flavoured with chilli powder and salt to be relished as snack product.

Indredients: Chayote slices


Chayote Papad

Chayote-Mandarin Blended Beverage

Chayote Petha

Dehydrated Chayote Slices

Chayote tuber chips

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Chayote

(Underutilized vegetable with potential for Processing and value addition)

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Chayote/ Chow-chow (*Sechium edule Sw.*), a hairy climbing shrub, belongs to Cucurbitaceae family along with cucumbers, squash and melons. It is known as isqush (Nepali), chayote (English), is-kush, squash (Sikkim), sikot (Meghalaya), dashkush (Manipur), is-kus (Nagaland), ishkus (Darjeeling) and iskut (Mizoram). The fruits have more than eighty-six variants found in the region of Meghalaya, Mizoram and Sikkim.

It is single seeded fruit with different colours (light yellow to dark green) and different shapes (ovoid, peer, spherical, elongated) and sizes. The flesh is white in colour and has fairly bland taste, and texture described as a cross between potato and a cucumber. The whole vine is edible i.e. leaves, fruits, stem and roots. Traditionally it has been eaten raw, cooked, mashed, baked, boiled, fried or even pickled.

Nutritive value of chayote

Chayote is rich in antioxidants, including myricetin, which can help lower cholesterol levels, reduce inflammation, and protect against diseases such as heart disease and cancer. The root, stem and seed contain high calorific value and carbohydrate content. It is a good source of amino acids and vitamin C and is also very rich in Calcium in stem. It is also a source of potassium and fibre.

Composition of chayote fruit

Components	Quantity
Water, %	89.6 – 94.5
Protein, %	1.46-1.71
Ash, %	0.5-0.67
Carbohydrates, %	2.76-7.55
Fat, %	0.57-0.68
Vitamin C, mg/100g	9.38-16.17
TSS, °Bx	5.17-5.59
pH	6.61-7.24

Pre Harvest Management

The chayote vine can be grown on ground, but fruits may touch soil and get spoiled easily. Thus the vines are trained to spread on bowers made from thin rope and/or bamboo sticks or a metallic structure may be made particularly in rainy season to prevent the fruit from rotting and allowing the vines and foliage for better exposure to light and air.

Chayote Farm in Sikkim

Harvesting of chayote

Index of maturity and harvesting: The fruits are harvested manually at tender stage before development of seed and spreading of apical portion i.e. when it grows to 1/3rd to half. Fruits attain edible maturity 10-12 days after flower development (anthesis) and are judged by pressing on fruit skin and noting pubescence persisting on skin. At edible maturity seeds are soft. Seeds become hard and flesh turn coarse and dry during aging. Tender fruits with cylindrical shape are preferred in market.

Harvesting starts 55-60 days after sowing and is done at 3-4 days intervals. While harvesting, care should be taken to avoid mechanical injury to vines as well as to fruits (brushing, cutting, etc). Plucking of individual fruits is done with sharp knives by keeping a small part of fruit stalk along with fruit. Fruits should be collected in lined bamboo basket of special fruit picking bags made from fabric to avoid injuries during handling. A grown plant produces about 100-200 fruit per year. Each fruit weighs about 170-340 grams. Chayote should not be allowed to become over mature and

Post Harvest Management

Fruits must be pre-cooled in cold room or through forced air. Fruits can be packed in card board boxes with dividers and cushioning materials or shrink – wrapping of individual fruit may be adopted. The fruit is susceptible to chilling injury below 5°C (Symptoms: Swollen, watery spots on the periderm). The fruits are also susceptible to sprouting at humid and warm climate (>25°C)

Value addition

Value addition of chayote fruit and tuber is essential to enhance its consumption and increase in market value. Chayote fruits can be converted into Dehydrated chayote slices, papad, petha, beverages, jam, jelly, etc. where as the the tubers can be made into flour and chips to be savoured as a snack.

