NMHS-Himalayan Institutional Project Grant

NMHS-FINAL TECHNICAL REPORT (FTR)

Demand-Driven Action Research and Demonstrations

NMHS Grant Ref. No.:	GBPNI/NMHS-2019-20/SG/306

Date of Submission:	2	4	0	7	2	0	2	3
	d	d	m	m	y	y	y	y

PROJECT TITLE

VALUE ADDITION OF FRUITS AND VEGETABLES OF WESTERN HIMALAYAS THROUGH ECO-FRIENDLY AND LOW-COST TECHNOLOGIES

Project Duration: *from* (**10.10.2019**) *to* (**09.10.2022**)

Submitted to:

Er. Kireet Kumar
Scientist 'G' and Nodal Officer, NMHS-PMU
National Mission on Himalayan Studies, GBP NIHE HQs
Ministry of Environment, Forest & Climate Change (MoEF&CC), New Delhi
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Submitted by:

Prof F.A.Masoodi
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GENERAL INSTRUCTIONS:

1. The Final Technical Report (FTR) has to commence from the start date of the Project (as mentioned in the Sanction Order issued by NMHS-PMU) till completion of the project duration. Each detail has to comply with the NMHS Sanction Order.
2. The FTR should be neatly typed (in Arial with font size 11 with 1.5 spacing between the lines) with all details as per the enclosed format for direct reproduction by photo-offset printing. Colored Photographs (high resolution photographs), tables and graphs should be accommodated within the report or annexed with captions. Sketches and diagrammatic illustrations may also be given detailing about the step-by-step methodology adopted for technology development/ transfer and/ or dissemination. Any correction or rewriting should be avoided. Please provide all information under each head in serial order.
3. Any supporting materials like Training/ Capacity Building Manuals (with detailed contents about training programme, technical details and techniques involved) or any such display material related to project activities along with slides, charts, photographs should be brought at the venue of the Annual Monitoring & Evaluation (M&E) Workshop and submitted to the NMHS-PMU, GBP NIHE HQs, Kosi-Katarmal, Almora 263643, Uttarakhand. In all Knowledge Products, the Grant/ Fund support of the NMHS should be duly acknowledged.
4. The FTR Format is in sync with many other essential requirements and norms desired by the Govt. of India time-to-time, so each section of the NMHS-FTR needs to be duly filled by the proponent and verified by the Head of the Lead Implementing Organization/ Institution/ University.
5. Five (5) hard-bound copies of the Project Final Technical Report (FTR) and a soft copy of the same should be submitted to the **Nodal Officer, NMHS-PMU, GBP NIHE HQs, Kosi-Katarmal, Almora, Uttarakhand**.

The FTR is to be submitted into following two (02) parts:

Part A – Project Summary Report

Part B –Detailed Project Report

In addition, the Financial and other necessary documents/certificates need to be submitted along with the Final Technical Report (FTR) as follows:

Annexure I	**Consolidated and Audited Utilization Certificate (UC) & Statement of Expenditure (SE)**, including the interest earned for the last Fiscal year and the duly filled GFR-19A (with year-wise break-up).
Annexure II	**Consolidated Interest Earned Certificate**
Annexure III	**Consolidated Assets Certificate** showing the cost of the equipment in Foreign/ Indian currency, Date of Purchase, etc. (with break-up as per the NMHS Sanction Order and year wise).
Annexure IV	**List of all the equipment, assets and peripherals** purchased through the NMHS grant with current status of use, including location of deployment.
Annexure V	**Transfer of Equipment** through Letter of Head of Institution/Department confirming the final status of equipment purchased under the Project.

Annexure VI **Details, Declaration and Refund of any Unspent Balance transferred through Real-Time Gross System (RTGS)/ PFMS in favor of NMHS GIA General**

NMHS-Final Technical Report (FTR)

Demand-Driven Action Research Project

DSL: Date of Sanction Letter

3	0	0	9	2	0	1	9
d	d	m	m	y	y	y	y

DPC: Date of Project Completion

0	9	1	0	2	0	2	2
d	d	m	m	y	y	y	y

Part A: Project Summary Report

1. Project Description

i.	Project Grant Ref. No.:	GBPNI/NMHS-2019-20/SG					
ii.	Project Category:	Small Grant	√	Medium Grant		Large Grant	
iii.	Project Title:	Value Addition Of Fruits And Vegetables Of Western Himalayas Through Eco-Friendly And Low-Cost Technologies					

<table>
<tr><td>iv.</td><td>Project Sites (IHR States/ UTs covered) (Location Maps attached):</td><td colspan="6">02 Union Territories covered(J&K and Ladakh)
Western Himalayan region of Jammu and Kashmir specifically Kashmir and Ladakh (Annexure A)

• Gurez
• Izmarg
• Tulail valley
• Baramulla
• Kangan
• Tangmarg
• Leh-Ladakh
• Kargil
• Nubra valley
• Srinagar
• CITH Rangreth</td></tr>
<tr><td>v.</td><td>Scale of Project Operation:</td><td>Local</td><td></td><td>Regional</td><td>√</td><td>Pan-Himalayan</td><td></td></tr>
<tr><td>vi.</td><td>Total Budget:</td><td colspan="6">Rs 40,28,600/-</td></tr>
<tr><td rowspan="3">vii.</td><td>Lead Agency:</td><td colspan="6">Department of Food Science and Technology, University of Kashmir, Hazratbal</td></tr>
<tr><td>Lead PI/ Proponent:</td><td colspan="6">Prof F.A.Masoodi</td></tr>
<tr><td>Co-PI/ Proponent:</td><td colspan="6">Dr Sabeera Muzzaffer</td></tr>
</table>

viii.	Implementing Partners:	• Central Institute of Temperate Horticulture(CITH), Rangreth • Jammu and Kashmir Department of Agriculture • SKUAST-K • Mountain Agriculture Research and Extension Station, Gurez • Baseej e Zaraat Baghbani, agriculture wing of Imam Khomeni Memorial Trust, Kargil
	Key Persons (Contact Details, Ph. No., E-mail):	1. Prof F.A.Masoodi, Principal Investigator(PI) Professor , Department of Food Science and Technology, University of Kashmir Ph no : 9419135876 masoodi_fa@yahoo.co.in 2. Dr Sabeera Muzzaffer , Co PI Assistant Professor, Department of Food Science and Technology, University of Kashmir Ph no: 9906308877

2. Project Outcomes

2.1. Abstract/ Summary (not more than 250-300 words)

Background: Jammu and Kashmir (J&K) forms a part of Himalayas and is located in the north-western part of the Himalayan mountain arc in India. Being an agrarian state/union territory, more than 70% of the population is directly or indirectly dependent on agriculture and allied activities for their livelihood. The Physiographic nature of this Himalayan region witnesses a favourable climate and topography which enables its local population to cultivate vegetables and high value horticulture crops such as cole crops, root crops, apricots, apples, walnuts, tomatoes etc apart from cereal crops for their livelihood. However, due to the remoteness of the Himalayan region of Jammu and Kashmir, especially Ladakh, producers sometimes find it very difficult transport their produce to terminal markets. Fruits and vegetables are perishable in nature and must be sent to market or processed into value-added goods shortly after harvesting. However, the region's lack of cold chain/refrigerated transportation facilities and high-tech processing infrastructure makes both of the aforementioned options difficult to implement. Although certain traditional practises, like as sun drying, are used by locals as a way of post-harvest management, however, these practises frequently result in unsanitary and low-quality final products. Owing to the above mentioned problems, a large quantity of fruits and vegetables gets wasted resulting in economical loss to the region in general and producers in particular. This necessitates the need for development and popularization of various eco-friendly, sustainable and cost effective techniques for processing, preservation and value addition of surplus produce keeping in view the fragile ecosystem of Himalayas. The project's goal was to disseminate methods for converting perishable goods into valuable commodities. The aim was to provide a base of livelihood support to locals by eco-friendly and sustainable processing and preserving of perishables, promoting skill development among rural and tribal communities for better utilization of the available resources

Objectives/ Aim:

- Value addition of fruits and vegetables grown in rural and tribal areas of Western Himalayas by use of natural lactic acid fermentation
- Value chain recognition by studying ecological diversity of lactic acid bacteria of Himalayan fermented vegetables
- Processing of fruits and vegetables grown in rural and tribal areas of western Himalayas into value added products by use of eco-friendly low cost techniques

- Training and educating people about various low cost processing techniques for enhancing employment generation

***Methodology/Approach**:* A through literature review was done to gather information pertaining to the traditional fermentation of vegetables carried out in the Himalayan belt especially the western Himalayan region of Jammu and Kashmir. The preservation and market potential of these fermented products was evaluated. Moreover information regarding other value added products being produced in the region was also collected. The literature was analysed and perused extensively to explore the potential of low cost and eco-friendly strategies that could be implemented seamlessly in the region for value addition of the locally available vegetable and horticultural crops. Field surveys on several vegetable farms was undertaken with the intention to know about the fate of vegetable produce. Central Institute of Temperate Horticulture (CITH) and SKAUST-K were also visited to gather information about the local cultivars and hybrids of cruciferous vegetables cultivated in the region. Experimental trials based on eco-friendly and low cost technologies such as fermentation and dehydration were conducted to standardize the process of value addition of locally available surplus vegetables and fruits. Various training programs and workshops were conducted throughout the duration of this project with the aim to education the local population about various techniques that can be easily implemented for processing, preservation and value addition of locally grown fruits and vegetables. Areas with tribal/rural population were selected.

***Results/ Outcomes*:** The interaction with growers highlighted many problems faced by them including low monetary returns, wastage of surplus produce and lack of knowledge about value addition of vegetables. In terms of controlling/slowing down the proliferation of lactic acid bacteria both microwave and conventional heat treatments demonstrated effectiveness in controlling the fermentation process. Microwave Treatment of 2.5 minutes was found to have better effect in terms of controlling pH, acidity and LAB counts in sauerkraut as compared to UV treatment of 5 minutes indicating the possibility of using Microwaves for controlling fermentation process. Irradiation dose of 2.0kGy was found to complete kill the microbial population in kohlrabi pickle after attainment of desired pH and acidity, indicating its effectiveness in extending the storage life of spontaneously fermented vegetable products. Use of Bacteriocins (Nisin) was also found to be successful in controlling the growth of lactic acid bacteria. However further research work needs to be done to optimize the dose for desired results in terms of extension of storage period. Owing

to the skills imparted via training programs 4 young entrepreneurs started apricot processing in Ladakh and one entrepreneur started a fruit and vegetable processing unit at Babanagri Kangan.

***Conclusions**:* The project findings suggest the possible use of low cost and eco-friendly techniques such as fermentation and dehydration as an effective way to prevent economic losses faced by vegetable growers and farmers in times of surplus production by preventing post-harvest losses. The trainings imparted to different stakeholders including farmers has enabled them to acquire skills for transforming their produce into value added products to fetch better price in the market and also generate and additional source of income for low income households. The processing techniques used for controlling the traditional fermentation processes such as conventional heat treatment, microwaves, gamma irradiation and use of nisin proved to be effective. However, further research needs to be conducted in order to fully optimize their use.

***Recommendations/ Way Forward with Exit Strategy**:* The solid state fermenter and vacuum assisted microwave dryer are to be scaled up to commercial level by various local industries for mechanization of the traditional product development. These assets are being kept available for the local farmers and growers to timely process their produce into value added products.More on field demonstrations need to be conducted keeping in view the needs on the local population and the food commodity locally available in the area.

2.2. Objective-wise Major Achievements

SNO	Objectives	Major achievements (***in bullets points***)

1		Value addition of fruits and vegetables grown in rural and tribal areas of western Himalayas by use of natural lactic acid fermentation	The traditional household art of fermentation was explored and mechanized using solid state fermenter which provided a scientific and hygienic process for preparation of vegetable products. Moreover, anaerobic jars were also successfully used for carrying out fermentation process. Fermentation trials were conducted using cruciferous vegetables especially kohlrabi and cabbage as raw material. Cabbage was first time explored for fermentation as it is not locally/traditionally fermented. Training programs were also conducted that were focused on imparting training on fermentation to housewives, tribals and technical persons
2		Value chain recognition by studying ecological diversity of lactic acid bacteria of Himalayan fermented vegetables	The field surveys were carried out to identify the problems faced by local vegetable growers and food industries in processing and preservation of fruit and vegetable commodities and commercialization of the value added products thereof. Different control measures that could prove to be effective in controlling the lactic acid fermentation and extending the shelf life of traditionally fermented vegetables were evaluated for their effectiveness. These included conventional heat treatment, microwaves, gamma irradiation and use of nisin. Attempts were made to study the microbial diversity of the traditionally fermented vegetables in the region. 17 LAB were isolated from kohlrabi pickle. Phenotypic and genotypic characterization was done. Although this objective has not been completed due to various roadblocks. So far the research team has managed to identify one *Lactobacillus* species

3		Processing of fruits and vegetables frown in rural and tribal areas of western Himalayas into value added products by use of eco-friendly low cost techniques	09 dehydrated food products were developed using non-conventional techniques (vacuum assisted microwave drying and solar drying). The use of these dehydration techniques in place of sun drying proved to be advantageous in terms of quality and time consumption. These techniques were also demonstrated to participants during training programs and also to various persons from local food industry so as to pave way for commercialization of these techniques in the region
4		Training and educating people about various low cost processing techniques for enhancing employment generation	16 training programs and 2 workshops have been conducted during the project tenure. These programs targeted young students, entrepreneurs, farmers and tribal women folk. 4 young entrepreneurs have successfully started their apricot processing units. One entrepreneur started fruit and vegetable processing unit at Babanagri Kangan. The young entrepreneurs were also made aware about the rules and regulations under FSSAI for registration of producers and new businesses.

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

2.3. Outputs in terms of Quantifiable Deliverables*

Sno	Quantifiable Deliverables*	Monitoring Indicators*	Quantified Output/ Outcome achieved	Deviations, if any, & Remarks thereof:
1	Development of value added products(6no) along with their storage strategies	Training of housewives, tribals and technical persons of local industry on product development an d safety	Experimental data on fermentation trials has been generated. Microbial diversity exploration has been carried out and so far *Latilactobacillus*	NA

		Collection of raw material, fermentation trials, physico chemical analysis, sensory evaluation and microbial analysis.	*sakei* strain MBEL1397 has been identified from kohlrabi pickle Trainings on Fermentation as a processing technique has been imparted to tribal women folk, farmers and technical persons	
2	Facilitating better returns to producers (100 HH largely including ST community) through value addition of their produce	Number of value added products developed(nos) Training and awareness programmes organized (nos)	09 dehydrated products developed along with fermented products , jams and tomato processing products 16 training programs conducted	Apart from trainings, 02 workshops and field surveys were also conducted
3	Empowerment of the inhabitants of Kashmir Himalayas through enhancement of their skills in processing and preservation of	Number of beneficiaries village/local people(nos)	909 people were trained	4 young entrepreneurs started apricot processing unit in Ladakh 1 Entrepreneur started Fruit and vegetable processing unit at Babanagri Kangan

	produce(>50 ST families)			
4	Develop the knowledge products: 01 policy, 01 manual document and 2-3 publications in well reputed journals	No of reports/research articles/policy documents prepared and published(nos)	-	One(01)documentary has been prepared keeping in view the post-harvest management concerns of Fruits and Vegetables of the Himalayan region of J&K Research papers and review articles have been communicated to the journals but not published yet

*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	Solid state fermenter and vacuum assisted microwave dryer designed and used for hygienic production of traditional products.

S#	Particulars	Number/ Brief Details	Remarks/ Attachment
2.	New Ground Models/ Process/ Strategy developed, *if any*:	02 prototypes were designed to provide a hygienic and scientific basis for traditional product development • Solid state fermenter with a mixer has been designed in collaboration with M/s Grizzly Technologies • Vacuum assisted microwave dryer has been designed in collaboration with M/s Twin Engineers The working of these prototypes was demonstrated to concerned entrepreneurs at one day Industry-Institution Interaction Session held on 24-11-2021 to provide a hygienic and scientific basis for traditional product development	Annexure C
3.	New Species identified, *if any*:	NA	NA

S#	Particulars	Number/ Brief Details	Remarks/ Attachment
4.	New Database established, *if any:*	NA	NA
5.	New Patent, *if any*:	NA	NA
	I. Filed (Indian/ International)	NA	NA
	II. Technology Transfer, *if any*:	NA	NA
6.	Others, *if any*	NA	NA

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.	Processing techniques such as conventional heat treatment, microwaves, gamma irradiation and use of bacteriocins have been explored for controlling lactic acid fermentation	The present status of vegetable processing in western Himalayas reveals that the fermentation is conducted in traditional manner without much emphasis on safety and hygiene. The processed product does not last longer. The new data generated during the experiments can be used for refinement of traditional fermentation process	The results from various experimental trials can be used as a base to further explore the effectiveness of these techniques at different environmental conditions and with different raw materials. Moreover the feasibility of these processing techniques can be evaluated on a commercial scale by local industries.

2.	Use of vacuum assisted microwave dryer for dehydration of fruits and vegetables	The dehydration of vegetables is traditionally done by sun drying process in the region. During this process the raw material is exposed to microbial and environmental contaminants resulting in low quality end product. The equipment and process of dehydration has been demonstrated to technical persons from various local industries as well as to budding entrepreneurs and farmers.	The equipment can be used for mechanization of traditional drying process. The vacuum assisted microwave drying has following advantages • Significant reduction in drying time • Superior quality of dehydrated product • High nutritional and sensory qualities • No severe shrinkage • Prevention of oxidation due to absence of air
3.	Solid state fermenter	The traditional fermentation in the region is confined to household scale without any mechanization and scientific intervention. The equipment and process of fermentation has been demonstrated to technical persons from various local industries as well as to budding entrepreneurs and farmers	The equipment can be used for mechanization of traditional fermentation process. It provides a hygienic and scientific basis for product development with temperature control and constant pH monitoring.

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

S#	Type of Activities	Details with number	Activity Intended for	Participants/Trained			
				SC	**ST**	**Women**	**Total**

1.	Workshops	02 workshops were conducted • One day workshop on " Fruit and Vegetable Preservation" organized by Department of Food Science and Technology, University of Kashmir in collaboration with Department of Botany, Government Degree College Baramulla was conducted on 08-04-2021 • A workshop on "Fermented Foods and Gut Health" was conducted on 9-11-2021 as a part of 2nd International conference on Advances in Biopolymers - 2021(Annexure B)	The program was conducted to make students aware about the entrepreneurship opportunities in the field on Food Science and Technology. They were made aware of the processing techniques and how they can employ them to add value to locally available fruits and vegetables and establish their start-up The workshop focused on the scope of Fermented Food industry in Kashmir and Start- up opportunities for young entrepreneurs				60 200

2.	On-Field Trainings	• 16 training programs have been conducted during the project tenure. These programs targeted young students, entrepreneurs, farmers and tribal women folk (Annexure B).	• Post-harvest management, processing and preservation of Fruits and vegetables				909
3.	Skill Development	• 16 training programs were indented to impart processing and preservation knowledge to vegetable growers, tribal women and young students with the aim to encourage them to become entrepreneurs	• Skill development				
4.	Academic Supports	NA	NA				NA

	Others (if any)	One Industry institution interaction session	The aim of this session was to bridge the technological gaps and to mechanize the production of traditional foods particularly pickles and dehydrated vegetables. The interactive session was joined by many budding and established entrepreneurs who could use these technologies on an industrial scale(Annexure C and Appendix 6)				15

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	NA	NA
2.	Any other:	NA	NA

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

S#	Stakeholders	Support Activities	Impacts in terms of income generated/green skills built
1.	Line Agencies/ Gram Panchayats:	NA	NA
2.	Govt Departments (Agriculture/ Forest/ Water):	J&K Department of Agriculture-Linkage for conduct of trainings/demonstrations. Since J& K department of Agriculture has a Strong network for extension activities, their field officers were involved for imparting trainings	NA
3.	Villagers/ Farmers:	Trainings related to processing and preservation of Fruits and vegetables were imparted to many people including villagers and farmers in the Himalayan region of J&K and Ladakh	Skill development via training One entrepreneur from Babanagri Kangan established a processing unit.
4.	SC Community:	The locations for training programs were selected in a manner so as to cover SC and ST communities	Skill development via training
5.	ST Community:	The locations for training programs were selected in a manner so as to cover SC and ST communities	Skill development via training
6.	Women Group:	Women Self-help group in Turtuk, Ladakh	Skill development via training to tribal women folk

	Others, *if any*:	Baseej e Zaraat wa Bagbani, Agricultural Wing of Imam Khomeni Memorial Trust, Kargil	Skill development via training 4 budding entrepreneurs started processing unit after receiving training

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)

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

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

S#	Name of Equipment	Quantity	Cost (INR)	Utilisation of the Equipment after project
1.	Solar Dryer	01	Rs 54,250/-	The equipments are being used in the Department by research scholars and for training purpose. Moreover these equipments are also being kept available for local growers and farmers for processing their produce.
2.	Vacuum Assisted Microwave Dryer	01	Rs 9,70,000/-	

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

9. Quantification of Overall Project Progress

S. No.	Parameters	Total (Numeric)	Remarks/ Attachments/ Soft copies of documents
1.	IHR States/ UTs covered:	*02*	*UT of J&K and Ladakh have been covered under this project. Location maps attached(Annexure A)*
2.	Project Sites/ Field Stations Developed:	*11*	*Annexure A*
3.	Scientific Manpower Developed (PhD/M.Sc./JRF/SRF/ RA):	*01*	*JRF who is also continuing PhD on related topic of research*
4.	Livelihood Options promoted	*NA*	*NA*

5.	Technical/ Training Manuals prepared	*NA*	*NA*
6.	Processing Units established, if any	*NA*	*NA*
7.	No. of Species Collected, if any	*NA*	*NA*
8.	No. of New Species identified, if any	*NA*	*NA*
9.	New Database generated (Types):	*NA*	*NA*
	Others (if any)	*NA*	*NA*

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:	NA	NA	NA	The research articles and review papers have been communicated but not published yet
2.	Book – Chapter(s)/ Monograph/ Contributed:	NA	NA	NA	NA
3.	Technical Reports:	NA	NA	NA	NA
4.	Training Manual (Skill Development/ Capacity Building):	NA	NA	NA	NA
5.	Papers presented in Conferences/Seminars:	NA	NA	NA	NA
6.	Policy Drafts/Papers:	NA	NA	NA	NA
7.	Others, if any:				A documentary has been prepared keeping in view the post-harvest management concerns of Fruits and vegetables in the region

Note: Please append the list of KPs/ publications (with impact factor, DOI, and further details) with due Acknowledgement to NMHS. Supporting materials may be enclosed as annexure/ appendix separately to the FTR.

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

Particulars	Recommendations
Utility of the Project Findings:	The project findings suggest the possible use of low cost and eco-friendly techniques such as fermentation and dehydration as an effective way to prevent economic losses faced by vegetable growers and farmers in times of surplus production by preventing post-harvest losses. The trainings imparted to different stakeholders including farmers has enabled them to acquire skills for transforming their produce into value added products to fetch better price in the market and also generate and additional source of income for low income households. The processing techniques used for controlling the traditional fermentation processes such as conventional heat treatment, microwaves, gamma irradiation and use of nisin proved to be effective. However, further research needs to be conducted in order to fully optimize their use.
Replicability of Project/ Way Forward:	The different processing techniques used in the project can be explored for their effectiveness at different environmental conditions and with different raw materials. Moreover the feasibility of these processing techniques can be evaluated on a commercial scale by local industries. The equipments namely solid state fermenter and vacuum assisted microwave dryer can be used for mechanization of traditional product development on an industrial scale.

Exit Strategy:	The working of equipment s namely solid state fermenter and vacuum assisted microwave dryer have been demonstrated to various stakeholders. It is expected that these equipments will be scaled up to commercial level by various local industries. These assets are being kept available for the local farmers and growers to timely process their produce into value added products. The data generated during this project can be used to further explore the different processing techniques. More on field demonstrations need to be conducted keeping in view the needs on the local population

Prof F. A. Masoodi
Principal Investigator
Project Cell, Value Addition of Fruits and Vegetables
NMHS Funded

(PROJECT PROPONENT/ COORDINATOR)

(Signed and Stamped)

(HEAD OF THE INSTITUTION)

(Signed and Stamped)

Dean Research
University of Kashmir

Place: Srinagar
Date: 20/07/2023

Annexure-I

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

For the Period: 10-10-2019 To 09-10-2022

1.	Title of the project/Scheme/Programme:	**Value Addition Of Fruits And Vegetables Of Western Himalayas Through Eco-Friendly And Low-Cost Technologies**
2.	Name of the Principle Investigator & Organization:	**Prof F.A.Masoodi** **Department of Food Science and Technology, University of Kashmir**
3.	NMHS-PMU, G.B. Pant National Institute of Himalayan Environment, Kosi-Katarmal, Almora, Uttarakhand Letter No. and Sanction Date of theProject:	**GBPNI/NMHS-2019-20/SG/306 dated 30-09-2019**
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):	**Rs.31,03,040.00** **1.GBPNI/NMHS-2019-20/SG/306** **Dated 30-09-2019 2.** **2.GBPNI/NMHS-2019-20/SG/306/159/164/274 dated** **Dated:16-03-2022**
5.	Total amount that was available for expenditure (Including commitments) incurred during the project period: 10-10-2019 To 09-10-2022	**Rs.31,03,040.00**
6.	Actual expenditure (excluding commitments) incurred during the project period: 10-10-2019 To 09-10-2022	**Rs. 30,15,606.00**
	Accrued bank Interest period : 10-10-2019 To 09-10-2022	**Rs.99,850.00**
7.	Unspent Balance amount refunded, if any (Earned/Accrued as interest from bank of (Rs.9563/- of FY 2019-20) & (Rs.54,055/- of FY 2020-21)	**Rs. 63,618.00**
9.	Balance amount available at the end of the project:	**Rs.1,23,666.00**
10.	Balance Amount:	**Rs.1,23,666.00**

Certified that the expenditure of **Rs.30,15,606.00 (Rupees Thirty Lakh Fifteen Thousand Six Hundred Six Only)** mentioned against Sr, no. 6 was actually incurred on the project/ scheme for the purpose it was sanctioned.

Date:

Signature
Prof. H. A. Masoodi
Principal Investigator
Date:

Project value addition of Fruits and vegetables NMHS Funded

Signature
Dean Research
Date:

Dean Research
University of Kashmir

Signature
Director Finance
Date:

Signature
Chartered Accountant
Date: 17/05/2019

M/s Jan & Associates
Chartered Accountants

OUR REF. No. GBPNI/NMHS-2019-20/SG/306

ACCEPTED AND COUNTERSIGNED

Date:

COMPETENT AUTHORITY
NATIONAL MISSION ON HIMALYAN STUDIES (GBPNIHESD)

STATEMENT OF CONSOLIDATED EXPENDITURE
NATIONAL MISSION ON HIMALAYAN STUDIES

Statement showing the expenditure of the period from 10-10-2019 to 09-10- 2022

Sanction No. & Date : GBPNI/NMHS-2019-20/SG/306 Dated 30-09-2019

Total outlay of the project : Rs. 40,28,600.00

1. Date of Start of the Project : 10-October-2019
2. Duration : 3 Years (Three Years)
3. Date of Completion : : 09-October-2022

a Amount received during theperiod : Rs. 31,03,040.00

b Unspent amount carried forward from previous financial year : : Rs. Nil

Total amount available for Expenditure (a+b) : Rs. 31,03,040.00

S.No.	Budget head	Amount received	Expenditure	Amount Balance / Excess Expenditure
I	II	IV	VI	VII=(V-VI)
1	Salaries	8,63,040.00	9,63,491.00	-1,00,451.00
2	Permanent Equipment	11,80,000.00	11,79,956.00	44.00
3	Travel	1,40,000.00	1,32,392.00	7,608.00
4	Consumables	2,30,000.00	2,27,223.00	2,777.00
5	Contingency	1,40,000.00	1,37,118.00	2,882.00
6	Activities & Other project cost	4,80,000.00	3,05,426.00	1,74,574.00
7	Overhead	70,000.00	70,000.00	-
9	Accrued bank Interest	-	-	36,252.00
10	Total	31,03,040.00	30,15,606.00	1,23,666.00

Note2 An amount of Rs.99,850/- earned/accrued as interest from bank during the period out of that Rs. 63,618/- (Rs.9563/- of FY 2019-20) & (Rs.54,055/- of FY 2020-21) Has been Refunded to funding agency

Principal Investigator

Director Finance

Dean Research

C.A

Certified that the expenditure of **Rs.30,15,606.00 (Rupees Thirty Lakh Fifteen Thousand Six Hundred Six Only)** mentioned against Sr, no.10 was actually incurred on the project/ scheme for the purpose it was sanctioned.

Date:

Prof. E.A. Masood
Signature
Principal Investigator
Date:

Signature
Director Finance
Date:

Signature
Dean Research
Date:

Signature
Chartered Accountant
Date: 17/05/20

OUR REF. No. GBPNI/NMHS-2019-20/SG/306

ACCEPTED AND COUNTERSIGNED

Date:

COMPETENT AUTHORITY
NATIONAL MISSION ON HIMALYAN STUDIES (GBPNIHESD)

Annexure-III

Consolidated Assets Certificate

Assets Acquired wholly/ substantially out of Government Grants

(Register to be maintained by Grantee Institution)

Name of the Sanctioning Authority: National Mission on Himalayan Studies (NMHS)

1. Sl. No. GBPNI/NMHS-2019-20/SG
2. Name of Grantee Institution: University of Kashmir
3. No. & Date of sanction order: GBPNI/NMHS-2019-20/SG/306 DATED 30-09-2019
4. Amount of the Sanctioned Grant: 40,28,600/-
5. Brief Purpose of the Grant: Livelihood options and Employment generation
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: NA
7. Particulars of assets actually credited or acquired
   - Solar dryer purchased from Ms Rudra Solar Energy
   - Vacuum assisted microwave dryer purchased from Ms Twin Engineers.
8. Value of the assets as on 19-07-2023: 10,24,520/-
9. Purpose for which utilised at present: Research work and trainings
10. Encumbered or not Reasons, if encumbered: NA
11. Disposed of or not: Not disposed of
12. Reasons and authority, if any, for disposal: NA
13. Amount realised on disposal: NA

Any Other Remarks: NA

Prof. F. A. Mashoo.
(PROJECT INVESTIGATOR)
Principal Investigator
(Signed and Stamped)
Project work was on Drying of Fruits and vegetables - NMHS Funded

(FINANCE OFFICER)

(Signed and Stamped)

(HEAD OF THE INSTITUTION)

(Signed and Stamped)

Dean Research
University of Kashmir

Annexure-IV

List or Inventory of Assets/ Equipment/ Peripherals

S. No.	Name of Equipment	Quantity	Sanctioned Cost	Actual Purchased Cost	Purchase Details
1	Solar Dryer	01	Rs 3,00,000/-	Rs 54,250/-	Purchased from Ms Rudra Solar Energy. The equipment was delivered on 17-07-2021
2	Vacuum Assisted Microwave Dryer	01	Rs 7,86,000/-	Rs 9,70,000/-	Purchased from Ms Twin Engineers. The equipment was successfully installed in the department on 5-08-2021

Prof F. A. [illegible]
Principal Investigator

(PROJECT INVESTIGATOR)

(Signed and Stamped)

Exploitation of Fruits & Vegetables ..... NMHS Funded.

(FINANCE OFFICER)

(Signed and Stamped)

(HEAD OF THE INSTITUTION)

(Signed and Stamped)

University of Kashmir

Annexure-V

Letter of Head of Institution/Department confirming Transfer of Equipment Purchased under the Project to the Institution/Department

To,

The Convener, Mountain Division
Ministry of Environment, Forest & Climate Change (MoEF&CC)
Indira Paryavaran Bhawan
Jor Bagh, New Delhi-110003

Sub.: Transfer of Permanent Equipment purchased under Research Project titled "Value Addition Of Fruits And Vegetables Of Western Himalayas Through Eco-Friendly And Low-Cost Technologies " 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. Solar Dryer
2. Vacuum Assisted Microwave Dryer

Head of Implementing Organization:
Name of the Implementing Organization:
Stamp/ Seal:
Dean Research
University of Kashmir
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

Annexure-VI

Details, Declaration and Refund of Any Unspent Balance

Please provide the details of refund of any unspent balance and transfer the balance amount through RTGS (Real-Time Gross System) in favor of **NMHS GIA General** and declaration on the official letterhead duly signed by the Head of the Institution.

The total unspent amount is Rs, 123666.00, which has not been transferred back to the funding agency. The interest accrued from the bank for the financial year 2019-20 and 2020-21 amounting for Rs, 63618.00 has been refunded back to the funding agency.

(PROJECT INVESTIGATOR)

(Signed and Stamped)

(HEAD OF THE INSTITUTE)

(Signed and Stamped)

Dean Research
University of Kashmir

PART B: DETAILED PROJECT REPORT

1. EXECUTIVE SUMMARY

The Himalaya, a very complex and diverse mountain range in terms of both physical and biological features. Himalaya's has both bio-physical and socio-cultural diversity, as well as rich heritage of Indigenous Knowledge and Practices. The geographical isolation and varied eco-climatic conditions of this region have supported a large number of ethnic and unique socio-cultural groups with distinct traditional knowledge and practices of resource use and conservation.Jammu and Kashmir (J&K) forms a part of Himalayas and is located in the north-western part of the Himalayan mountain arc in India. Ladakh lies in the Trans Himalaya, extending from north of the Higher Himalaya to Karakoram mountains.These mountainous regions have been inhabited by the rural communities and tribals Being an agrarian state/union territory, the population mainly dependent on agriculture and allied activities for their livelihood. However, due to the remoteness of the region, farmers often find it difficult to get their goods to terminal markets. Fruits and vegetables are perishable in nature and must be sold or processed into value-added items as soon as possible after harvesting. However, due to a lack of cold chain/refrigerated transportation and high-tech processing infrastructure in the region, both of the aforementioned approaches are challenging to execute. Although communities adopt traditional practises such as sun drying as a method of post-harvest management, these practises sometimes result in low-quality end products. Because of the aforementioned issues, a considerable amount of fruits and vegetables are wasted, resulting in economic losses for the region as a whole and growers in particular. Therefore, there is a need for development and popularization of various eco-friendly, sustainable and cost effective techniques for processing, preservation and value addition of surplus produce keeping in view the fragile ecosystem of Himalayas. The project aimed to disseminate methods for converting perishable goods into valuable commodities. The focus was on providing livelihood support to locals by eco-friendly and sustainable processing and preserving of perishable commodities, promoting skill development among rural and tribal communities for better utilization of the available resources and income generation. Various training programs, workshops, field surveys and experimental trials have been conducted to achieve the objectives of the project. During the course of this project it was observed that local population involved in cultivation of fruits and vegetables, faced challenges in the form of low monetary returns, wastage of surplus produce and lack of adequate knowledge post-harvest management. Keeping in view these problems, the project activities were formulated to impart knowledge and skill to the concerned

people regarding post-harvest management, processing and preservation of surplus produce to prevent losses and explore some alternate livelihood options. The experimental trials were designed to evaluate different processing conditions for their effectiveness in controlling lactic acid fermentation. The results from various experimental trials can be used as a base to further explore the effectiveness of these techniques at different environmental conditions and with different raw materials. Moreover the feasibility of these processing techniques can be evaluated on a commercial scale by local industries. Prototypes, solid state fermenter and vacuum assisted microwave dryer, designed to provide a hygienic and scientific basis for traditional product development are to be scaled up to industrial scale.

2- INTRODUCTION

2.1 Background

Jammu and Kashmir (J&K) forms a part of Himalayas and is located in the north-western part of the Himalayan mountain arc in India(Romshoo et al., 2020). Topographically, Kashmir valley, in particular, depicts an elliptical bowl-shaped character, encapsulated between the mighty Pir Panjal range in its south and southwest, and the great Himalayan range in the north and east(Zargar et al., 2021). Ladakh lies in the Trans Himalaya, extending from north of the Higher Himalaya to Karakoram mountains(Dame et al., 2019).The mountainous region of Ladakh and Kashmir is inhabited by the rural communities and tribals Being an agrarian state/union territory, more than 70% of the population is directly or indirectly dependent on agriculture and allied activities for their livelihood(Zargar et al., 2021). The Physiographic nature of this Himalayan region witnesses a favourable climate and topography which enables its local population to cultivate vegetables and high value horticulture crops such as cole crops, root crops, apricots, apples, walnuts, tomatoes etc apart from cereal crops for their livelihood(Romshoo et al., 2020). However, due to the remoteness of the Himalayan region of Jammu and Kashmir, especially Ladakh, producers sometimes find it very difficult transport their produce to terminal markets. Fruits and vegetables are perishable in nature and must be sent to market or processed into value-added goods shortly after harvesting. However, the region's lack of cold chain/refrigerated transportation facilities and high-tech processing infrastructure makes both of the aforementioned options difficult to implement. Although certain traditional practises, like as sun drying, are used by locals as a way of post-harvest management, however, these practises frequently result in unsanitary and low-quality final products. Owing to the above mentioned problems, a large quantity of fruits and vegetables gets wasted resulting in economical loss to the region in general and producers in particular. This necessitates the need for development and popularization of

various eco-friendly, sustainable and cost effective techniques for processing, preservation and value addition of surplus produce keeping in view the fragile ecosystem of Himalayas. The project's goal was to disseminate methods for converting perishable goods into valuable commodities. The aim was to provide a base of livelihood support to locals by eco-friendly and sustainable processing and preserving of perishables, promoting skill development among rural and tribal communities for better utilization of the available resources.

2.2 Overview of Major issues Addressed

The major issue of economic loss and unemployment were addressed during the project duration. All the activities were focused on skill development among rural and tribal population especially women and enhancement of the supplementary livelihood options in the western Himalayas for employment generation. Moreover the project staff worked to bridge the technological gaps and to mechanize the production of traditional foods for better quality control and marketing.

2.3 Baseline Data and Project Scope

Baseline data

The Department of Food Science and Technology has a mandate to cater the technological needs and requirements of the people of the region. In this regard many linkages have been developed with the various stakeholders and industries existing in this region. Many entrepreneurs have approached the department with various technical problems they face. Moreover the Department of Food Science and Technology admits scholars from different regions of the state. They also provide their inputs and feedback pertaining to food processing done by people on grass root level. Such active interactions has enabled the department to identify the problems faced by the locals and entrepreneurs. This project is an outcome of such interactions and feedbacks. Some of the scholars supervised by the principal investigator have worked on fermentation of some indigenous vegetables. The work has focused on standardization of use of sodium benzoate and microwave treatment to control the growth of lactic acid bacteria in cauliflower and carrot pickle once a desirable pH and acidity is attained. The observations revealed that the microwave treatment had a better control on microbial population (LAB) as compared to sodium benzoate (Figure 1). Microwave treated carrot pickle showed significantly lower microbial count and titratable acidity value than samples treated with sodium benzoate. Sensory evaluation indicated significantly higher overall acceptability score for microwave treated sample (2.5 min) than control. The research findings indicated that microwave treatment could be employed to extend the shelf life and preserve the organoleptic attributes of carrot pickle(Mir et al., 2020).It was also observed

that microwave treatment was able to arrest/slowdown fermentation of the Cauliflower pickle by inhibiting the growth of lactic acid bacteria (LABs), there by controlling the acid production (Raja et al., 2020). Moreover the other scholars under supervision of the principal investigator have also been working on the supplementary livelihood options for local communities in Ladakh and extent of production and promotion of value added organic food in Kargil. The principal investigator has also worked on probiotics isolated from different food sources. The probiotic isolates have been successfully characterized for acid and bile tolerance. Moreover the stability of *Lactobacillus* in GI tract has been enhanced by microencapsulation. LAB were isolated and identified from Kradi cheese. The results revealed the presence of five LAB namely *Lb. curvatus, Lb. sake, Lb. planatrum, Pediococcus pentosaceous* and *Enterococcus faecium*. Among these probiotic strains, *Lb. planatrum* showed highest hydrophobicity and antimicrobial activity against different pathogenic strains(Mushtaq et al., 2021).

Project scope

The project will help to overcome the livelihood problems faced by the rural and tribal communities in Himalayan region of Jammu and Kashmir. It will enable the local producers to prevent economic losses by converting their surplus produce into value added products ensuring good monetary returns. Creation of better marketing facilities for the produce and value added products will also add to the above mentioned gains. Moreover use of eco-friendly techniques such as fermentation with proper scientific interventions can be popularized in the region that will ensure good quality end product and in turn will create better customer base for naturally fermented vegetables that form the integral part of Himalayan diet. Training of local tribal/rural population will generate skilled manpower and therefore can also contribute in employment generation in the state.