Dehydrated chayote slice

Traditionally, fruits were slice and sundried. The dehydrated slices then used for cooking as vegetable or in stew or in soups after rehydration. The vaccum drying showed potential application for commertial drying of chayote slices.

Chayote Papad

Papad is a popular tasty food item in Indian dietary science times immemorial and is in great demand always because most of the people like papads as one of the items in the daily lunch and dinner menu to make the food tastier.

Ingredients: Black gram, chayote, salt, papadkhar, black pepper and chilli powder.

TECHNICAL REPORTS

Development of Chayote (*Sechium edule*) Papad

A project report

Submitted to the

Central Agricultural University, Imphal
in partial fulfilment of the requirements
for the award of the degree of
Bachelor of Technology
in
Food Technology
by

Malemleima Waikhom

(REGN. No. U-18-SK-01-009-B-T-007)

&

Mayanglambam Gyanita Devi

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Ranipool, Gangtok, Sikkim-737135, India

February, 2022

Development of a Prototype of Chayote Kernel Remover

A project report

Submitted to the

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Bachelor of Technology

in

Agricultural Engineering

by

Mr. Adarsh Kumar

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Mr. Avinash Kumar

(I-18-SK-01-009-B-E-007)

COLLEGE OF AGRICULTURAL ENGINEERING & POST HARVEST TECHNOLOGY

(CENTRAL AGRICULTURAL UNIVERSITY, IMPHAL)

Ranipool, Gangtok, Sikkim-737135, India

July, 2022

STUDY ON EFFECT OF HOT AIR DRYING PARAMETERS ON PHYSICAL AND SENSORY CHARACTERISTICS OF RED CHERRY PEPPER BASED CHUTNEY POWDER

A project report

Submitted to the

Central Agricultural University, Imphal

In partial fulfillment of the requirements For
the award of the degree of

Bachelor of Technology
in
Food Technology

by

Ms. Anubhuti Singh(Admission no./REGN.NO.09/FT/18)

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FEBRUARY 2022

Optimization of chayote-mandarin blended beverage

A project report

Submitted to the

Central Agricultural University, Imphal
in partial fulfilment of the requirements
for the award of the degree of
Bachelor of Technology

in

Food Technology

by

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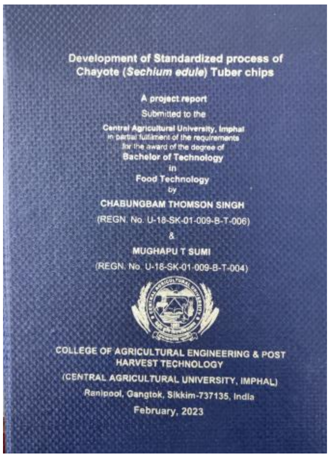
February, 2022


Development of Standardized process of Chayote (*Sechium edule*) Tuber chips

A project report

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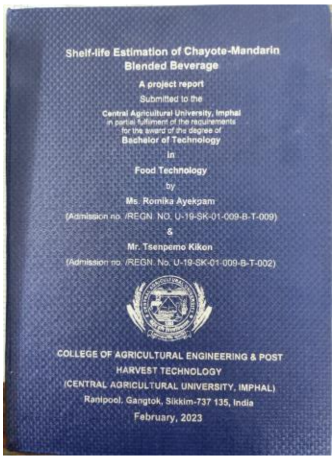
February, 2023


Shelf-life Estimation of Chayote-Mandarin Blended Beverage

A project report

Submitted to the

Central Agricultural University, Imphal
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for the award of the degree of
Bachelor of Technology
in
Food Technology
by

Ms. Romika Ayekpam
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&
Mr. Tsenpemo Kikon
(Admission no. /REGN. No. U-19-SK-01-009-B-T-002)