EFFECT OF MICROWAVE AND SODIUM BEZOATE TREATMENT ON LAB COUNT

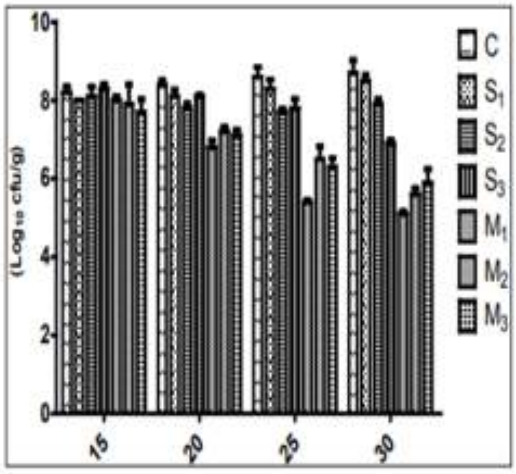

Fig. 1: Microbial load of different samples of cauliflower

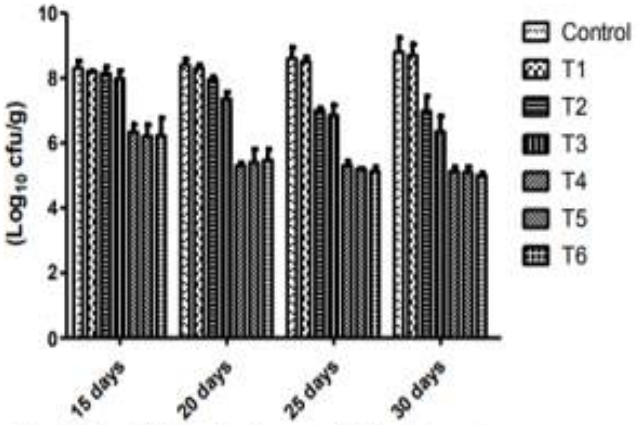

Fig.1. Microbial load of carrot pickle during storage

Figure 1: Effect of Microwave and Sodium Benzoate treatment on LAB count

2.4 Project objective and Target deliverables

Project objectives

- Value addition of fruits and vegetables grown in rural and tribal areas of Western Himalayas by use of natural lactic acid fermentation
- Value chain recognition by studying ecological diversity of lactic acid bacteria of Himalayan fermented vegetables
- Processing of fruits and vegetables grown in rural and tribal areas of western Himalayas into value added products by use of eco-friendly low cost techniques
- Training and educating people about various low cost processing techniques for enhancing employment generation

Target deliverables

- Development of value added products(06) along with their storage strategies
- Facilitating better returns to producers (100 HH largely including ST community) through value addition of their produce

- Empowerment of the inhabitants of Kashmir Himalayas through enhancement of their skills in processing and preservation of produce(>50n ST families)
- Develop the knowledge products; 01 policy, 01 manual document and 2-3 publications in well reputed journal.

3- METHODOLOGY/STRATEGY/APPROACH

3.1 Methodologies used

Firstly, a through literature review was done to gather information pertaining to the traditional fermentation of vegetables carried out in the Himalayan belt especially the western Himalayan region of Jammu and Kashmir. The preservation and market potential of these fermented products was evaluated. Moreover information regarding other value added products being produced in the region was also collected. The literature was analysed and perused extensively to explore the potential of low cost and eco-friendly strategies that could be implemented seamlessly in the region for value addition of the locally available vegetable and horticultural crops. The literature review was followed by on field work, where survey on several vegetable farms was undertaken with the intention to know about the fate of vegetable produce. The interaction with growers highlighted many problems faced by them including low monetary returns, wastage of surplus produce and lack of knowledge about value addition of vegetables. Central Institute of Temperate Horticulture (CITH) and SKAUST-K were also visited to gather information about the local cultivars and hybrids of cruciferous vegetables cultivated in the region. Secondly, experimental trials based on eco-friendly and low cost technologies such as fermentation and dehydration were conducted to standardize the process of value addition of locally available surplus vegetables and fruits. Different techniques such as conventional heating, microwaves, gamma irradiation and bio preservation techniques were used to evaluate their effectiveness in controlling the growth of LAB (Appendix1).Moreover, LAB were also isolated on MRS agar from fermented samples using spread plate technique. These isolates were further characterized phenotypically and genotypically. For DNA extraction Promega Genomic DNA extraction and purification kit was used. The extracted DNA was amplified using thermocycler and identified using BLAST sequencing(Appendix1).Moreover to bridge the technological gaps and to mechanize the production of traditional fermented vegetable products for better quality control and marketing, a solid state fermenter was designed in association with M/s Grizzly technologies. Further A vacuum assisted microwave dryer from M/s Twin engineers and solar dryer for M/s Rudra Solar Energy were used for dehydration of vegetables and fruits as alternatives for sun drying. Further the design and working of these equipments were demonstrated to established

and budding entrepreneurs in an interactive industry- institution session. Lastly, various training programs and workshops were conducted throughout the duration of this project with the aim to education the local population about various techniques that can be easily implemented for processing, preservation and value addition of locally grown fruits and vegetables. Areas with tribal/rural population were selected. These training programs not only targeted women folk of tribal/rural areas but also farmers, young students, scholars and budding entrepreneurs that could channelize all the gained knowledge for skill development and employment generation via start-ups.

3.2 Data collected and equipments used

The data collected during different experimental trials is presented below

a) General procedure for manufacturing of vegetable pickle

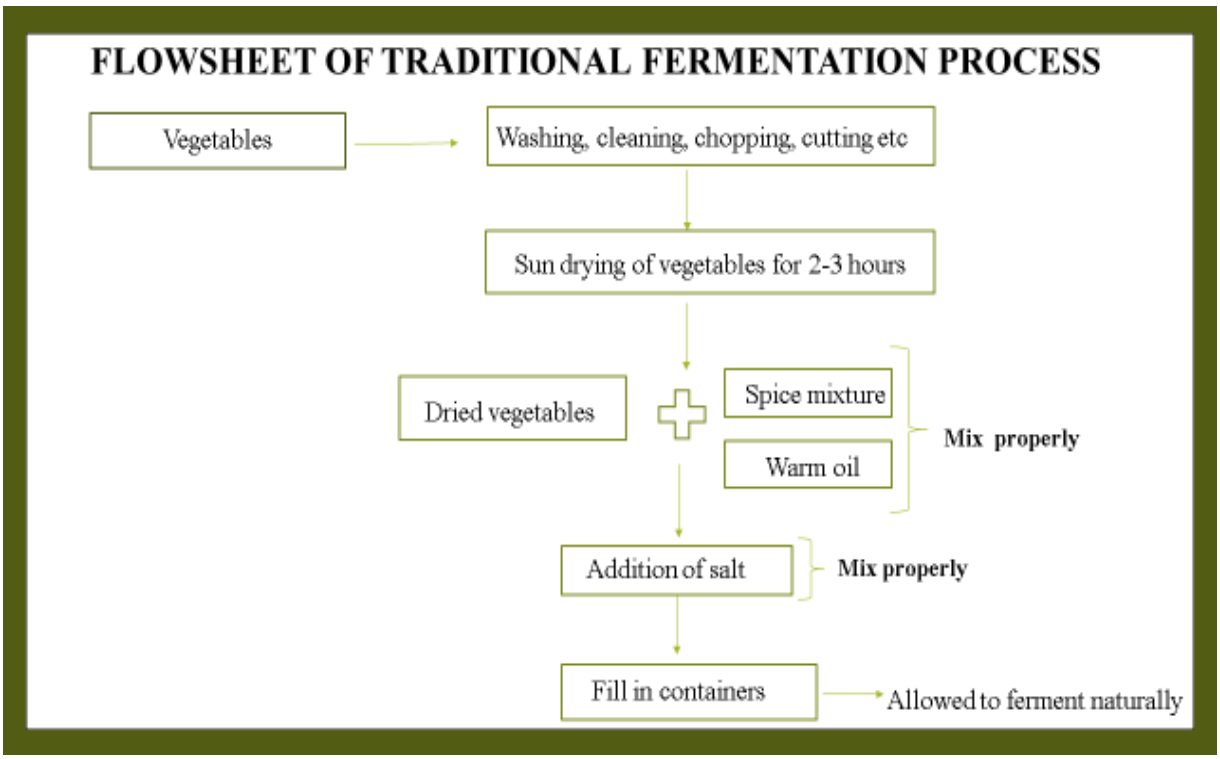

Figure 1: Flowsheet of traditional fermentation process

b) To examine the influence of conventional heat and microwave treatment on desired quality parameters including pH, acidity, microbial load, and sensory characteristics of fermented kohlrabi pickle over a 25-day storage period. Microwave-treated samples T1(2min), T2(2.5min), T3(3min), T4(3.5 min), and T5(4mins), as well as conventional heat-treated samples T6, T7, and T8(90 C

for 5,10, and 15 min, respectively) and T9, T10, and T11(100 C for 5,10, and 15 min, respectively) were analyzed for various quality attributes over 25 days at regular intervals in comparison with controls (T0).

Proximate composition(%) of raw material					
	Ash	Carbohydrate	Moisture	Fat	Protein
whole sample	1.57±0.06	6.64±0.25	89.07±0.39	0.17±0.01	2.10±0.37

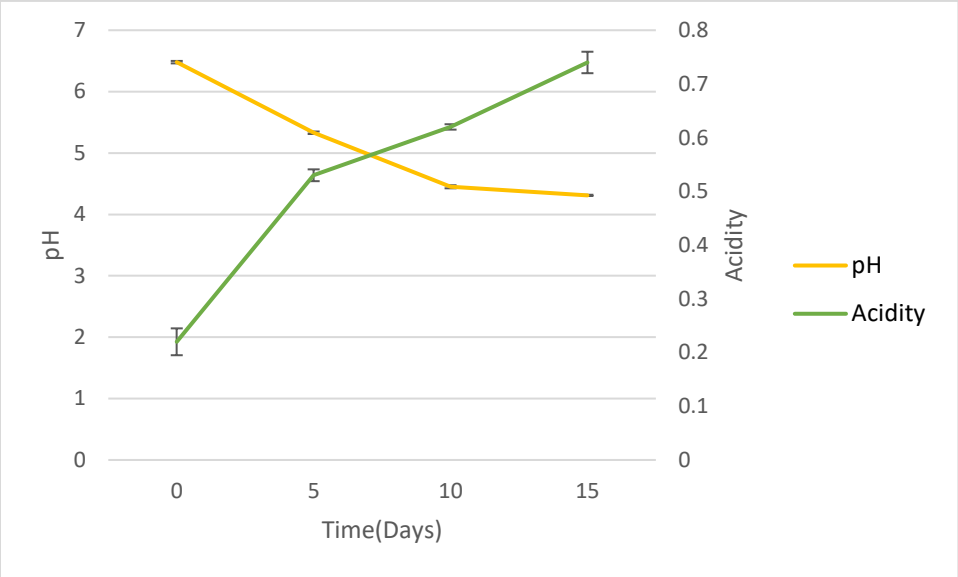

Figure 1: pH and Acidity (%) values of product (P) during fermentation before treatment

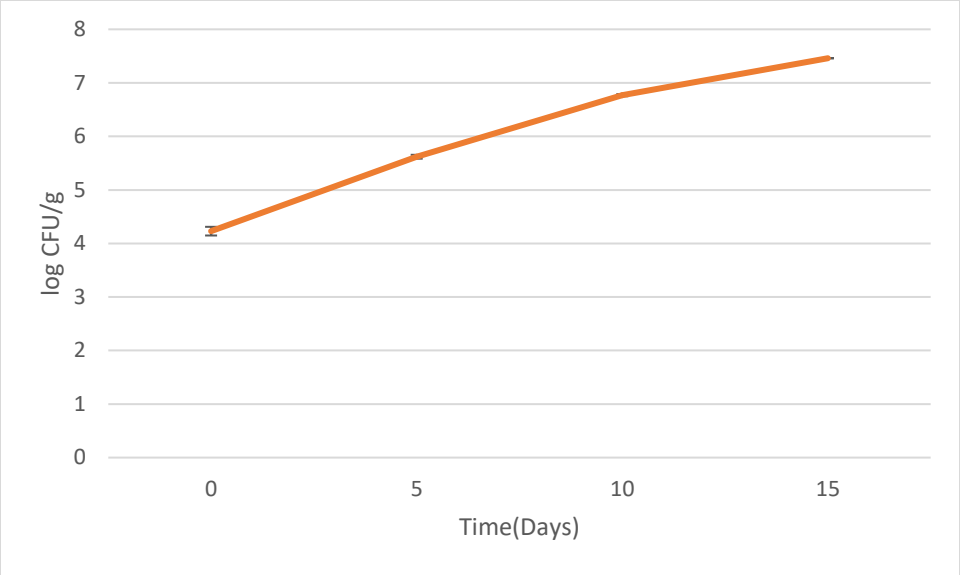

Figure 2: LAB count of product (P) during fermentation before treatment

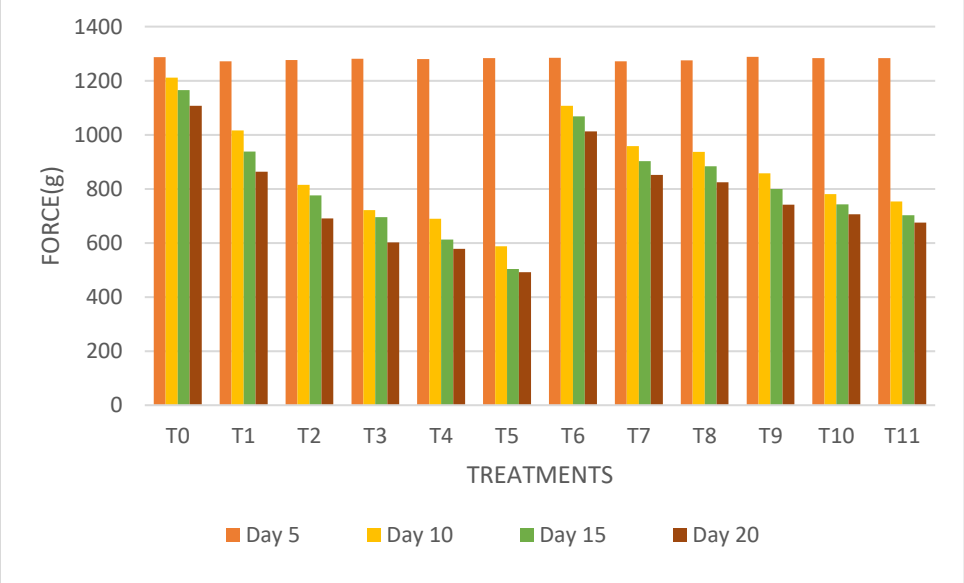

Figure 3: Hardness (H) values of kohlrabi pickle during storage

Table 1: pH of fermented kohlrabi pickle samples during storage

	Day 5	Day 10	Day 15	Day 20	Day 25
T0	4.14 ± 0.015^{aq}	4.04 ± 0.023^{bq}	3.96 ± 0.020^{cs}	3.75 ± 0.020^{ds}	3.64 ± 0.030^{es}
T1	4.21 ± 0.015^{ap}	4.15 ± 0.025^{ap}	4.11 ± 0.015^{bp}	3.95 ± 0.035^{br}	3.83 ± 0.030^{br}
T2	4.21 ± 0.015^{ap}	4.14 ± 0.025^{abcp}	4.12 ± 0.020^{bp}	4.11 ± 0.020^{bcp}	4.04 ± 0.040^{cdp}
T3	4.17 ± 0.026^{aq}	4.13 ± 0.020^{abp}	4.06 ± 0.030^{bq}	4.02 ± 0.026^{bcq}	3.98 ± 0.025^{cdpq}
T4	4.13 ± 0.015^{aq}	4.11 ± 0.015^{ap}	4.04 ± 0.020^{br}	4.01 ± 0.015^{bqr}	4.01 ± 0.015^{bp}
T5	4.14 ± 0.020^{aq}	4.11 ± 0.020^{abp}	4.04 ± 0.052^{br}	4.02 ± 0.020^{bqr}	4.00 ± 0.015^{bp}
T6	4.13 ± 0.015^{aq}	4.07 ± 0.015^{abq}	4.02 ± 0.025^{brs}	3.94 ± 0.041^{cqr}	3.78 ± 0.030^{dr}
T7	4.15 ± 0.020^{aq}	4.13 ± 0.020^{ap}	4.04 ± 0.040^{br}	3.99 ± 0.015^{bcpq}	3.87 ± 0.025^{dqr}
T8	4.15 ± 0.025^{aq}	4.12 ± 0.020^{abp}	4.06 ± 0.036^{bq}	4.05 ± 0.030^{bcpq}	3.93 ± 0.094^{cdq}
T9	4.15 ± 0.015^{aq}	4.13 ± 0.020^{ap}	4.07 ± 0.015^{bcp}	4.07 ± 0.020^{cpq}	4.00 ± 0.015^{dpq}
T10	4.16 ± 0.020^{aq}	4.13 ± 0.025^{abp}	4.09 ± 0.010^{bp}	4.05 ± 0.045^{bdpq}	4.01 ± 0.015^{dep}
T11	4.16 ± 0.015^{aq}	4.14 ± 0.020^{ap}	4.08 ± 0.020^{abcp}	4.04 ± 0.050^{bpq}	$4.00 \pm 0.040^{bc\ p}$

Values are represented as mean± SD

Mean values ± SD within a row and column with different superscript letters are significantly different ($P \leq 0.05$).

Table 2: Acidity (%) of fermented kohlrabi pickle samples during storage

	Day 5	Day 10	Day 15	Day 20	Day 25
T0	1.02 ± 0.049^{dp}	1.11 ± 0.051^{cdp}	1.18 ± 0.023^{cbp}	1.24 ± 0.028^{bp}	1.41 ± 0.051^{ap}
T1	0.96 ± 0.055^{cp}	1.05 ± 0.051^{bcp}	1.12 ± 0.045^{abp}	1.20 ± 0.051^{ap}	1.24 ± 0.028^{aq}
T2	0.99 ± 0.005^{cdp}	1.02 ± 0.049^{bcp}	1.10 ± 0.023^{bp}	1.12 ± 0.045^{abq}	1.19 ± 0.023^{aq}
T3	1.02 ± 0.051^{bp}	1.09 ± 0.023^{abp}	1.12 ± 0.045^{abp}	1.13 ± 0.028^{abq}	1.19 ± 0.070^{aq}
T4	1.02 ± 0.046^{bp}	1.09 ± 0.023^{abp}	1.12 ± 0.045^{abp}	1.16 ± 0.045ap	1.18 ± 0.023^{aq}
T5	1.05 ± 0.051^{bp}	1.10 ± 0.023^{abp}	1.13 ± 0.028^{abp}	1.15 ± 0.028^{ap}	1.16 ± 0.040^{aq}
T6	1.05 ± 0.051^{ap}	1.09 ± 0.087^{ap}	1.11 ± 0.098^{ap}	1.20 ± 0.051^{ap}	1.22 ± 0.032^{aq}
T7	1.05 ± 0.058^{bcp}	1.09 ± 0.023^{bp}	1.15 ± 0.028^{abp}	1.19 ± 0.023^{ap}	1.22 ± 0.028^{aq}
T8	1.02 ± 0.046^{bcp}	1.09 ± 0.023^{bp}	1.13 ± 0.028^{abp}	1.18 ± 0.017^{ap}	1.19 ± 0.023^{aq}
T9	1.06 ± 0.061^{cp}	1.05 ± 0.046^{bcp}	1.12 ± 0.045^{abcp}	1.18 ± 0.023^{ap}	1.19 ± 0.020^{aq}
T10	1.02 ± 0.046^{cdp}	1.09 ± 0.023^{cp}	1.10 ± 0.023^{bcp}	1.19 ± 0.020^{ap}	1.19 ± 0.023^{aq}
T11	1.02 ± 0.049^{cdp}	1.09 ± 0.023^{cp}	1.10 ± 0.023^{bcp}	1.19 ± 0.020^{ap}	1.19 ± 0.020^{aq}

Values are represented as mean± SD

Mean values ± SD within a row and column with different superscript letters are significantly different ($P \leq 0.05$).

Table 3: LAB count (log cfu /g) of fermented kohlrabi pickle during storage

	Day 5	Day 10	Day 15	Day 20	Day 25
T0	7.97 ± 0.016^{ap}	8.01 ± 0.010^{bp}	8.12 ± 0.010^{cp}	8.17 ± 0.006^{dp}	8.21 ± 0.010^{ep}
T1	7.20 ± 0.005^{aq}	7.27 ± 0.004^{br}	7.38 ± 0.006^{cq}	7.42 ± 0.007^{dq}	7.45 ± 0.004^{eq}
T2	7.17 ± 0.008^{aq}	7.20 ± 0.006^{bs}	7.29 ± 0.002^{cs}	7.33 ± 0.007^{dr}	7.40 ± 0.004^{er}
T3	6.97 ± 0.014^{at}	7.01 ± 0.018^{bv}	7.08 ± 0.010^{cw}	7.13 ± 0.008^{dv}	7.22 ± 0.009^{et}
T4	6.83 ± 0.028^{au}	6.92 ± 0.008^{bw}	7.01 ± 0.010^{cx}	7.10 ± 0.010^{dw}	7.15 ± 0.012^{eu}
T5	6.65 ± 0.024^{av}	6.81 ± 0.013^{bx}	7.00 ± 0.013^{cx}	7.08 ± 0.013^{dw}	7.16 ± 0.007^{eu}
T6	7.22 ± 0.014^{aq}	7.31 ± 0.005^{bq}	7.37 ± 0.004^{cq}	7.41 ± 0.005^{dq}	7.45 ± 0.006^{eq}
T7	7.18 ± 0.009^{aq}	7.25 ± 0.007^{br}	7.33 ± 0.005^{cr}	7.40 ± 0.007^{dq}	7.43 ± 0.006^{eqr}
T8	7.12 ± 0.008^{ar}	7.19 ± 0.004^{bs}	7.26 ± 0.005^{ct}	7.33 ± 0.005^{dr}	7.40 ± 0.006^{er}
T9	7.10 ± 0.007^{ar}	7.15 ± 0.007^{bt}	7.21 ± 0.008^{cu}	7.30 ± 0.009^{ds}	7.38 ± 0.031^{er}
T10	7.02 ± 0.012^{as}	7.12 ± 0.014^{bt}	7.19 ± 0.014^{cu}	7.25 ± 0.005^{dt}	7.31 ± 0.023^{es}
T11	6.8 ± 0.024^{au}	7.05 ± 0.013^{bu}	7.13 ± 0.006^{cv}	7.19 ± 0.007^{du}	7.28 ± 0.005^{es}

Values are represented as mean± SD

Mean values ± SD within a row and column with different superscript letters are significantly different ($P \leq 0.05$).

Table 4: Overall acceptability of fermented kohlrabi pickle during storage

	Day 5	Day 10	Day 15	Day 20	Day 25
T0	7.78 ± 0.298^{ap}	7.51 ± 0.310^{bp}	7.07 ± 0.230^{cpq}	6.97 ± 0.172^{cp}	6.90 ± 0.170^{cpq}
T1	7.58 ± 0.276^{ap}	7.24 ± 0.262^{bcp}	6.97 ± 0.172^{cpq}	6.74 ± 0.297^{cdpq}	6.67 ± 0.267^{deq}
T2	7.57 ± 0.302^{ap}	7.32 ± 0.289^{bpr}	6.94 ± 0.145^{cpq}	6.92 ± 0.099^{cp}	6.75 ± 0.178^{cpq}
T3	7.52 ± 0.216^{ap}	7.07 ± 0.267^{br}	6.91 ± 0.187^{bcq}	6.84 ± 0.194^{cdpq}	6.70 ± 0.103^{deq}
T4	7.47 ± 0.278^{ap}	6.78 ± 0.183^{bs}	6.58 ± 0.146^{bcr}	6.41 ± 0.253^{cdrq}	6.37 ± 0.132^{cdes}
T5	7.40 ± 0.350^{aq}	6.78 ± 0.214^{bs}	6.58 ± 0.228^{bcr}	6.27 ± 0.201^{drq}	6.18 ± 0.228^{des}
T6	7.64 ± 0.377^{ap}	7.50 ± 0.311^{abp}	7.17 ± 0.281^{bp}	6.98 ± 0.308^{bcp}	6.95 ± 0.262^{bcdp}
T7	7.50 ± 0.268^{ap}	7.38 ± 0.253^{apq}	7.05 ± 0.227^{bpq}	6.94 ± 0.165^{bcp}	6.82 ± 0.154^{bcdp}
T8	7.42 ± 0.302^{ap}	7.18 ± 0.276^{bqr}	6.97 ± 0.189^{bcpq}	6.91 ± 0.151^{cdp}	6.81 ± 0.146^{cdep}
T9	7.40 ± 0.248^{aq}	7.14 ± 0.213^{bqr}	6.92 ± 0.201^{bcq}	6.85 ± 0.198^{cdp}	6.74 ± 0.182^{cdepq}
T10	7.38 ± 0.318^{aq}	7.08 ± 0.187^{bqr}	6.94 ± 0.165^{bcpq}	6.72 ± 0.168^{cdp}	6.62 ± 0.205^{deqr}
T11	7.30 ± 0.257^{aq}	7.02 ± 0.132^{br}	6.82 ± 0.205^{bcqr}	6.64 ± 0.210^{dq}	6.40 ± 0.175^{ers}

*Based on 9 point Hedonic scale

Values are represented as mean± SD

Mean values ± SD within a row and column with different superscript letters are significantly different ($P \leq 0.05$).

c) Isolation and Characterization of LAB from Kohlrabi Pickle

The LAB were isolated from Kohlrabi pickle on MRS agar using spread plate techniques. On the basis of morphological differences, 17 isolates were selected and sub cultured. Sub culturing was carried out multiple times to ensure pure cultures. The isolates were designated as L1, L2, L3……L17.

Isolate L7 was characterized phenotypically as well as genotypically.

Table 1: Phenotypic features

	Colony shape	Colony size	Edge	Elevation	Colour	Gram staining	Catalase test	Oxidase test	Motility	Cell shape
L7	Circular	Small	Smooth	Convex	Creamish white	Positive	Negative	Negative	Non motile	rod

Table 2: Growth on different sugars

Sugars	Sucrose	Fructose	Mannose	Cellobiose	Galactose	Fructose	Mannitol	Xylose	Raffinose
L7	+++	+++	+++	+++	++=	+++	+++	+/-	+/-

*+++ indicates good growth, +/- indicates moderate growth while - indicates no growth

Table 3: Growth on different salt concentrations

Salt concentration (%)	3	5	10	15	30
L7	+++	+++	++	-	-

*+++ indicates good growth, +/- indicates moderate growth while - indicates no growth

The DNA was extracted using Promega DNA extraction kit and PCR reaction was carried out using thermos fisher thermocycler. After sequence analysis the strain was identified as ***Latilactobacillus sakei*** **strain MBEL1397**(Appendix1).

d) To examine the effect of storage containers on desired quality parameters including pH, acidity, microbial load, and sensory characteristics of fermented cabbage pickle over a 25-day storage period. Bulk fermentation was carried out in anaerobic jars and then after attaining desired pH and Acidity the fermented sample was equally divided and stored separately in plastic containers (T1) and earthen pots (T2).The stored pickle samples were analyzed for various quality attributes over 25 days at regular intervals.

Table 1: pH of Cabbage pickle stored in plastic containers and earthen pots

	Day 0	Day 5	Day 10	Day 15	Day 20	Day 25
T1	4.25 ± 0.01^{ap}	4.06 ± 0.01^{bp}	3.84 ± 0.01^{cp}	3.71 ± 0.01^{dp}	3.61 ± 0.01^{ep}	3.57 ± 0.02^{ep}
T2	4.25 ± 0.01^{ap}	4.23 ± 0.02^{aq}	4.03 ± 0.01^{bq}	3.88 ± 0.01^{cq}	3.85 ± 0.01^{cq}	3.78 ± 0.02^{dp}

Values are represented as mean± SD

Mean values ± SD within a row and column with different superscript letters are significantly different ($P \leq 0.05$).

Table 2: Acidity (%) of Cabbage pickle stored in plastic containers and earthen pots

	Day 0	Day 5	Day 10	Day 15	Day 20	Day 25
T1	0.93 ± 0.05^{ap}	1.03 ± 0.04^{bp}	1.19 ± 0.01^{cp}	1.22 ± 0.03^{cp}	1.24 ± 0.02^{cp}	1.25 ± 0.03^{cp}
T2	0.92 ± 0.05^{ap}	1.00 ± 0.01^{acp}	1.04 ± 0.04^{cq}	1.06 ± 0.02^{cq}	1.2 ± 0.05^{dp}	1.22 ± 0.03^{dp}

Values are represented as mean± SD

Mean values ± SD within a row and column with different superscript letters are significantly different ($P \leq 0.05$).

Table 3: LAB count (cfu/g) of cabbage pickle stored in plastic containers and earthen pots

	Day 0	Day 5	Day 10	Day 15	Day 20	Day 25
T0	7.23 ± 0.05^{ap}	7.37 ± 0.10^{ap}	8.01 ± 0.01^{bp}	8.12 ± 0.01^{cp}	8.20 ± 0.06^{dp}	8.30 ± 0.01^{ep}
T1	7.23 ± 0.05^{ap}	7.30 ± 0.01^{ap}	7.58 ± 0.01^{bq}	7.71 ± 0.06^{cbq}	7.75 ± 0.05^{dcq}	8.01 ± 0.07^{dq}

Values are represented as mean± SD

Mean values ± SD within a row and column with different superscript letters are significantly different ($P \leq 0.05$).

Table 4: Overall acceptability of Cabbage pickle stored in plastic containers and earthen pots

	Day 0	Day 5	Day 10	Day 15	Day 20	Day 25
T1	7.80 ± 0.28^{ap}	7.97 ± 0.52^{ap}	8.0 ± 0.73^{ap}	7.59 ± 0.60^{abp}	7.25 ± 0.40^{bp}	7.10 ± 0.39^{bp}
T2	7.87 ± 0.51^{ap}	7.91 ± 0.54^{abp}	8.03 ± 0.80^{acp}	7.46 ± 0.64^{ap}	7.30 ± 0.81^{ap}	7.16 ± 0.60^{ap}

*Based on 9 point Hedonic scale

Values are represented as mean± SD

Mean values ± SD within a row and column with different superscript letters are significantly different ($P \leq 0.05$).

e) To examine the influence of storage containers on desired quality parameters including pH, acidity and microbial load of sauerkraut over a 25-day storage period. Bulk fermentation was carried out in anaerobic jars and then after attaining desired pH and Acidity the fermented sample was equally divided and stored separately in plastic containers (T1) and earthen pots (T2).The stored pickle samples were analyzed for various quality attributes over 25 days at regular intervals.

Table 1: pH of Sauerkraut stored in plastic containers and earthen pots

	Day 0	Day 5	Day 10	Day 15	Day 20	Day 25
T1	4.07 ± 0.005^{ap}	3.86 ± 0.01^{bp}	3.65 ± 0.02^{cp}	3.53 ± 0.02^{dp}	3.49 ± 0.01^{dp}	3.45 ± 0.02^{dp}
T2	4.07 ± 0.005^{ap}	4.02 ± 0.01^{aq}	3.76 ± 0.04^{bq}	3.64 ± 0.02^{cq}	3.56 ± 0.01^{dq}	3.51 ± 0.02^{dq}

Values are represented as mean± SD

Mean values ± SD within a row and column with different superscript letters are significantly different ($P \leq 0.05$).

Table 2: Acidity (%) of Sauerkraut stored in plastic containers and earthen pots

	Day 0	Day 5	Day 10	Day 15	Day 20	Day 25
T1	0.91 ± 0.02^{ap}	1.05 ± 0.04^{bp}	1.22 ± 0.03^{cdp}	1.22 ± 0.03^{cdp}	1.24 ± 0.02^{dp}	1.3 ± 0.07^{ep}
T2	0.90 ± 0.02^{ap}	0.99 ± 0.005^{abp}	1.04 ± 0.04^{bq}	1.06 ± 0.02^{bq}	1.23 ± 0.05^{cp}	1.24 ± 0.03^{cp}

Values are represented as mean± SD

Mean values ± SD within a row and column with different superscript letters are significantly different ($P \leq 0.05$).

Table 3: LAB count (cfu/g) of sauerkraut stored in plastic containers and earthen pots

	Day 0	Day 5	Day 10	Day 15	Day 20	Day 25
T0	7.24 ± 0.05^{ap}	7.41 ± 0.11^{ap}	8.08 ± 0.05^{bp}	8.17 ± 0.05^{cp}	8.30 ± 0.04^{dp}	8.40 ± 0.01^{ep}
T1	7.23 ± 0.01^{ap}	7.30 ± 0.01^{aq}	7.78 ± 0.20^{bq}	7.91 ± 0.10^{bcq}	8.07 ± 0.05^{cq}	8.11 ± 0.13^{dcq}

Values are represented as mean± SD

Mean values ± SD within a row and column with different superscript letters are significantly different ($P \leq 0.05$).

f) To examine the influence UV (T1-5 min) and microwave treatment (T2-2.5 min) on desired quality parameters including pH, acidity and microbial load of sauerkraut over a 25-day storage period in comparison to control (T0). Bulk fermentation was carried out in anaerobic jars and then after attaining desired pH and Acidity the fermented sample was equally divided and stored separately in plastic containers. The stored pickle samples were analyzed for various quality attributes over 25 days at regular intervals.

Table 1: pH of Sauerkraut during storage after UV and Microwave treatment

	Day 0	Day 5	Day 10	Day 15	Day 20	Day 25
T0	4.27 ± 0.01^{ap}	3.84 ± 0.02^{bp}	3.65 ± 0.02^{bp}	3.54 ± 0.02^{cdp}	3.49 ± 0.01^{dp}	3.45 ± 0.02^{edp}
T1	4.27 ± 0.01^{ap}	3.84 ± 0.02^{bp}	3.65 ± 0.02^{bp}	3.55 ± 0.01^{cdp}	3.51 ± 0.01^{dp}	3.49 ± 0.01^{edp}
T2	4.27 ± 0.01^{ap}	4.02 ± 0.01^{abq}	3.97 ± 0.02^{bq}	3.94 ± 0.02^{bq}	3.88 ± 0.01^{cq}	3.84 ± 0.03^{cq}

Values are represented as mean± SD

Mean values ± SD within a row and column with different superscript letters are significantly different ($P \leq 0.05$).

Table 2: Acidity (%) of Sauerkraut during storage after UV and Microwave treatment

	Day 0	Day 5	Day 10	Day 15	Day 20	Day 25
T0	0.90 ± 0.005^{ap}	1.03 ± 0.04^{bp}	1.23 ± 0.04^{cp}	1.29 ± 0.03^{cdp}	1.31 ± 0.02^{dp}	1.42 ± 0.03^{ep}
T1	0.90 ± 0.005^{ap}	0.99 ± 0.005^{bp}	1.21 ± 0.03^{cp}	1.27 ± 0.04^{cdp}	1.32 ± 0.02^{dp}	1.41 ± 0.02^{ep}
T2	0.90 ± 0.005^{ap}	0.99 ± 0.005^{bp}	1.00 ± 0.01^{bq}	1.11 ± 0.06^{cq}	1.21 ± 0.03^{dq}	1.29 ± 0.03^{dq}

Values are represented as mean± SD

Mean values ± SD within a row and column with different superscript letters are significantly different ($P \leq 0.05$).

Table 3: LAB count (cfu/g) of sauerkraut during storage after UV and Microwave treatment

	Day 0	Day 5	Day 10	Day 15	Day 20	Day 25
T0	7.18 ± 0.01^{ap}	7.41 ± 0.11^{bp}	8.08 ± 0.05^{cp}	8.28 ± 0.05^{dp}	8.30 ± 0.04^{dp}	8.44 ± 0.04^{dp}
T1	7.02 ± 0.02^{aq}	7.27 ± 0.02^{bq}	8.06 ± 0.04^{cp}	8.12 ± 0.10^{cq}	8.28 ± 0.07^{dp}	8.37 ± 0.04^{dp}
T2	6.96 ± 0.06^{ar}	7.06 ± 0.04^{br}	7.35 ± 0.04^{cq}	7.48 ± 0.01^{dr}	7.51 ± 0.08^{dq}	7.98 ± 0.02^{eq}

Values are represented as mean± SD

Mean values ± SD within a row and column with different superscript letters are significantly different ($P \leq 0.05$).

g) To examine the effect of gamma irradiation on desired quality parameters including pH, acidity, microbial load, and sensory characteristics of fermented kohlrabi pickle over a 40-day storage period.

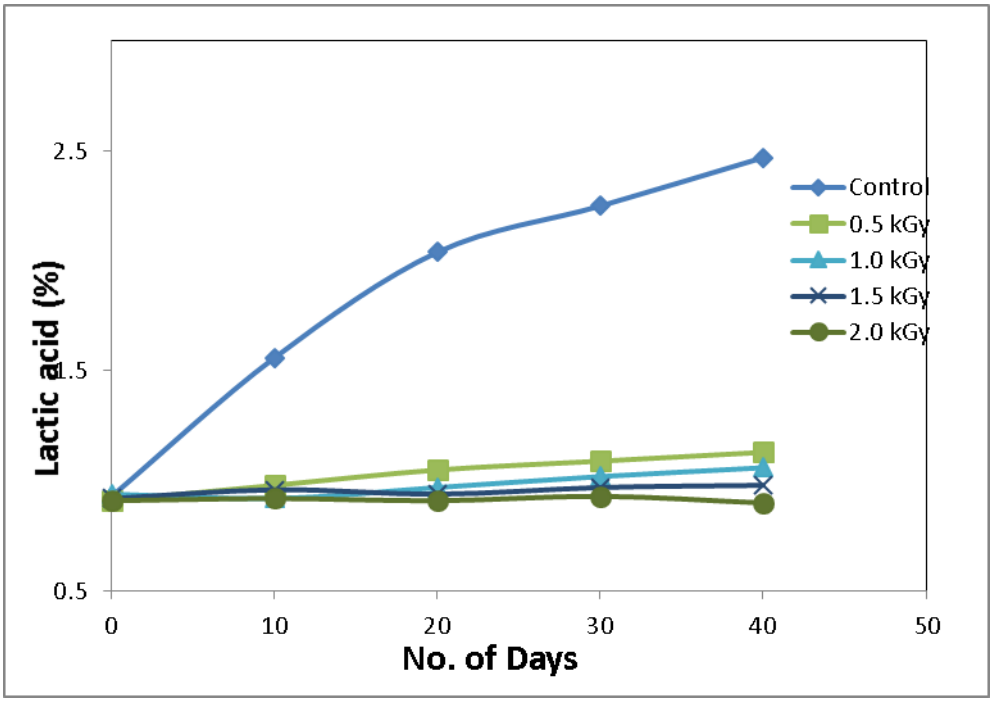

Figure 1. Effect of different irradiation dose on the lactic acid production of pickles.

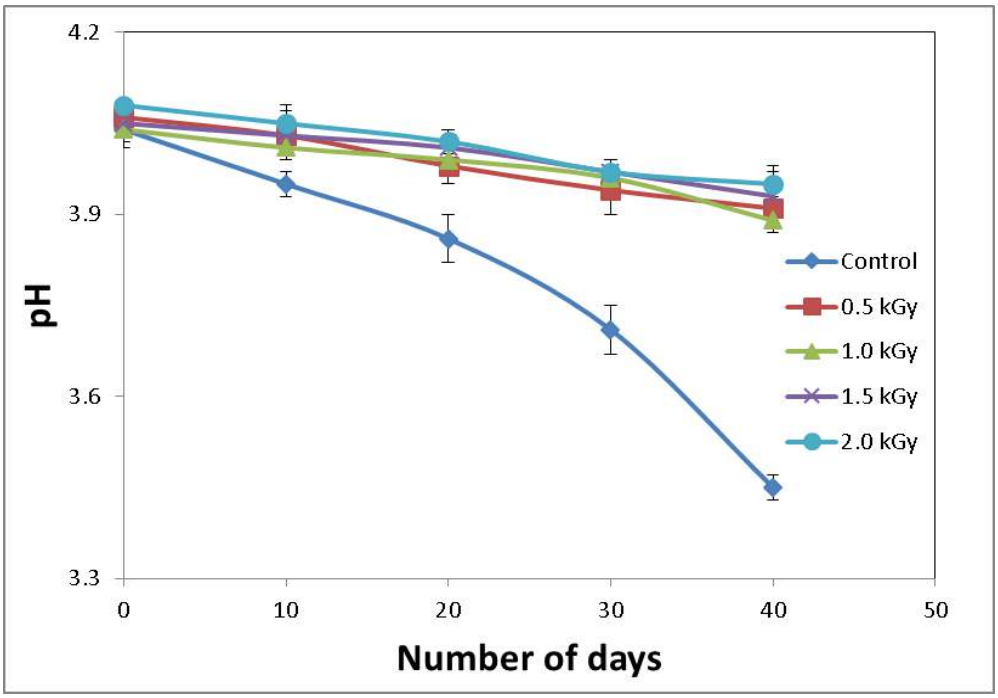

Figure 2. Variation in the pH of pickles as affected by irradiation dose.

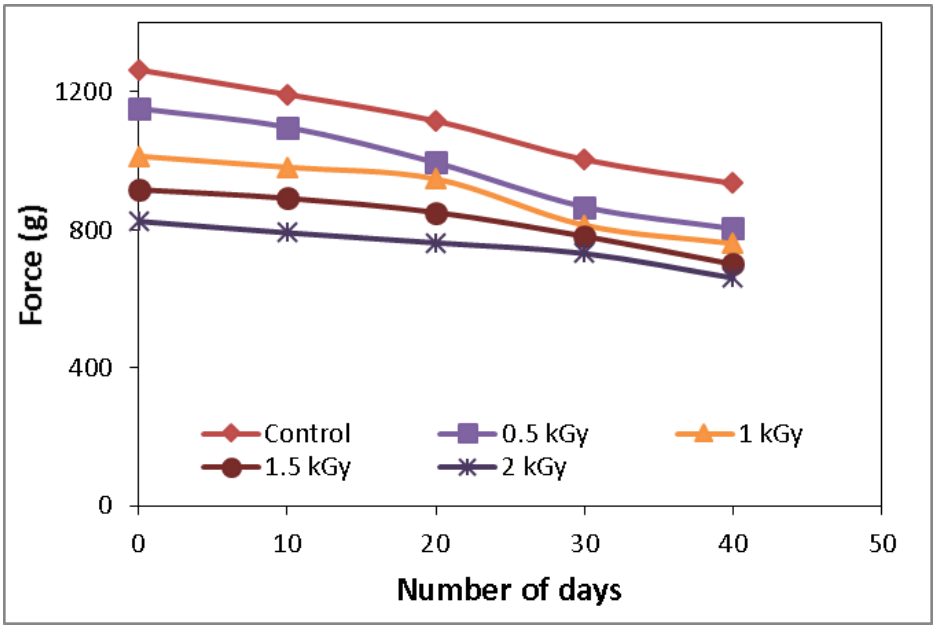

Figure 3. Textural characteristics of pickles affected by radiation dose.