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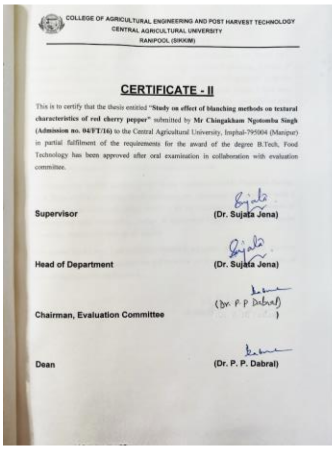
(CENTRAL AGRICULTURAL UNIVERSITY, IMPHAL)
Ranipool, Gangtok, Sikkim-737 135, India
February, 2023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RANIPOOL (SIKKIM)

CERTIFICATE - II

This is to certify that the thesis entitled "**Study on effect of blanching methods on textural characteristics of red cherry pepper**" submitted by **Mr Chingakham Ngotomba Singh (Admission no. 04/FT/16)** to the Central Agricultural University, Imphal-795004 (Manipur) in partial fulfilment of the requirements for the award of the degree B.Tech. Food Technology has been approved after oral examination in collaboration with evaluation committee.

Supervisor (Dr. Sujata Jena)

Head of Department (Dr. Sujata Jena)

Chairman, Evaluation Committee (Dr. P P Dabral)

Dean (Dr. P. P. Dabral)

Ergonomic Evaluation of a Prototype of Chayote Kernel Remover

A project report

Submitted to the

Central Agricultural University, Imphal
in partial fulfilment of the requirements
for the award of the degree of
Bachelor of Technology

in

Agricultural Engineering

by

Ms. H. Lalchhandami

(Admission no. /REGN. No.03/AE/2019)

Mr. Laimayum Pritamdatta Sharma

(Admission no. /REGN. No. 33/AE/2019)

COLLEGE OF AGRICULTURAL ENGINEERING & POSTHARVESTTECHNOLOGY
(CENTRAL AGRICULTURAL UNIVERSITY, IMPHAL)
Ranipool, Gangtok, Sikkim-737135, India
July, 2023

Performance Evaluation of Different Peeling Methods for Chayote

A project report

Submitted to the

Central Agricultural University, Imphal
in partial fulfilment of the requirements
for the award of the degree of
Bachelor of Technology

in

Food Technology

by

Shyamkumar Yumnam
(Admission no. /REGN. No.03/FT/16)

COLLEGE OF AGRICULTURAL ENGINEERING & POST HARVEST TECHNOLOGY
(CENTRAL AGRICULTURAL UNIVERSITY, IMPHAL)
Ranipool, Gangtok, Sikkim-737135, India
DECEMBER, 2019

SEMINAR SOUVENIER

PDFE/DJRF/042

Optimization of Chayote-Mandarin Blended Beverage

Said P.P., Sujata Jena, K. Majumder and Robin Subba
Department of Processing and Food Engineering,
College of Agricultural Engineering and Post-Harvest Technology, Ranipool, Gangtok (Sikkim)

Chayote is an underutilized fruit with bland flavour and is available abundantly in Sikkim. In order to minimize post-harvest losses through value addition, an investigation was conducted to produce refreshing RTS beverage. The blending of mandarin juice was done to make it flavourful and one of the healthy alternatives for the consumers. The full factorial experimental design was followed to optimize chayote juice to mandarin juice and level of juice contents. The optimum composition from 15 experiments were decided based quality of the juice i.e., Colour, TSS, pH, titratable acidity, ascorbic acid, and sensory attributes. Statistical analysis (ANOVA) showed that the process variables had significant effect on TSS, pH, titratable acidity, and ascorbic acid. However, the highest values of dependent variables like TSS (16.27°Brix) were found for treatment T_4, pH (4.40) for treatment T_4, titratable acidity (1.08%) for treatment T_{12}, ascorbic acid (14.91mg/100g) for treatment T_9. The DMRT analysis also showed that treatments with different letters are significantly different. The

APPENDIX 3

List of Trainings/ Workshops/ Seminars

Sl. No	Title of the program	Location	Date	No. of participants				
				SC	ST	Female	Male	Total
1.	Awareness Programme on "Processing and Value addition of Chayote & Dalley"	Mamzey village	05/01/22	0	2	5	17	22
2.	Technology demonstration Mela	CAEPHT, Ranipool	25/01/23	0	13	67	65	132
			Total	**0**	**15**	**72**	**82**	**154**
1.	Demonstration Programme on "Processing and Value addition of Chayote & Dalley"	Dalapchen	13/03/22	1	5	9	17	26
2.	Demonstration Programme on "Processing and Value addition of Chayote & Dalley"	Bikmat	24/05/22	0	4	17	7	24
3.	Demonstration Programme on "Processing and Value addition of Chayote & Dalley"	Toong Naaga	21/09/22	0	4	12	3	15
4.	Demonstration Programme on "Processing and Value addition of Chayote & Dalley"	Nessa and Arithang-chungrang	24/09/22	0	9	10	4	14
5.	Demonstration Programme on "Processing and Value addition of Chayote & Dalley"	Bikmat	06/03/23	0	4	23	1	24
6.	Demonstration Programme on "Processing and Value addition of Chayote & Dalley"	Dalapchen	10/03/23	0	1	16	0	16
7.	Demonstration Programme on "Processing and Value addition of Chayote & Dalley"	Lamatin Tingmoo	18/03/23	0	12	11	1	12

8.	Demonstration Programme on "Processing and Value addition of Chayote & Dalley"	Dabling	21/03/23	0	14	16	0	16
			Total	**1**	**63**	**114**	**33**	**147**
9.	Skill development Programme on "Processing and Value addition of Chayote & Dalley"	CAEPHT, Ranipool (Farmers of Ringhim)	23/03/23	0	11	11	0	11
10.	Skill development Programme on "Processing and Value addition of Chayote & Dalley"	CAEPHT, Ranipool (Farmers of Pakhang)	27/03/23	0	13	20	1	21
11.	Skill development Programme on "Processing and Value addition of Chayote & Dalley"	CAEPHT, Ranipool (Farmers of Nessa and Toong Naaga)	28/03/23	0	14	19	0	19
			Total	**01**	**101**	**164**	**34**	**198**
1.	Celebration of World Food Day	CAEPHT, Ranipool	**16/10/20**	**-**	**-**	**-**	**-**	**78**

Annexure-I

Consolidated and Audited
Utilization Certificate (UC) and Statement of Expenditure (SE)

For the Period: 01.02.19 to 31.03.23

1.	Title of the project/Scheme/Programme:	Enhancing livelihood of farmers in Sikkim Darjeeling Himalayan belt thorough possible interventions in processing and value addition of underrated horticultural and spice crops
2.	Name of the Principal Investigator & Organization:	Dr. Sujata Jena Professor and Head Department of Processing and Food Engineering College of Agricultural Engineering and Post Harvest Technology Central Agricultural University Ranipool, Sikkim
3.	NMHS-PMU, G.B. Pant National Institute of Himalayan Environment, Kosi-Katarmal, Almora, Uttarakhand Letter No. and Sanction Date of the Project:	Ref. No.: GBPNI/NMHS-2018-19/SG dated 29/01/19
4.	Amount received from NMHS-PMU, G.B. Pant National Institute of Himalayan Environment, Kosi-Katarmal, Almora, Uttarakhand during the project period (Please give number and dates of Sanction Letter showing the amount paid):	see table below
5.	Total amount that was available for expenditure (Including commitments) incurred during the project	48,34,392.00