Table 1. Changes in the total phenolic content, DPPH and metal chelating activity of pickles at varying days of storage as affected by radiation dose

		Days of storage				
		0	10	20	30	40
TPC						
	Control	64.01 ± 0.36^{a}	65.04 ± 0.51^{a}	66.41 ± 0.43^{a}	67.34 ± 0.64^{a}	67.65 ± 0.54^{a}
	0.5 kGy	62.47 ± 0.41^{b}	62.42 ± 0.39^{b}	63.21 ± 0.38^{b}	64.26 ± 0.37^{b}	64.22 ± 0.38^{b}
	1.0 kGy	60.51 ± 0.53^{c}	60.88 ± 0.47^{c}	61.76 ± 0.55^{c}	62.49 ± 0.61^{c}	62.85 ± 0.58^{c}
	1.5 kGy	59.44 ± 0.58^{cd}	59.15 ± 0.26^{d}	59.72 ± 0.51^{d}	59.90 ± 0.46^{d}	60.45 ± 0.49^{d}
	2.0 kGy	58.33 ± 0.49^{d}	58.83 ± 0.34^{d}	59.45 ± 0.30^{d}	59.21 ± 0.62^{d}	59.65 ± 0.46^{d}
DPPH	**Control**	44.67 ± 0.59^{a}	45.84 ± 0.32^{a}	47.56 ± 0.60^{a}	48.93 ± 0.52^{a}	49.51 ± 0.56^{a}
	0.5 kGy	43.25 ± 0.61^{b}	44.74 ± 0.56^{b}	45.80 ± 0.63^{b}	46.05 ± 0.44^{b}	46.39 ± 0.54^{b}
	1.0 kGy	40.53 ± 0.43^{c}	41.11 ± 0.57^{c}	41.36 ± 0.36^{c}	41.19 ± 0.39^{c}	41.27 ± 0.38^{c}
	1.5 kGy	38.97 ± 0.58^{d}	38.05 ± 0.59^{d}	37.80 ± 0.61^{d}	37.20 ± 0.31^{d}	36.80 ± 0.46^{d}
	2.0 kGy	37.35 ± 0.34^{e}	37.01 ± 0.41^{d}	36.79 ± 0.45^{d}	35.87 ± 0.56^{e}	35.06 ± 0.51^{e}
MCA	**Control**	23.07 ± 0.48^{a}	24.53 ± 0.62^{a}	25.34 ± 0.39^{a}	26.37 ± 0.38^{a}	26.69 ± 0.39^{a}
	0.5 kGy	22.31 ± 0.37^{a}	22.38 ± 0.33^{b}	22.60 ± 0.37^{b}	23.04 ± 0.51^{b}	23.46 ± 0.44^{b}
	1.0 kGy	20.83 ± 0.35^{b}	20.17 ± 0.65^{c}	20.67 ± 0.50^{c}	20.35 ± 0.40^{c}	20.19 ± 0.45^{c}
	1.5 kGy	19.34 ± 0.42^{c}	19.05 ± 0.42^{cd}	18.50 ± 0.66^{d}	18.80 ± 0.45^{d}	18.60 ± 0.56^{d}
	2.0 kGy	18.04 ± 0.38^{d}	18.31 ± 0.47^{d}	17.61 ± 0.44^{d}	17.69 ± 0.03^{e}	17.24 ± 0.24^{e}

Values are represented as mean± SD

Mean values ± SD within a column with different superscript letters are significantly different ($P \leq 0.05$).

Table 2. Effect of radiation dose on the lactic count of pickles at varying days of storage

No of days	LAB count (cfu/g)				
0	7.01 ± 0.15[a]	3.62 ± 0.09	3.55 ± 0.06	NO	NO
10	7.67 ± 0.13[b]	3.69 ± 0.06	3.44 ± 0.08	NO	NO
20	8.06 ± 0.18[c]	3.65 ± 0.04	3.47 ± 0.06	2.54 ± 0.02	NO
30	8.37 ± 0.19[d]	3.71 ± 0.02	3.60 ± 0.05	2.58 ± 0.01	NO
40	8.41 ± 0.16[d]	3.84 ± 0.05	3.64 ± 0.06	2.69 ± 0.03	NO

Values are represented as mean± SD

Mean values ± SD within a column with different superscript letters are significantly different ($P \leq 0.05$).

h) To study the effect of different concentrations of nisin on desired quality parameters including pH, acidity and microbial load of fermented kohlrabi pickle over a 30-day storage period. Nisin was used in samples at different concentrationsT1 (50IU/g), T2 (100IU/g), T3 (150 IU/g) and T4 (200IU/g)

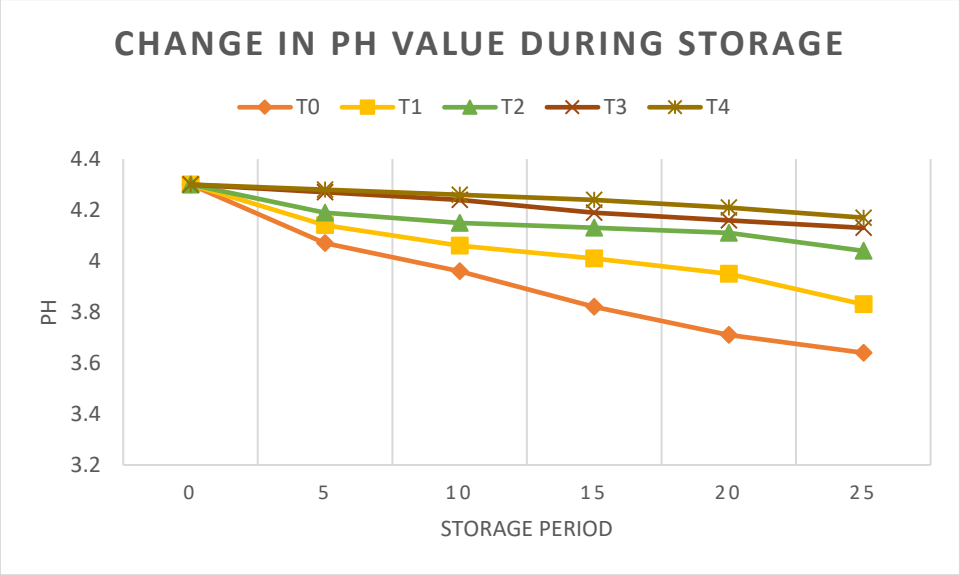

Figure 1. Variation in the pH of pickle as affected by nisin treatment

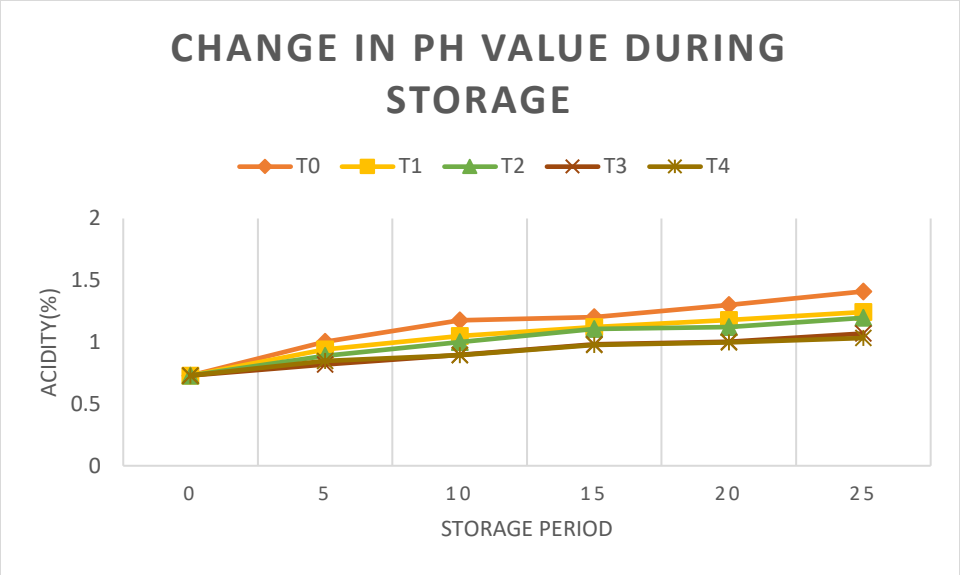

Figure 2. Variation in the acidity (%) of pickle as affected by nisin treatment

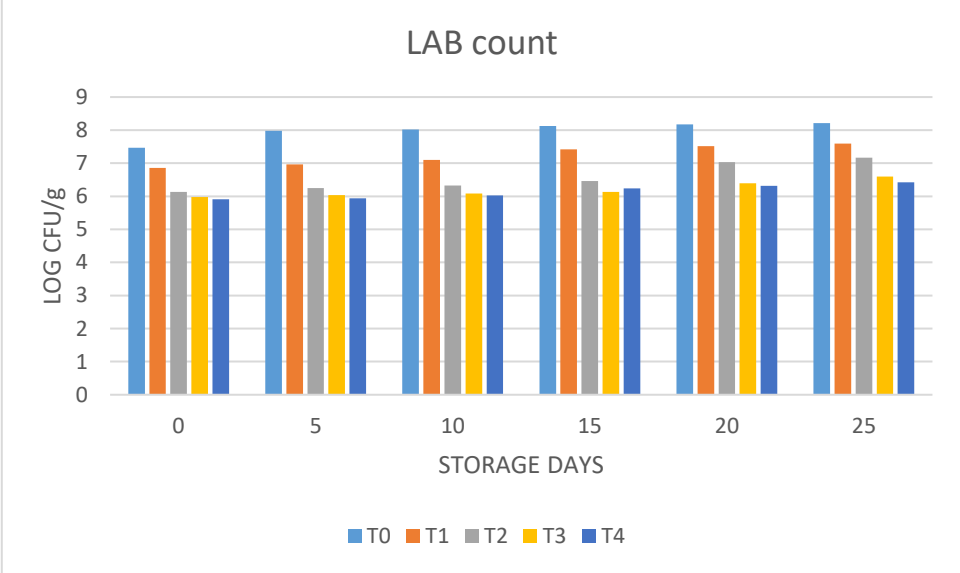

Figure 3. LAB count of pickle as affected by nisin treatment

Equipments used

- pH meter
- Solid state fermenter
- Laminar air flow
- Incubator
- Solar dryer
- Vacuum assisted microwave dryer
- Cabinet dryer
- Thermocycler

3.3 Details of the field surveys conducted (Appendix 3)

- Visit to research institutions of the region which include Central Institute of Temperate Horticulture (CITH), Rangreth, Budgam and SKAUST-K, Shalimar was organized to gather knowledge regarding different local cultivars and hybrids of Cruciferous vegetables being cultivated in the region

- Vegetable clusters in district Baramulla were visited to know about the involvement of local farmers in cultivation of local and hybrid cultivars of cruciferous vegetables. The survey team was accompanied by the Chief Agriculture Officer of J&K Department of Agriculture.

- The information gathered during these surveys have been documented in the form of a documentary

- A field survey was also conducted at different locations of Gurez and Tulail Valleys located in Himalayas in northern Kashmir. The Survey was conducted in collaboration with Mountain Agriculture Research and Extension Station(MAR&ES), SKAUST-K

3.4 Strategic planning for each activity with time frame

The activities under each objective were planned properly with a set time frame to conduct them. The release of grand for implementation of the project in the month of October (2019) was followed by severe winters in Kashmir, which was not suitable to conduct training programs and field surveys. Therefore implementation remained confined to appointment of Project staff, notification of tenders for purchase of equipments and literature review. Further due to the onset

of the Global pandemic at the very beginning of this project, the project activities could not go as per the set timeline. However, despite these challenges the project staff managed to work even during the pandemic, following the SOPs. As major part of this project focused on enhancement of livelihood of rural/tribal population, skill development and employment generation, collaborative activities were planned with different partners working on ground level for better reach. Involvement of community based organisations, industries, local government and research bodies was thought to be the best strategy for implementation of the project objectives. Although the PI tried his best to carry out the work in a streamlined manner but multiple setbacks in terms of unfavourable conditions due to COVID -19 pandemic and resignation by man power made it difficult to achieve desired progress.

4. KEY FINDINGS AND RESULTS

4.1 Major Activities/Findings

- Various problems of vegetable growers were identified. The field surveys conducted revealed that vegetable growers huge economic loss due to lack of post-harvest management of their produce. It was also noted that farmers were not well aware about the different incentives provided by the Government nor were they knowing about the low-cost technologies for post-harvest management and processing of fruits and vegetables
- The research team also identified local cultivars and hybrids of cruciferous vegetables grown in the region
- Field survey conducted in Gurez and Tulail regions revealed that cruciferous vegetables especially cabbage and kohlrabi performed well in the region and gave high yields. However this surplus produce was not exploited well.
- It was also observed that pits and cellars were still being used by locals/tribals for storing tuber crops. Moreover peas and strawberry cultivation could be promoted in the region as these crops are produced during off season in the region. The farmers can be motivated to grow these commodities and provided with marketing facilities.
- Survey team also identified Siberian kale cultivated in the region. Abundance of this crop in the region may be because of its ability to withstand colder temperatures.
- Walnut cultivation was not carried out on a commercial scale and size of walnuts was observed to be small. The research team was of the opinion that biotechnological interventions are needed to increase the size of walnuts.

- In terms of controlling/slowing down the proliferation of lactic acid bacteria in Kohlrabi pickle after attainment of desired pH and Acidity, both microwave and conventional heat treatments demonstrated effectiveness in controlling the fermentation process.
- *Latilactobacillus sakei* strain MBEL1397 was identified from kohlrabi pickle
- Microwave Treatment of 2.5 minutes was found to have better effect in terms of controlling pH, acidity and LAB counts in sauerkraut as compared to UV treatment of 5 minutes indicating the possibility of using Microwaves for controlling fermentation process
- Earthen pots used for storage of fermented traditional pickle proved to be effective storage containers. However when used for sauerkraut storage, it resulted in drying of product and fungal growth on the exterior of the pots. This might be due to oozing out of nutrient loaded liquid from the pores of earthen pot.
- Irradiation dose of 2.0kGy was found to complete kill the microbial population in kohlrabi pickle after attainment of desired pH and acidity, indicating its effectiveness in extending the storage life of spontaneously fermented vegetable products.
- Use of Bacteriocins (Nisin) was also found to be successful in controlling the growth of lactic acid bacteria. However further research work needs to be done to optimize the dose for desired results in terms of extension of storage period.
- It was also found that addition of nisin at different concentrations at the start of fermentation process resulted in failure to ferment.

4.2 Key results

- The interaction with growers highlighted many problems faced by them including low monetary returns, wastage of surplus produce and lack of knowledge about value addition of vegetables.
- In terms of controlling/slowing down the proliferation of lactic acid bacteria both microwave and conventional heat treatments demonstrated effectiveness in controlling the fermentation process.
- Microwave Treatment of 2.5 minutes was found to have better effect in terms of controlling pH, acidity and LAB counts in sauerkraut as compared to UV treatment of 5 minutes indicating the possibility of using Microwaves for controlling fermentation process.
- Irradiation dose of 2.0kGy was found to completely kill the microbial population in kohlrabi pickle after attainment of desired pH and acidity, indicating its effectiveness in extending the storage life of spontaneously fermented vegetable products.

- Use of Bacteriocins (Nisin) was also found to be successful in controlling the growth of lactic acid bacteria. However further research work needs to be done to optimize the dose for desired results in terms of extension of storage period.
- Owing to the skills imparted via training programs 4 young entrepreneurs started apricot processing in Ladakh and one entrepreneur started a fruit and vegetable processing unit at Babanagri Kangan.

4.3 Conclusion of the study

The project findings suggest the possible use of low cost and eco-friendly techniques such as fermentation and dehydration as an effective way to prevent economic losses faced by vegetable growers and farmers in times of surplus production by preventing post-harvest losses. These techniques can be used to transform surplus produce into value added products. The trainings imparted to different stakeholders including farmers, young students and tribals has enabled them to acquire skills for transforming their produce into value added products to fetch better price in the market and also generate and additional source of income for low income households. Moreover the trainings also encouraged young students and budding entrepreneurs to start their own businesses which would change them from job seeker to job provider, solving the problem of unemployment that is very prevalent in the region. The processing techniques used for controlling the traditional fermentation processes such as conventional heat treatment, microwaves, gamma irradiation and use of nisin proved to be effective. However, further research needs to be conducted in order to fully optimize their use.

5. OVERALL ACHIEVEMENTS

5.1 Achievements on Project Objectives/Target deliverables

- 16 training programs and 2 workshops have been conducted during the project tenure. These programs targeted young students, entrepreneurs, farmers and tribal women folk (Annexure B)

- Through these training programs and workshops we have been able to impart skill to a significant amount of people especially young entrepreneurs, students and women folk.

- Workshops were attended by about 260 young students, scientist and researchers.

- Approximately 900 participants have been registered in the above mentioned training programs that have been conducted at different locations of Himalayan region of J&K and Ladakh

- At Babanagri Kangan, budding entrepreneurs have started a small scale processing unit. They have so far manufactured 400 bottles of Apple Jam and 300 bottles of Pickle

- 4 young entrepreneurs have successfully started their apricot processing units in Ladakh.

- Field surveys that have been conducted, successfully identified various problems that are faced by vegetables growers in the region.

- A documentary has been prepared keeping in view the post-harvest management concerns of Fruits and vegetables in the region. All the field surveys and visits along with some insights regarding the work being carried out in the project has been recorded in the form of this documentary

- Experimental trials aimed at controlling lactic acid fermentation using different low cost and eco friendly techniques were successfully carried out with promising results that need to be further explored and evaluated for their feasibility to be used on a commercial scale

5.2 Interventions

The project was based on the mandate to carter the technological needs and requirements of the people in the region. Keeping this in mind the Research team along with the PI aimed to bridge the technological gaps and to mechanize the production of traditional foods for better quality control and marketing. 02 prototypes were designed to provide a hygienic and scientific basis for traditional product development

- Solid state fermenter with a mixer has been designed in collaboration with M/s Grizzly Technologies

- Vacuum assisted microwave dryer has been designed in collaboration with M/s Twin Engineers

The working of these prototypes was demonstrated to concerned entrepreneurs at one day Industry-Institution Interaction Session held on 24-11-2021 (Annexure C and Appendix 6)

5.3 On-filed demonstrations and value addition of Products

16 training programs have been conducted during the project tenure. These programs targeted young students, entrepreneurs, farmers and tribal women folk (Annexure B and Appendix 3). Through these training programs and workshops we have been able to impart skill to a significant amount of people especially young entrepreneurs, students and women folk. Approximately 900 participants have been registered in the above mentioned training programs that have been conducted at different locations of Himalayan region of J&K and Ladakh. The training programs imparted hands on training to the participants for preparation of value added products from the locally cultivated fruits and vegetables. The participants were trained to prepare vegetable pickles, apple jam, tomato sauce and ketchup and apricot jam. Moreover vacuum assisted microwave dryer and solar dryer were used to mechanize the drying process. Many locally available commodities were dehydrated. These included conventional commodities such as tomato and bottle guard and some non-conventional commodities such as banana, apples, pear, onion, garlic, fenugreek etc. The vacuum dried tomato, banana and bottle gourd exhibited a better rehydration ratio as compared to the sun dried counter parts. The sensory evaluation data also revealed that vacuum assisted microwave dehydrated products has better acceptability (Annexure D).

Process parameters optimized-

- Tomato (3-4 kg)
  Microwave power 2000W, vacuum 500mmHg, Temperature 50°C and Time 2hours
  Microwave power 2000W, vacuum 500mmHg, Temperature 40°C and Time 3hours
- Onion (2kg)
  Microwave power 2000W, vacuum 500mmHg, Temperature 60°C and Time 30 minutes
  Microwave power 2000W, vacuum 500mmHg, Temperature 70°C and Time 20 minutes
- Garlic(2 kg)
- Microwave power 2000W, vacuum 500mmHg, Temperature 60°C and Time 20 minutes
- Microwave power 2000W, vacuum 500mmHg, Temperature 70°C and Time 15 minutes

The vacuum assisted microwave drying resulted in

- Significant reduction in drying time
- Superior quality of dehydrated product
- High nutritional and sensory qualities
- No severe shrinkage
- Prevention of oxidation due to absence of air

5.4 Green skills developed in State/UT

While imparting trainings, it was kept in mind that environmental friendly techniques are promoted. The local population were made aware about the low cost and eco-friendly processing and preservation techniques such as fermentation that can be exploited for generation of additional income and also minimize the post-harvest loss of surplus produce. The trainings were focused on imparting processing and preservation skills to local people especially tribal population so that they can use them to add to their livelihood options and improve their living standards.

5.5 Addressing cross cutting issues

The Himalayan states including J&K and Ladakh suffer various locational disadvantages such as difficult terrains, inhospitable weather conditions, poor connectivity and lack of basic amenities. Government of India through NMHS has attached highest priority to Indian Himalayan region. Keeping in view the mandate of funding agency, we have focused on targeting and addressing some key issues prevalent in the region. The project activities were framed in such a way so that sustainable use of naturally available resources could be achieved. Moreover scientific knowledge interventions to provide scalable solutions to the existing problems in production and marketability of traditional products. Further, easy livelihood options were promoted via training programs that would contribute to improvement of living standards of people in the region.

6. PROJECT'S IMPACTS IN IHR

6.1 Socio-Economic impact

The aim of the project was to collect information about the problems and challenges faced by the local population of Himalayan region of J&K and Ladakh. The gathered information was used to design training programs in a way so that use of low cost and eco-friendly processing techniques such as fermentation are being promoted. These skill based trainings are assumed to pave way

for employment generation that would directly benefit low income households in tribal areas and also aid farmers to acquire additional economic gains for their produce in the form value added products. A significant number of households have been targeted in different areas of J&K via training programs so that they derive earnings from production and sale of value added products from locally grown fruits and vegetables and generate considerable increase in their household income. The entrepreneurs who established their own processing units have been able to earn sufficient money for supporting their livelihood. Moreover a special attention was given to training women population so as to train them in a way that they can independently earn for themselves surpassing obstacles of gender bias.

6.2 Impact on of Natural Resources/Environment- not applicable

6.3 Conservation of Biodiversity/land rehabilitation in IHR- not applicable

6.4Developning Mountain Infrastructures- not applicable

6.5Strengthening networking in State/UT- not applicable

7. EXIT STRATEGY AND SUSTAINABILITY

7.1 Utility of project findings

The project findings suggest the possible use of low cost and eco-friendly techniques such as fermentation and dehydration as an effective way to prevent economic losses faced by vegetable growers and farmers in times of surplus production by preventing post-harvest losses. The present status of vegetable processing in western Himalayas reveals that the fermentation is conducted in traditional manner without much emphasis on safety and hygiene. Moreover it is confined to household scale without any mechanization and scientific intervention. The processed product does not last longer due to uncontrolled lactic acid fermentation during the storage period. The processing techniques used for controlling the traditional fermentation processes such as conventional heat treatment, microwaves, gamma irradiation and use of nisin proved to be effective. The new data generated during the experimental trials can be used for refinement of traditional fermentation process. Moreover the solid state fermenter designed can be used for mechanization of traditional fermentation process. It provides a hygienic and scientific basis for product development with temperature control and constant pH monitoring. These interventions can aid in commercialization and marketing of traditional fermented vegetables. Apart from fermentation, dehydration of vegetables is traditionally done by sun drying in the region. During this process the raw material is exposed to microbial and environmental contaminants resulting

in low quality end product. The vacuum assisted microwave dryer can serve as a potential alternative to sun drying as it not only will mechanize the process but also provide various advantages in terms of Significant reduction in drying time, Superior quality of product, high nutritional and sensory qualities, no severe shrinkage and pprevention of oxidation due to absence of air.The trainings imparted to different stakeholders including farmers has enabled them to acquire skills for transforming their produce into value added products to fetch better price in the market and also generate and additional source of income for low income households.

7.2 Other Gap areas

- Feasibility of other locally grown vegetable cultivars for fermentation and dehydration can be evaluated
- Starter cultures can be developed from indigenous microflora of traditional fermented products
- Feasibility of different processing techniques such as conventional heat treatment, microwaves, gamma irradiation and use of nisin can be evaluated for their effectiveness with other raw materials

7.3 Major recommendations/way forward

- The different processing techniques used in the project can further be explored for their effectiveness at different environmental conditions and with different raw materials. Moreover the feasibility of these processing techniques can be evaluated on a commercial scale by local industries.
- The equipments namely solid state fermenter and vacuum assisted microwave dryer can be used for mechanization of traditional product
- Scaling up of technology developed for controlled fermentation and vacuum assisted microwave drying of surplus produce
- Provide marketing support for fermented products
- Cool chain transportation of commodities to terminal markets
- Off- season fruit and vegetable production can create dramatic income improvement for growers. Growers of Gurez valley need some intervention to gain off seasonal advantages for fruits like strawberries that are cultivated outside the regular cultivation calendar
- Industrial tie ups need to be developed for surplus produce like potatoes in Gurez valley
- Although the training programs have been based on the needs of the local population and mainly focused on post-harvest management of fruits and vegetables. However there are

other crops that suffer significant losses due to inadequate post-harvest management, lack of proper market channel and lack of awareness regarding processing and preservation. Therefore, more on field demonstrations need to be conducted keeping in view the needs on the local population and focusing on other commercial and non-commercial crops grown in the region such as walnuts.

7.4Replication/ Upscaling/ Post-Project Sustainability of Interventions

The different processing techniques evaluated for their effectiveness for controlling the lactic acid fermentation have shown promising results. The data generated can be used to further explore these different processing techniques and evaluate their feasibility for being used on an industrial scale. The working of equipment s namely solid state fermenter and vacuum assisted microwave dryer have been demonstrated to various stakeholders. These equipments have the potential to completely mechanize the traditional production system if scaled up to commercial level by various local industries. These assets are also being kept available for the local farmers and growers to timely process their produce into value added products.

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ACKNOWLEDGEMENTS

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The team acknowledges the financial support given by the funding agency for the work done under this project.

We would also like to express our sincere acknowledgement to our parent institute, University of Kashmir, for providing assistance and support in every way possible for smooth functioning of the project.

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We also express our heartfelt gratitude to our implementing partners Central Institute of Temperate Horticulture(CITH), Rangreth ,Jammu and Kashmir Department of Agriculture ,SKUAST-K ,Mountain Agriculture Research and Extension Station, Gurez and Baseej e Zaraat Baghbani, agriculture wing of Imam Khomeni Memorial Trust, Kargil for assistance for conducting field surveys and training programs

APPENDICIES

APPENDIX 1: DETAILS OF TECHNICAL ACTIVITIES

Treatments used for controlling lactic acid fermentation

- *Conventional heat treatment at different temperature - time combinations*

  90ºC for 5 minutes 100ºC for 5 minutes

  90ºC for 10 minutes 100ºC for 10 minutes

  90ºC for 15 minutes 100ºC for 15 minutes

- *Microwave Treatment for different time intervals*

  Microwave treatment for 2 minutes

  Microwave treatment for 2.5 minutes

  Microwave treatment for 3 minutes

  Microwave treatment for 3.5minutes

  Microwave treatment for 4 minutes

- *Gamma Irradiation at different doses*

  0.5 kGy

  1.0kGy

  1.5kGy

  2.0kGy

- *Use of Nisin at different concentrations*

  50 IU/g

  100 IU/g

  150 IU/g

  200 IU/g

- Use of different storage containers

  Earthen pots

  Plastic boxes

Figure 1: Sauerkraut stored in plastic containers and earthen pots

Figure 2: Use of anaerobic jars for carrying out fermentation

Figure 3: Mold growth on earthen pots containing sauerkraut

Figure 4: Mold isolated from earthen pots

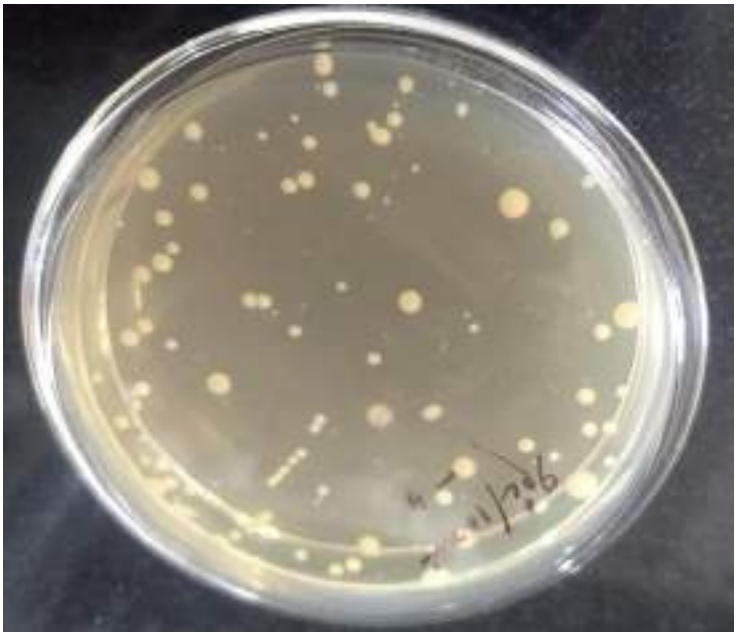

Figure 5: Petri plates with LAB colonies


CARBOHYDRATE FERMEN-
TATION TEST


MOTILITY TEST


NaCl Tolerance Test
10%
15%
30%

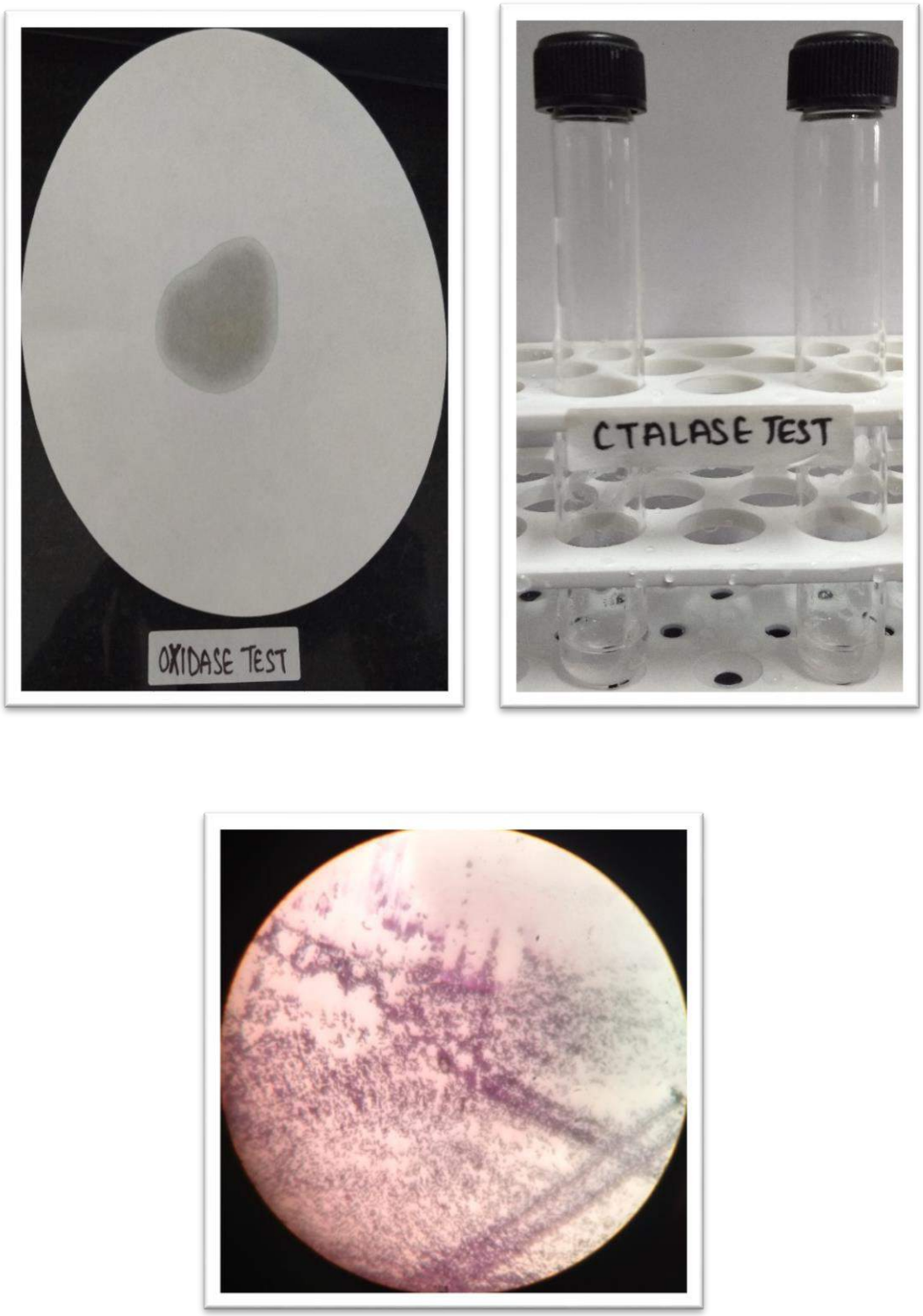

Figure 6: Phenotypic characterization of isolates

Primer sequence used for Identification of Bacterial strain

fD1: AGAGTTTGATCCTGGCTCAG

Length: 20

MW: 6148.1

Tm: 52°C

rP2: ACGGCTACCTTGTTACGACTT

Length: 21

MW: 6372.2

Tm: 52°C

Latilactobacillus sakei strain MBEL1397

Forward Sequence

TACTCCTATAGGGCGATTGGGCCCGACGTCGCATGCTCCCGGCCGCCATGGCGGCCGCGGGAATTCGATTACG
GCTACCTTGTTACGACTTCACCCTAATCATCTGTCCCACCTTAGACGGCTGGCTCCCCGAAGGGTTACCCCACC
GGCTTTGGGTGTTACAAACTCTCATGGTGTGACGGGCGGTGTGTACAAGGCCCGGGAACGTATTCACCGCGGC
ATGCTGATCCGCGATTACTAGCGATTCCGGCTTCATGTAGGCGAGTTGCAGCCTACAATCCGAACTGAGAATGG
TTTTAAGAGATTAGCTAAACCTCGCGGTCTCGCAACTCGTTGTACCATCCATTGTAGCACGTGTGTAGCCCAGGT
CATAAGGGGCATGATGATTTGACGTCGTCCCCACCTTCCTCCGGTTTGTCACCGGCAGTCTCACTAGAGTGCCC
AACTAAATGCTGGCAACTAGTAATAAGGGTTGCGCTCGTTGCGGGACTTAACCCAACATCTCACGACACGAGCT
GACGACAACCATGCACCACCTGTCACTTTGTCCCCGAAGGGAAAGCTCTATCTCTAGAGTGGTCAAAGGATGTC
AAGACCTGGTAAGGTTCTTCGCGTTGCTTCGAATTAAACCACATGCTCCACCGCTTGTGCGGGCCCCCGTCAAT
TCCTTTGAGTTTCAACCTTGCGGTCGTACTCCCCAGGCGGAGTGCTTAATGCGTTAGCTGCGGCACTGAAGGGC
GGAAACCCTCCAACACCTAGCACTCATCGTTTACGGCATGGACTACCAGGGTATCTAATCCTGTTTGCTACCCAT
GCTTTCGAGCCTCAGCGTCAGTTACAGACCAGACAGCCGCCTTCGCCACTGGTGTTCTTCCATATATCTACGCAT
TTCACCGCTACACATGGAGTTCCACTGTCCTCTTCTGCACTCAAGTTTCCCAGTTTCCGATGCACTTCTTCGGTT
GAGCCGAAAGCTTTCACATCAGACTTAAGAAAACCGCCTGGGCTCGCTTTTCGCCCATAAAATCCGGAGAAAGC
T

Reverse Sequence

CAGCATTTAGTGAACTATAGAATACTCAAGCTATGCATCCAACGCGTTGGGAGCTCTCCCATATGGTCGACCTGC
AGGCGGCCGCGAATTCACTAGTGATTAGAGTTTGATCCTGGCTCAGGACGAACGCTGGCGGCGTGCCTAATAC
ATGCAAGTCGAACGCACTCTCGTTTAGATTGAAGGAGCTTGCTCCTGATTGATAAACATTTGAGTGAGTGGCGGA
CGGGTGAGTAACACGTGGGTAACCTGCCCTAAAGTGGGGGATAACATTTGGAAACAGATGCTAATACCGCATAA
AACCTAACACCGCATGGTGTAGGGTTGAAAGATGGTTTCGGCTATCACTTTAGGATGGACCCGCGGTGCATTAG
TTAGTTGGTGAGGTAAAGGCTCACCAAGACCGTGATGCATAGCCGACCTGAGAGGGTAATCGGCCACACTGGG
ACTGAGACACGGCCCAGACTCCTACGGGAGGCAGCAGTAGGGAATCTTCCACAATGGACGAAAGTCTGATGGA
GCAACGCCGCGTGAGTGAAGAAGGTTTTCGGATCGTAAAACTCTGTTGTTGGAGAAGAATGTATCTGATAGTAAC
TGATCAGGTAGTGACGGTATCCAACCAGAAAGCCACGGCTAACTACGTGCCAGCAGCCGCGGTAATACGTAGG
TGGCAAGCGTTGTCCGGATTTATTGGGCGTAAAGCGAGCGCAGGCGGTTTCTTAAGTCTGATGTGAAAGCCTTC
GGCTCAACCGAAGAAGTGCATCGGAAACTGGGAAACTTGAGTGCAGAAGAGGACAGTGGAACTCCATGTGTAG
CGGTGAAATGCGTAGATATATGGAAGAACACCAGTGGCGAAGGCGGCTGTCTGGTCTGTAACTGACGCTGAGG
CTCGAAAGCATGGGTAGCAAACAGGATTAGATACCCTGGTAGTCCATGCCGTAAACGATGAGTGCTAGGTGTTG

GAGGGTTTCCGCCCTTCAGTGCCGCAGCTAACGCATTAAGCACTCCGCTGGGGAGTACGACCGCAGGTTGAAA
CTCAAAGAAATTTACGGGGCCCGCCAAACCGTGGGACATTTGTGTTATTTCAGACACCCCAAGAAACTTTCCAGT
TTGTAATCCTTTTCACTCCCAGAATAGAATTTCCCTTCGGGAGAAAAGACAAGGGGGGGAGGGTTTGTCCACCC
CCGTCGGGAAAATTTGGTGATCCCCCCCCACCCCGCCC

Final Sequence

ACGGCTACCTTGTTACGACTTCACCCTAATCATCTGTCCCACCTTAGACGGCTGGCTCCCCGAAGGGTTACCCC
ACCGGCTTTGGGTGTTACAAACTCTCATGGTGTGACGGGCGGTGTGTACAAGGCCCGGGAACGTATTCACCGC
GGCATGCTGATCCGCGATTACTAGCGATTCCGGCTTCATGTAGGCGAGTTGCAGCCTACAATCCGAACTGAGAA
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ATGTATTAGGCACGCCGCCAGCGTTCGTCCTGAGCCAGGATCAAACTCT

APPENDIX 2- CPOIES OF PUBLICATIONS DULY ACKNOWLEDGING THE GRANT/FUND SUPPORT OF NMHS – Not applicable

APPENDIX 3- LIST OF TRAININGS/WORKSHOPS/SEMINARS WITH DETAILS OF TRAINED RESOURCES AND DISSEMINATION MATERIAL AND PROCEEDINGS

List of Trainings and Workshops

- Three training program based on processing and value addition of fruits and vegetables was conducted in the Food Processing Pilot Plant of the Department of Food Science and Technology
- Two training programs comprising of lectures by experts were also conducted to educate participants about post-harvest management of vegetables through various eco-friendly techniques.
- One on farm training was imparted at Babanagri Kangan regarding preparation, preservation and marketing of vegetable pickle
- One day workshop on “Fruit and Vegetable Preservation” was organized in collaboration with Department of Botany, Government Degree College Baramulla on 08-04-2021.
- Workshop on “Fermented Food and Gut Health” was conducted on 9-11-2021 as a part of 2nd International Conference on Advances in Biopolymers-2021
- 5 day survey cum training program was conducted at different locations of Gurez and Tulail valleys in collaboration with MAR&ES, SKUAST-K (7-7-2021 to 11-7-2021)
- 7 day visit was organized to UT of Ladakh and training programs on preparation of value added products from fruits and vegetables were conducted at various places(28-08-2021 to 03-09-2021)

    - Training program on processing and preservation of local cultivars of apricots was conducted at Hussaini park, Kargil in collaboration with Baseej-e-Zaraat wa Baghbani, Imam Khomeni Memorial Trust, Kargil on 29-08-2021

    - Training program was conducted at Government High School, Lotsum, Kargil on 30-08-2021

- Training programs was conducted at Skur Buchan, Leh on 31-08-2021

- Another training program was conducted at Diskit town in Nubra valley on 02-09-2021

- One day training program on Vegetable processing and preservation conducted at Heechmarg Kupwara on 05-07-2022
- 8 Day visit to UT of Ladakh (16-08-2022 to 23-08-2022) for conduction of training programs at various locations (50 participants). Keeping in view the interest of the local population, the training programs were mainly focused on processing and preservation of apricots.