Sanction order No & date	Amount, (INR)
1. Ref. No.: GBPNI/NMHS-2018-19/SG dated 29/01/19	23,86,000.00
2. Ref. No.: GBPNI/NMHS-2018-19/SG/226 /295/51 dated 15/07/20	52,000.00
3. Ref. No.: GBPNI/NMHS-2018-19/SG/226/ 295/51/ 105/227 dated 27/11/20	13,68,000.00
4. Ref. No.: GBPNI/ NMHS-2018-19/ SG/226/295/51/105/ 227/69/119/6 /209 dated 01/12/22	10,80,392.00
Total	**48,34,392.00**

	period: INR	
6.	Actual expenditure (excluding commitments) incurred during the project period: INR	44,52,836.00
7.	Unspent Balance amount refunded for opening zero balance account. (Please give details of Cheque no. etc.): INR	1,34,143.00 via cheque no: 354414 dated 31/10/22
8.	Balance amount available at the end of the project: INR	* Nil
9.	Balance Amount: INR	Nil
10.	Accrued bank Interest: INR	1,23,013.00

1. Note: * An amount of ₹ 1,89,443.00 has been refunded via cheque no 354434 on 11/08/23.

Certified that the expenditure of **Rs. 44,52,836.00 (Rupees: Forty Four Lakhs Fifty Two Thousand Eight Hundred Thirty Six)** mentioned against Sr. No. 6 was actually incurred on the project/scheme for the purpose it was sanctioned.

Date:

(Signature of Principal Investigator) | (Signature of Registrar/ Finance Officer) | (Signature of Head of the Institution)

OUR REF. No.

ACCEPTED AND COUNTERSIGNED

Date:

COMPETENT AUTHORITY
NATIONAL MISSION ON HIMALAYAN STUDIES (GBP NIHE)

Statement of Consolidated Expenditure

[NATIONAL MISSION ON HIMALAYAN STUDIES]

Statement showing the expenditure of the period from
Sanction No. and Date : 01.02.19- 31.03.23
Ref. No.: GBPNI/NMHS-2018-19/SG dated 29/01/19

1. Total outlay of the project : ₹ 48,93,000.00/-

2. Date of Start of the Project : 01/02/19

3. Duration : 04 years 02 months

4. Date of Completion : 31/03/23

a) Amount received during the project period : ₹ 48,34,392.00

b) Total amount available for Expenditure : ₹ 48,34,392.00

S. No.	Budget head	Amount received, ₹	Expenditure, ₹	Amount Balance/ excess expenditure, ₹
1	Salaries	10,69,514.00	9,09,524.00	1,59,130.00 **
2	Permanent Equipment Purchased (List enclosed)	14,50,000.00	13,84,283.00	0 *
3	Travel	3,59,090.00	2,04,489.00	25,228.00 **
4	Consumables	12,87,720.00	12,87,117.00	539.00 **
5	Contingency	6,57,720.00	2,32,423.00	601.00**
6	Institutional charges	4,35,000.00	4,35,000.00	-
A	**Total**	**48,34,392.00**	**44,52,836.00**	**1,85,498****
B	Accrued bank Interest	1,23,013.00	1,19,068.00***	3,945.00
C	**Grand total (A+B)**	**49,57,405.00**	**45,71,904.00**	**0********

Note:

2. * The unspent amount of ₹65,717/- was refunded to the funding agency via cheque no 354409 dated 27/07/22.
3. ** The total amount is after excluding the refunded money under NRC head (as above) and another amount of ₹1,34,143.00 (Salary: ₹ 860/-, Travel: ₹ 1,29,373/-, Consumables: ₹ 64/-, Contingency: ₹ 44/- and Interest: ₹3,802/-) that was refunded to funding agency via cheque no 354414 dated 31/10/22 for opening ZBBSA.
4. *** Includes an amount of ₹81,817/- that was adjusted under recurring head by funding agency, ₹14,276/- & ₹19,173/- refunded to the funding agency via online transaction on 15/07/21 &15/06/22 respectively and ₹3,802/- that was refunded as mentioned at S. No. 1 above.

5. **** Balance amount of ₹ 1,89,443.00 has been refunded via cheque no. 354434 on 11/08/23.