  - Training program at Kargil in collaboration with G&G Skills Developers Pvt Ltd and Food and Drug Department, UT of Ladakh

  - Training program on processing and preservation of apricots at Lamayaru on 18-08-2022

  - Training program on apricot and vegetable processing was conducted at Turtuk village Leh on 21-08-2022

- Survey cum training program was conducted at different locations of Gurez and Tulail valley from 17-09-2022 to 20-09-2022 in collaboration with Mountain Agriculture Research and Extension station, SKUAST-K

- Number of Participants : 909

APPENDIX 4- LIST OF NEW PRODUCTS

09 Dehydrated products

- Tomato slices
- Tomato powder
- Apple slices using different varieties grown locally
- Pear slices using different varieties grown locally
- Onion powder
- Garlic powder
- Dehydrated fenugreek leaves
- Dehydrated coriander leaves
- Banana slices/chips

Apart from the above mentioned products, value added products were also prepared from tomatoes, apples, apricots and locally grown vegetables. These products include tomato sauce, tomato ketchup, apple jam, apricot jam, carrot pickle and mixed vegetable pickle.

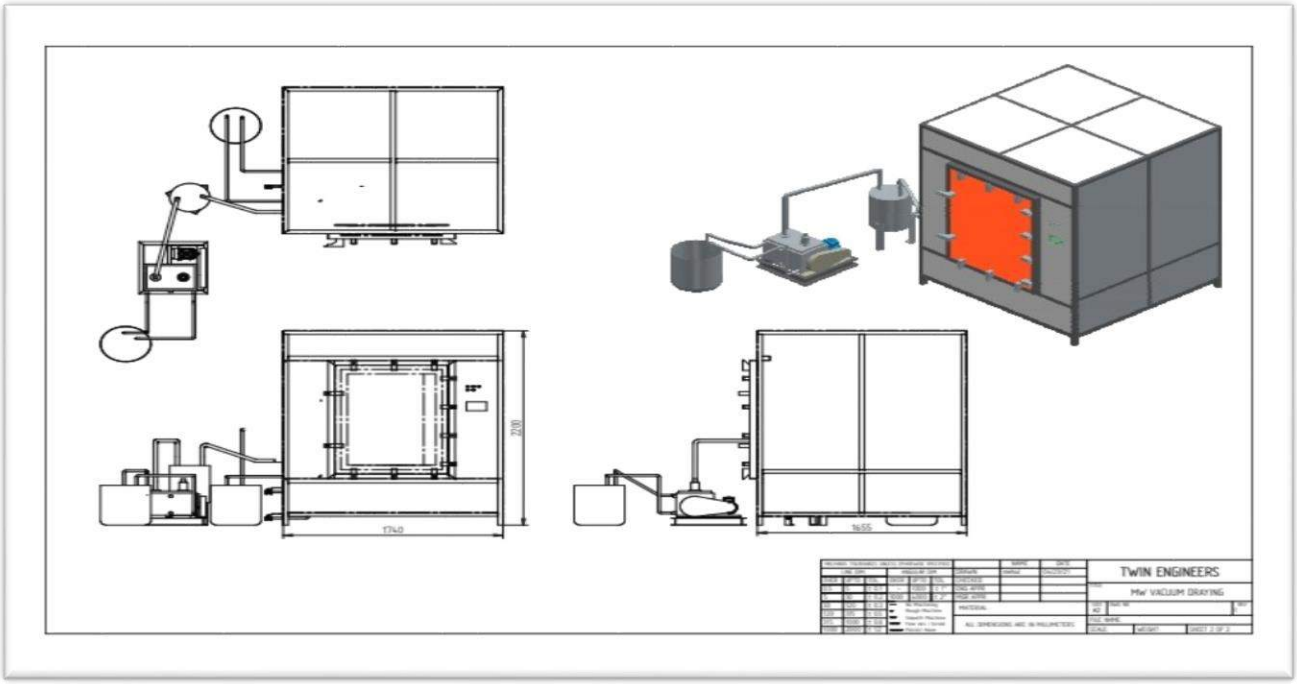
APPENDIX 5- COPIES OF THE SUPPORTING MATERIALS LIKE MANUAL OF STANDARD OPERATING PROCEDURES (SOPs) DEVELOPED UNDER PROJECT: Not applicable

APPENDIX 6-DETAILS OF TECHNOLOGY DEVELOPED/ PATENTS FILLED, IF ANY

Vacuum assisted Microwave dryer

Equipment details

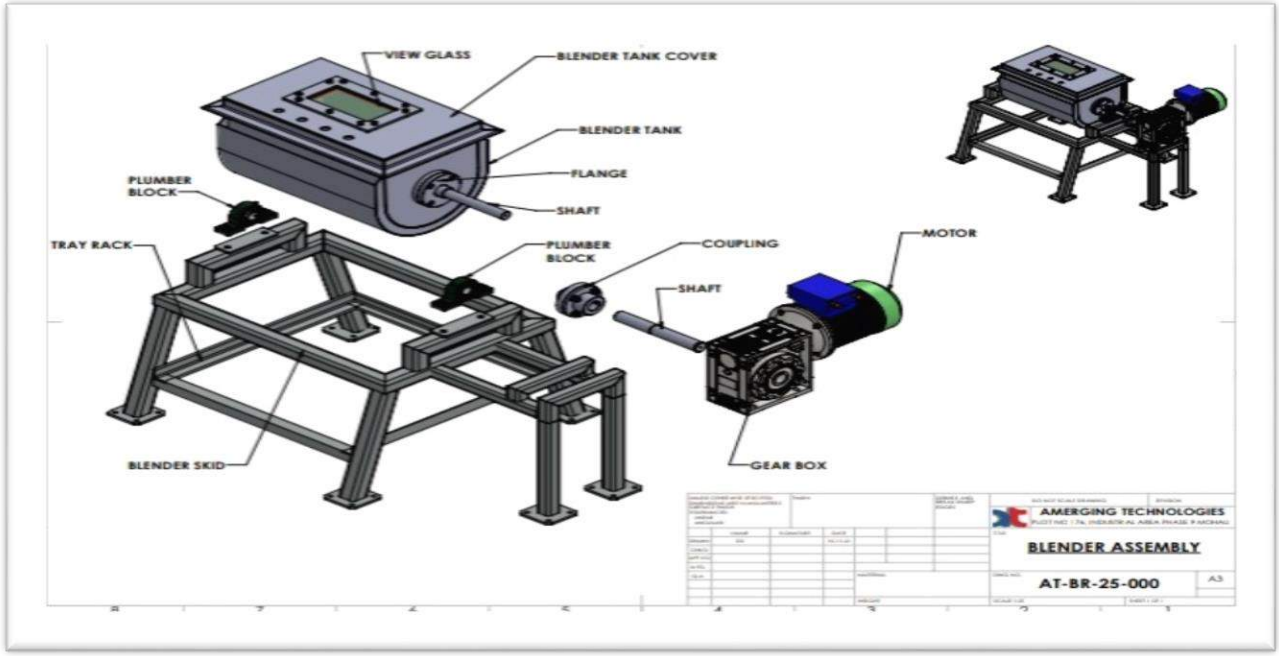
- Model no : TW/MWVAC/BATCH/012
- Manufacturer: M/s Twin Engineers
- Power supply: three phase 415 VAC, 50 Hz
- Input power- 18KWH
- Microwave output power- 12KW
- Microwave frequency- 2450±50MHz
- Maximum vacuum pressure- -650mm of Hg
- Magnetron cooling- forced air cooling


TWIN ENGINEERS
MW VACUUM DRYING

- **Solid state fermenter with mixer**

Equipment details

- Custom designed in association with M/s Grizzly Technologies
- Solid state fermenter with temperature control and pH monitoring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COUPLING
SHAFT
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BLENDER SKID
GEAR BOX
AMERGING TECHNOLOGIES
BLENDER ASSEMBLY
AT-BR-25-000
A3

VEGETABLES

- washed properly to remove adhered dust and dirt
- This is followed by chopping to desired size

Sun drying for 2-3 days

Spices and oil

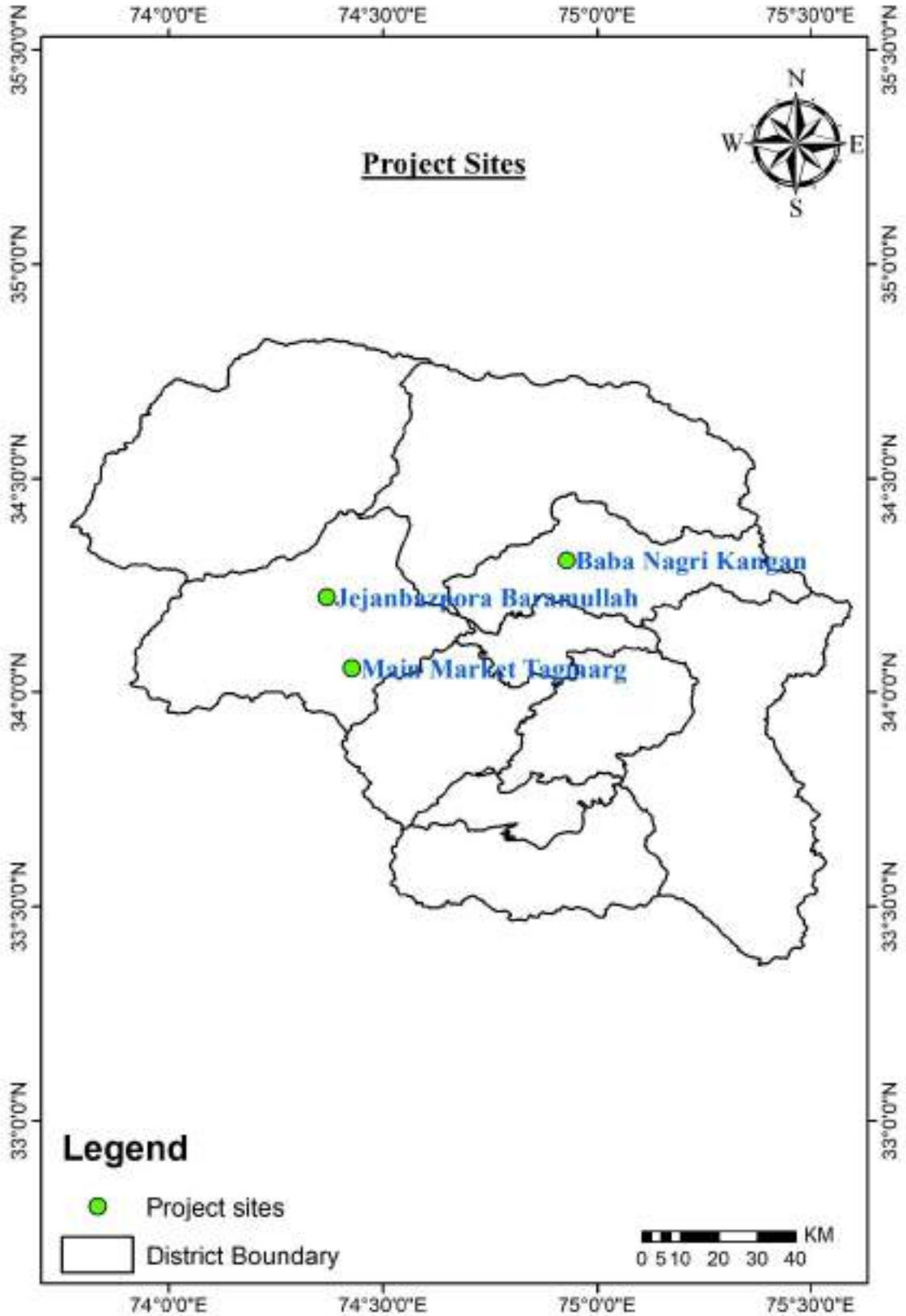
Mixer

Load into fermenter

APPENDIX 7: OTHERS

- A Documentary on Himalayan vegetables, and their value addition has been prepared keeping in view the post-harvest management concern in the Himalayan region of Jammu and Kashmir .This documentary is an outcome of collaborative efforts of the experts from Education Multimedia Research Centre(EMMRC) and concerned scientists from Department of Food Science and Technology

- One day industry interaction program was held on 24-11-2021 to demonstrate the prototypes (Vacuum assisted microwave dryer and solid state fermenter) to concerned entrepreneurs. The program was attended by many established as well as budding entrepreneurs of the region.


Project Sites
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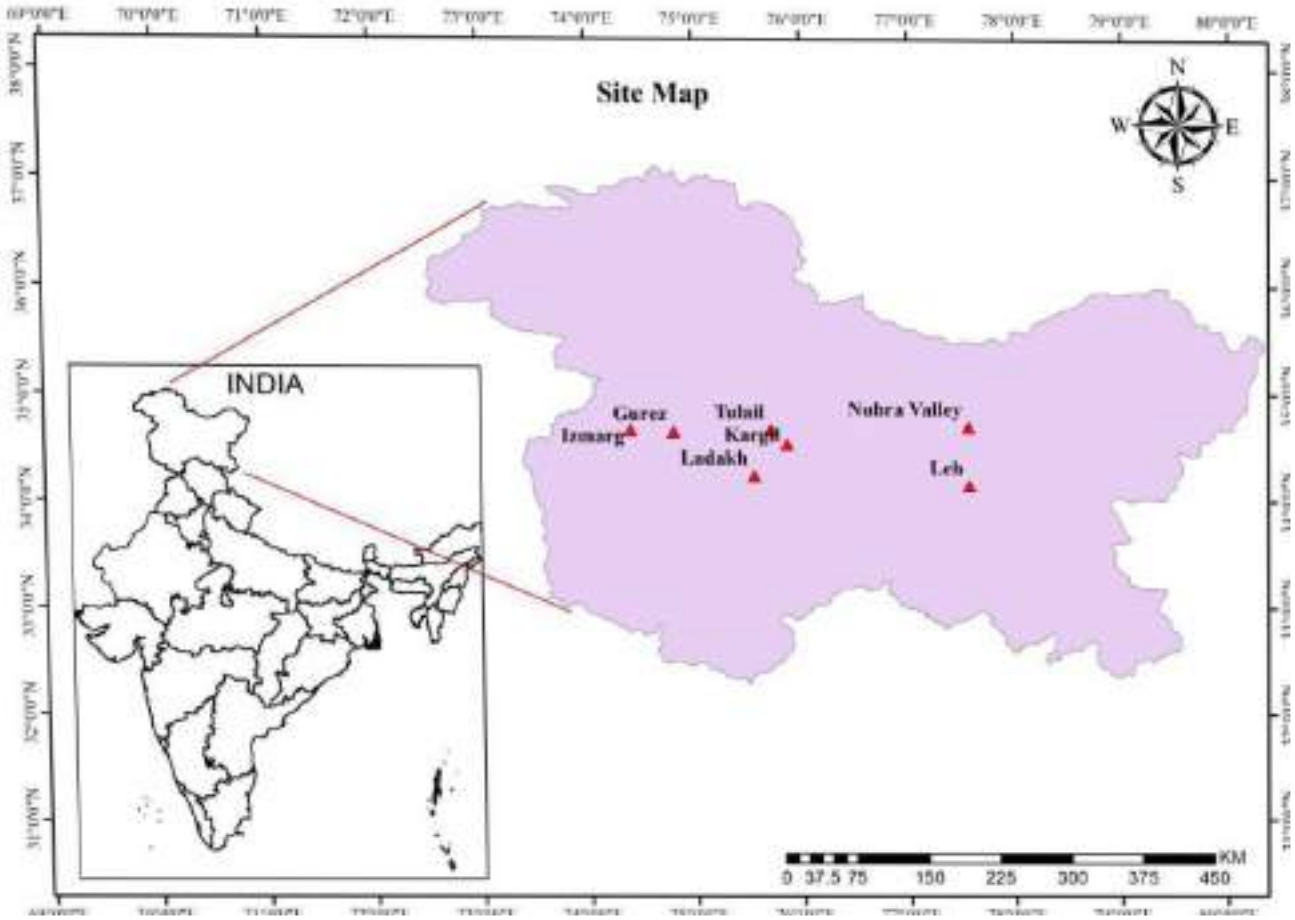
Site Map
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INDIA
Gurez
Izmarg
Tulail
Kargil
Ladakh
Nubra Valley
Leb
0 37.5 75 150 225 300 375 450
KM

Sites photographs

Mountain Agriculture Research and Extension Station,Gurez


Department of Food Science and Tech
University of Kashmir
Training Program on Vegetable
7-11th JULY 2021
Sponsored by
National Mission on Himalaya

Training programs in Gurez

Siberian Kale

Pits and Cellars


Department of Food Science and Technology
IN THE SERVICE

Training programs in Ladakh

One day workshop at GDC,Baramulla

2nd Int conference on 'Advances in Biopolymers' concludes at KU

Posted on Nov 11, 2021 | **Author** RK News

Srinagar, Nov 10: The second international conference on 'Advances in Biopolymers' concluded at the University of Kashmir.

The two-day conference was orga
varsity's Department of Food Sci
(DFST) in collaboration with the
Food Scientists & Technologists

TRENDING

Baramull 'hijabi Vlogge...
Video blogs or...

Breathin Srinagar's Air righ...

Meet Srinagar boy wh...
He had previous...

9-year-old Shakir...
The nine-year-old,...

Kulgam girl pens poetry...
"I do not know...

Sonam – the Lotus o...
"Where I

Dean Academic Affairs Prof Farooq A Masoodi graced the conference as a special guest on both days and underscored the importance of the event in the backdrop of recent advances in the area of Biopolymers.

He congratulated the DFST for organising the international event, which has the participation of renowned experts from different parts of the country and abroad.

The first technical session, chaired by Prof Zafar Ahmad Reshi, Dean School of Biological Sciences, was attended by Prof Kasiviswanthan Muthukumarappan, a renowned professor of Food Science at South Dakota State University, USA. Prof Muthukumarappan delivered the keynote address and emphasised the importance of novel biosensors and bioresins.

Prof Reshi also emphasised the importance of biopolymers in day-to-day life and thanked the noted speakers from various countries for delivering insightful lectures.

The other sessions of the conference were attended by renowned speakers, including Prof Giorgia Spigno from Italy, who delivered her talk on biodegradable packaging using nano-particles. Dr Shakeel-ur-Rehman from the US
biodegradable plastics and Dr Na
Rutgers University USA spoke o
carbon dots.

The conference was also attended in online mode by Dr Ali Abas Wani from Germany. Dr Wani, an eminent Kashmiri-origin Food Scientist and Editor-in-Chief of "Food Packaging and Shelf Life", discussed plant proteins and highlighted their role in developing food formulations.

Dr Adil Gani, Coordinator DFST welcomed the guests and participants and felicitated the best presenters with awards.

Many other renowned professors and scientists from the University of Kashmir, SKUAST-K and IUST Awantipora participated and delivered their lectures on various aspects of biopolymers, the advances in their use and their role in our life.

The speakers highlighted the applications of biopolymers in food and pharmaceutical product development.

The conference was attended by more than 300 delegates in online and offline mode.

A workshop on 'Fermented Foods and Gut Health' was also held as part of the two-day event.