Certified that the expenditure of **Rs. 44,52,836.00 (Rupees: Forty Four Lakhs Fifty Two Thousand Eight Hundred Thirty Six)** mentioned against Sr. No.12 was actually incurred on the project/ scheme for the purpose it was sanctioned.

Date: 11/08/23

(Signature of Principal Investigator)	(Signature of Registrar/ Finance Officer)	(Signature of Head of the Institution)

OUR REF. No.

ACCEPTED AND COUNTERSIGNED

Date:

COMPETENT AUTHORITY
NATIONAL MISSION ON HIMALYAN STUDIES (GBP NIHE)

कृषि अभियांत्रिकी एवं कटाई उपरांत प्रौद्योगिकी महाविद्यालय
(केंद्रीय कृषि विश्वविद्यालय, इम्फाल)
रानीपुल, गान्तोक - ७३७१३५ (सिक्किम)
College of Agricultural Engineering & Post Harvest Technology
(Central Agricultural University, Imphal)
Ranipool, Gangtok – 737 135 (Sikki

Ph.: 03592-251359
Email: dean-caepht@gov.in
caepht.dean@gmail.com

Annexure-II

Consolidated Interest Earned Certificate

This is to certify that an amount of INR 41,196.00 /1,23,013.00 was earned as interest in the project "Enhancing livelihood of farmers in Sikkim Darjeeling Himalayan belt thorough possible interventions in processing and value addition of underrated horticultural and spice crops" funded under the NMHS Scheme of MoEF&CC during the period 01.02.19 to 31.03.23. The detail year wise break up of interest earned is as follows.

Sl. No	Period	Interest Earned, INR	Remarks
1.	01.04.19 - 31.03.20	73,789.00	-
2.	01.04.20 - 31.03.21	22,304.00	• An amount of INR 81,817.00 (73,789.00 +8,028.00) was adjusted against recurring/consumable head of the project. • The remaining amount of INR 14,276.00 was refunded via online transaction on 15.07.21.
3.	01.04.21 - 31.03.22	19,173.00	The total amount of INR 19,173.00 was refunded via online transaction on 15.06.22.
4.	01.04.22 - 31.03.23	7,747.00	• An amount of INR 3,802/- was refunded via cheque no 354414 dated 31/10/22 for opening ZBBSA .
	Total	**1,23,013.00**	• An amount of INR 3,945.00 has been refunded via cheque no 354434 on 11/08/23. Current balance against interest incurred is zero

(Signature of
Finance Officer)

(Signature of Head
of the Institution)

Annexure-III

Consolidated Assets Certificate

Assets Acquired Wholly/ Substantially out of Government Grants

(Register to be maintained by Grantee Institution)

1. Name of the Sanctioning Authority: **NATIONAL MISSION ON HIMALYAN STUDIES (GBP NIHE)**
2. Name of Grantee Institution: College of Agricultural Engineering and Post Harvest Technology (Central Agricultural University), Ranipool
3. No. & Date of sanction order: Ref. No.: GBPNI/NMHS-2018-19/SG dated 29/01/19
4. Amount of the Sanctioned Grant: INR 48.93 lakhs
5. Brief Purpose of the Grant: To develop processing machinery and process technologies for new value added products from chayote and cherry pepper and its popularization through capacity building activities.
6. Whether any condition regarding the right of ownership of Govt. in the property or other assets acquired out of the grant was incorporated in the grant-in-aid Sanction Order: No
7. Particulars of assets actually credited/acquired: Desktop computer with accessories (UPS, printer, webcam etc.), Vacuum oven, Colorimeter, Digital refractometer, Autoclave, Digital LCD projector.
8. Value of the assets as on 31.03.23: INR 10.58 lakhs
9. Purpose for which utilized at present: Academic and Research activities
10. Encumbered or not: No
11. Reasons, if encumbered: NA
12. Disposed of or not: No
13. Reasons and authority, if any, for disposal: NA
14. Amount realized on disposal: NA
15. Any Other Remarks: NA

(PROJECT INVESTIGATOR) **(FINANCE OFFICER)**

(HEAD OF THE INSTITUTION)

Annexure-IV

List or Inventory of Assets/ Equipment/ Peripherals

S. No.	Name of Equipment	Quantity	Sanctioned Cost, INR	Actual Purchased Cost, INR	Purchase Details	
					Make/Model	Date of purchase/ Installation
1.	Desktop computer	01	70,000.00	45,500.00	ACER VERITON M4660G	31/01/20
2.	UPS (accessories for computer)	01		4,490.00	Microtek 1 KVA	06/01/20
3.	Printer (accessories for computer)	01		15,550.00	Epson L4160 printer	19/03/20
4.	Accessories for Desktop computer (Webcam, HDD and head phone)	01 each		11,234.00	Logitech webcam, HDD (Seagate) and JBL Headphone	05/11/20
5.	Vacuum Oven with Vacuum Pump	01	1,50,000.00	85,000.00	IIC Industrial Corporation, Kolkata, India	25/02/20
6.	Colorimeter	01	10,00,000.00	9,96,450.00	Chroma meter CR-410	24/03/20
7.	Digital LCD Projector	01	30,000.00	31,760.00	Sony VPL EX430	19/03/20
8.	Autoclave	01	1,50,000.00	1,50,000.00	IGENE LABSERVE Vertical model	05/12/20
9.	Digital Refractometer	01	50,000.00	44,299.00	ATAGO PAL Alpha	31/03/20
10.		**Total**	**14,50,000.00**	**13,84,283.00**		

(PROJECT INVESTIGATOR) **(FINANCE OFFICER)**

(HEAD OF THE INSTITUTION)

Annexure-V

COLLEGE OF AGRICULTURAL ENGG. & POST HARVEST TECHNOLOGY
(CENTRAL AGRICULTURAL UNIVERSITY)
RANIPOOL, GANGTOK, SIKKIM – 737135

Phone- +91-3592-251359 **Fax- +91-3592-251390** **Email: dean-caepht@gov.in**

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 "Enhancing livelihood of farmers in Sikkim Darjeeling Himalayan belt thorough possible interventions in processing and value addition of underrated horticultural and spice crops" funded under the NMHS Scheme of MoEF&CC – reg.

Sir/ Madam,

This is hereby certified that the following permanent equipment purchased under the aforesaid project have been transferred to the Implementing Organization/ Nodal Institute after completion of the project:

1. Desktop computer
2. UPS
3. Printer
4. Computer accessories (webcam, HDD and Head phone)
5. Vacuum oven
6. Colorimeter
7. Digital refractometer
8. Autoclave
9. Digital LCD projector

Head of Implementing Organization:
Name of the Implementing Organization: College of Agricultural Engineering and Post harvest Technology, Ranipool
Stamp/ Seal:
Date:

Copy to:

1. The Nodal Officer, NMHS-PMU, National Mission on Himalayan Studies (NMHS), G.B. Pant National Institute of Himalayan Environment (NIHE), Kosi-Katarmal, Almora, Uttarakhand-263643

COLLEGE OF AGRICULTURAL ENGG. & POST HARVEST TECHNOLOGY
(CENTRAL AGRICULTURAL UNIVERSITY)
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Phone- +91-3592-251359 **Fax- +91-3592-251390** **Email: dean-caepht@gov.in**

Details, Declaration and Refund of Any Unspent Balance

It is hereby declared that an unspent balance amount of INR 1,89,443.00 under the project "Enhancing livelihood of farmers in Sikkim Darjeeling Himalayan belt thorough possible interventions in processing and value addition of underrated horticultural and spice crops" funded under the NMHS Scheme of MoEF&CC" has been refunded in favour of **NMHS GIA General** via cheque No. 354434 on 11/08/23.

(FINANCE OFFICER) **(HEAD OF THE INSTITUTION)**