DAILY 24X7 NEWS
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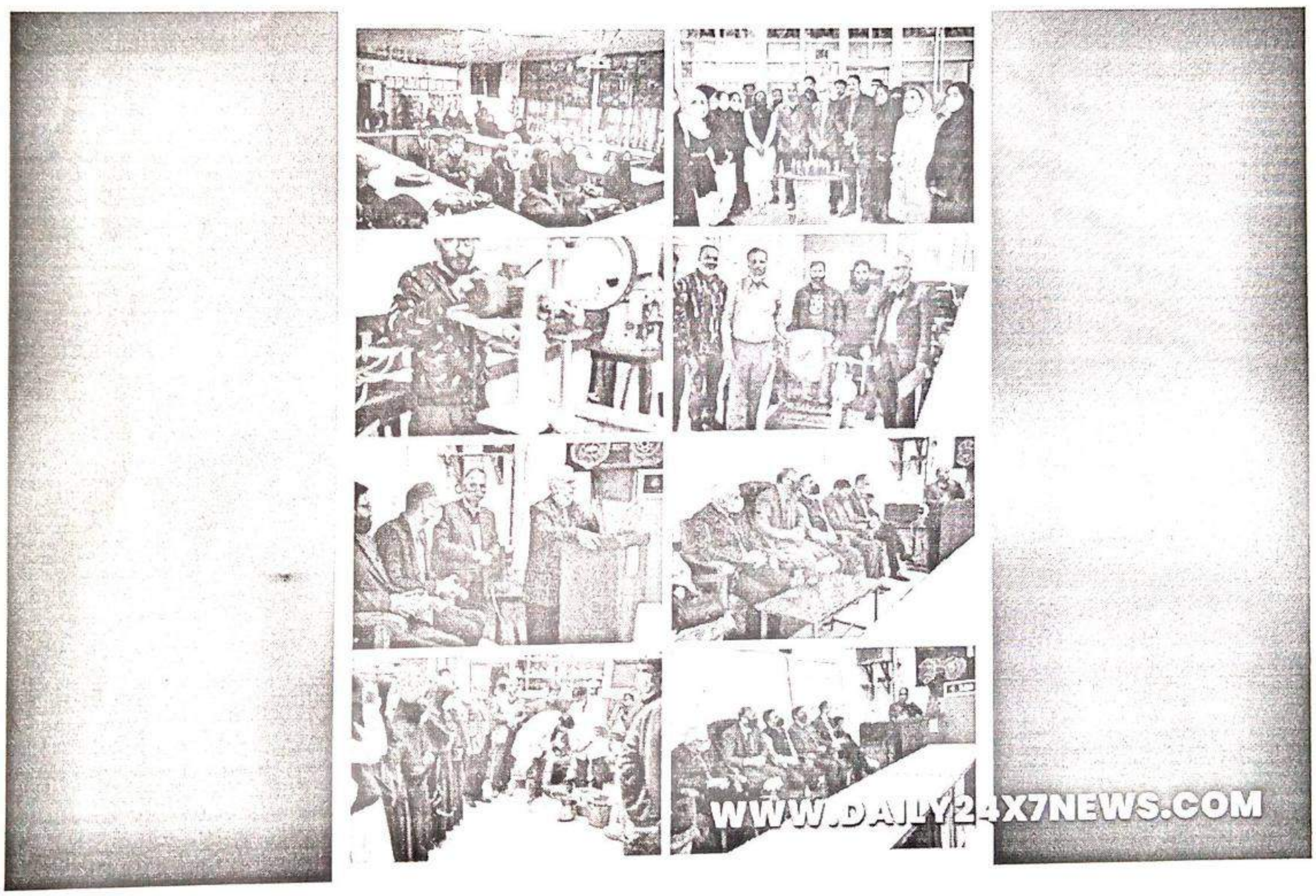
English

GDC Baramulla Organizes One Day Workshop On Fruit Processing And Vegetable Preservation

As a skill development initiative, and to impart hands-on training to students, Department of Food Science Technology, University of Kashmir, Srinagar in collaboration with Department of Botany Government Degree College (GDC), Baramulla organized one day work shop on "Fruit Processing and Vegetable Preservation" on April 08, 2021 at GDC, Baramulla under

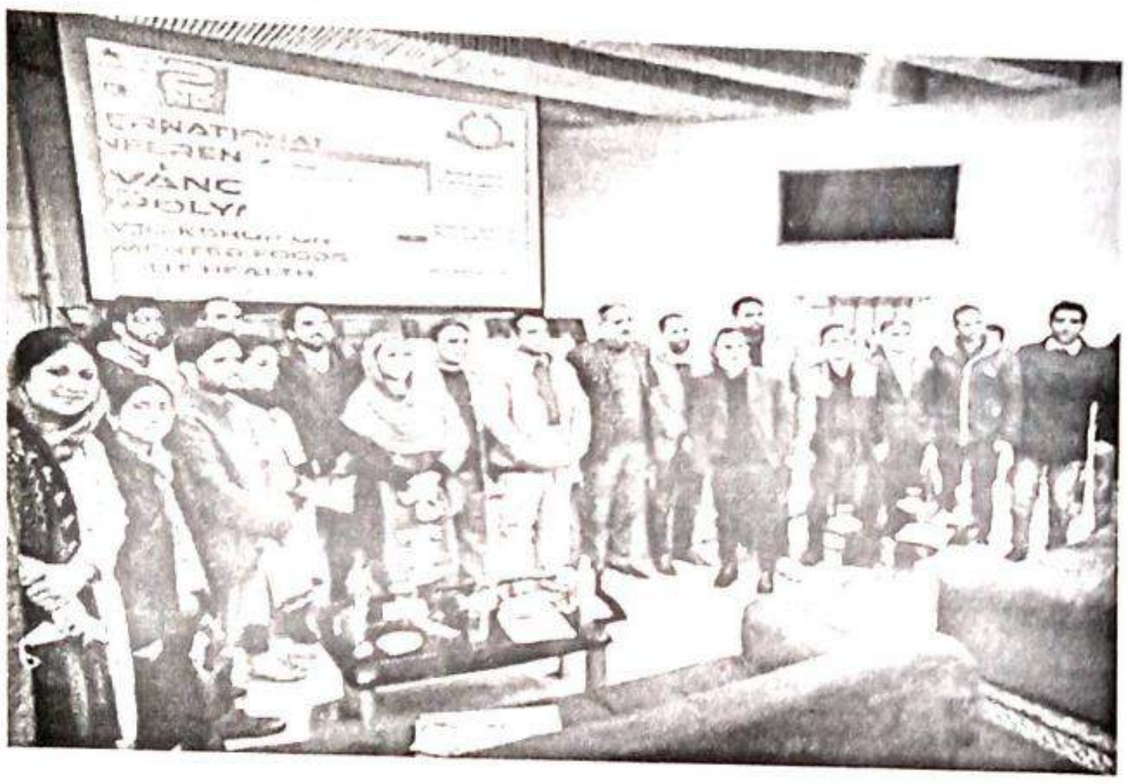
By **Daily 24x7 News** Published on **Apr 9, 2021** BARAMULLA JAMMU & KASHMIR REGIONAL NEWS J&K



Baramulla : As a skill development initiative, and to impart hands-on training to students, Department of Food Science Technology, University of Kashmir, Srinagar in collaboration with Department of Botany Government Degree College (GDC), Baramulla organized one day work shop on "Fruit Processing

2nd Int conference on 'Advances in Biopolymers' concludes at KU

Posted on Nov 11, 2021 | **Author** RK News



Srinagar, Nov 10: The second international conference on 'Advances in Biopolymers' concluded at the University of Kashmir.

The two-day conference was org
varsity's Department of Food Sci
(DFST) in collaboration with the
Food Scientists & Technologists

TRENDING


Baramull 'hijabi Vlogge... Video blogs or...


Breathin Srinagar' Air righ...


Meet Srinagar boy wh... He had previous...


9-year-old Shakir... The nine-year-old,...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Kashmir University, Baseej-E-Zaraat Conduct Training Program on Value-Added Products

KARGIL, AUGUST 29, 2021: The Department of Food Science and Technology, University of Kashmir in collaboration with Baseej e Zaraat wa Baghbani, IKMT organized a one-day training programme on processing and preservation of local cultivars of apricots at Imam Khomieni Tower, Kargil here today.

The training programme was part of a project sanctioned by National Mission on Himalayan studies (NMHS), Ministry of Environment, Forest and Climate Change, GoI.

Prof F. A. Masoodi Dean, Academic Affairs and Head Department of Food Science & Technology, University of Kashmir, Dr Sajad Ahmad Mir were the resource persons for the training programme. Mr Jeelani Raja and Shoib Mohmad Wani assisted in organizing the training programme while Mr Mohd Ali Research Scholar Botany of Baseej e zaraat performed the job of Stage secretary.

About 100 participants comprising of youths, women folk, farmers, producers and entrepreneurs participated in the programme. The resource persons trained the participants about the post-harvest losses of the fruits and the development of different value-added products like apricot jam, chutney and juice.

Speaking during the event President, Baseej e Zaraat w Baghbani Haji Mohammad Ali impressed the youths to avail the benefits from such training programmes. He stated that such kind of training programmes may be conducted in future to help the youths of Kargil for setting up fruit processing units in Kargil. He also impressed that the Department of Food Science and Technology, University of Kashmir to assist both technical and scientific support to the entrepreneurs of Kargil through the Baseej e Zaraat wa Baghbani.

RisingKashmir

KU organises one-day Institution-Industry interaction session

Posted on Nov 25, 2021 | Author RK News

Srinagar, Nov 24: Kashmir University's Department of Food Science and Technology (DFST) on Wednesday organised a one-day Institutional-Industry interaction session.

Vice-Chancellor Prof Talat Ahmad presided over the inaugural session of the programme, which was aimed at enhancing the varsity's linkage with the Industry.

On the occasion, Dean Academic Affairs Prof Farooq Masoodi demonstrated three prototypes designed at the DFST to help vegetable producers and entrepreneurs to increase the shelf-life of vegetables and also retain t quality for longer durations.

The prototypes include Vacuum-assisted Microwave Dryer, Solid Stat Fermenter and Kalari Making Machine.

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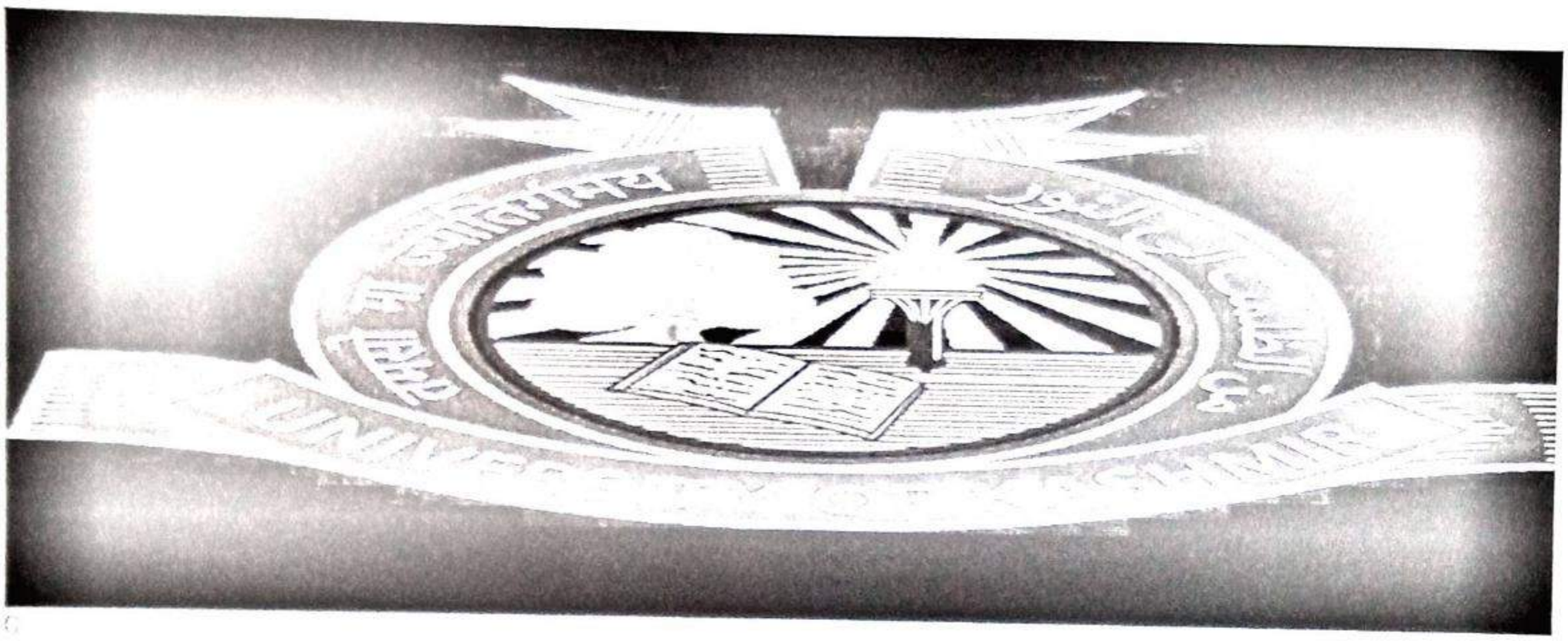
KU reaches Gurez



July 12, 2021 | BK News Service

Department of Food Science and Technology, University of Kashmir, in collaboration with Mountain Agriculture Research and Extensio Station (MAR&ES) Gurez of SKUAST-K conducted a five-day survey-cum-training programme at different locations of Gurez and Tulail.

The programme was part of a project entitled "Value addition of fruits and vegetables of Western Himalayas through eco-friendly and lo cost technologies", sponsored by National Mission on Himalayan Studies, Ministry of Environment, Forest and Climate Changes.

One of the objectives of the programme, undertaken by a joint team of scientists, was to impart training to local producers and womenfo preservation and value addition of vegetables cultivated in the region using low-cost and eco-friendly technologies.

The team documented the traditional methods of vegetable preservation to refine and upgrade the technology.

While interacting with the farmers, they identified some problems faced by the producers, including, among others, poor cooking quality potatoes and delicate skin of tubers.

The joint team identified early harvesting of potatoes as the major reason for the delicate skin of tubers and was of the opinion that the tu be given adequate time to mature in the field before their harvest to let their skin complete its development.

The farmers were further advised to plant the varieties that withstand cooking and retain their firmness. In order to enhance the market potato produced in the region, linkages with industry can be of great help, the team said, adding that vegetables like cabbage, knol-khol

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Kale which give high yields and perform well in the region need preservation and value-addition.

The team trained local farmers in preservation of cabbage and tomato through a method demonstration at MAR&ES, Izmarg, Gurez whi was highly appreciated by them.

It was also observed by the visiting team that marketing support for products like strawberry and peas can motivate the farmers to cultiv these crops and transportation of these commodities through cold chain can make the cultivation of these crops highly remunerative.

Gurez has a seasonal advantage in cultivation of both strawberry and peas as these are produced there in off-season.

The join team of scientists comprised Prof Farooq Masoodi and Dr Sajad Ahmad Mir from University of Kashmir and Dr Bilal A Bhat, Dr Wasim Ali Dar and Dr M Muddasir Magray from MAR&ES, Gurez, SKUAST Kashmir.

BREAKING NEWS

DC Srinagar conducts extensive tour of Khonmoh; inspects dev ... (dc-srinagar-conducts-extensive-tour-o khonmoh-inspects-developmental-works)
Feb 09 | BK News Service

Kut kul passing through Shaher-e-Khas to be cleaned, made Na ... (kut-kul-passing-through-shaher-e-khas be-cleaned-made-navigable-by-march)
Feb 09 | BK News Service

Several Delegations call on Lt Governor at Srinagar (several-delegations-call-on-lt-governor-at-srinagar)
Feb 09 | BK News Service

J&K Reports 681 Covid-19 Cases, 4 Deaths (jk-reports-681-covid-19-cases-4-deaths-)
Feb 09 | BK News Service

Cyber Police Station Kashmir Zone traced/recovered Smartphon ... (cyber-police-station-kashmir-zone-tracedrecovered-smartphones-worth-lakhs-of-rupees)
Feb 09 | BK News Service

VIDEO

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Tweets by @brighterkashmir

Brighter Kashmir
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FACEBOOK

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reduced fermentation time and other advantages which can help growers and entrepreneurs in a big way.

In his presidential remarks, Prof Talat congratulated three faculty members of the DFST for figuring in Stanford University's research database. These include Prof Farooq Masoodi, Dr Adil Gani and Dr Idrees Ahmad.

"Under National Education Policy-2020, it is important to enhance participation of Industry in research and teaching endeavours in terms of modifying curriculums and providing practical exposure to students to the Industry functioning and requirements," Prof Talat said, inviting the interested entrepreneurs from J&K to make use of the prototypes created at the DFST.

KU Registrar Dr Nisar A Mir, who was a guest of honour, underscored the importance of Academia-Industry linkage. He said the university can explore the possibility of providing some dedicated space/kiosk to the DFST where it can manufacture some foods, like pickles, which can eventually become a brand-name from the university.

He also assured that under the leadership of VC Prof Talat, the University is committed to providing all possible support to the DFST vis-à-vis infrastructure and human resources.

Dean School of Applied Sciences DrNahida Tabassum also spoke on the occasion and congratulated the department for developing the prototypes.

Dr Adil Gani, Coordinator DFST gave a power-point presentation highlighting the achievements of the department since its establishment in 2008. He said the department has been regularly organising Institution-Industry interaction programmes with the larger objective of increasing the Academia-Industry Linkage.

ANNEXURE D: Product development

Dehydrated Products

Figure 1: Trays containing raw material for drying in a vacuum assisted microwave drying

Figure 2:Dehydrated banana slices

Figure 3: Dehydrated Tomato slices

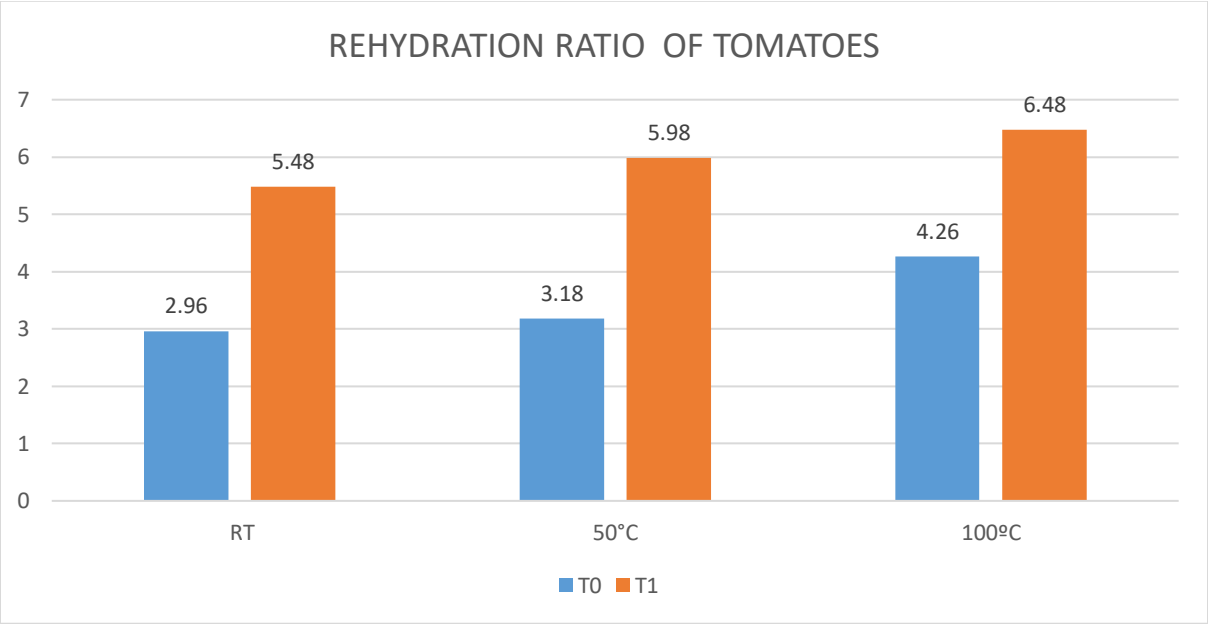
Figure 4: Tomato Powder

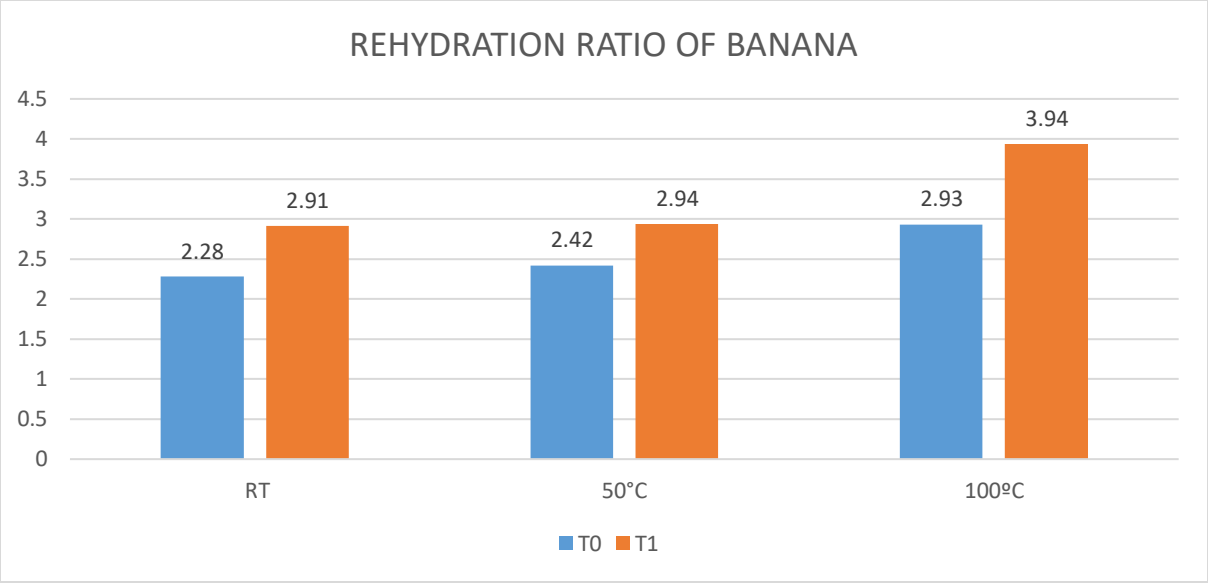
Figure 5: Dehydrated Apple slices

Figure 6: Dehydrated Bottle gourd strips

Figure 7: Dehydrated cherries

Figure 8: Solar drying of Different varieties of apple


REHYDRATION RATIO OF TOMATOES
7
6
5
4
3
2
1
0
2.96
5.48
3.18
5.98
4.26
6.48
RT
50°C
100ºC
T0
T1



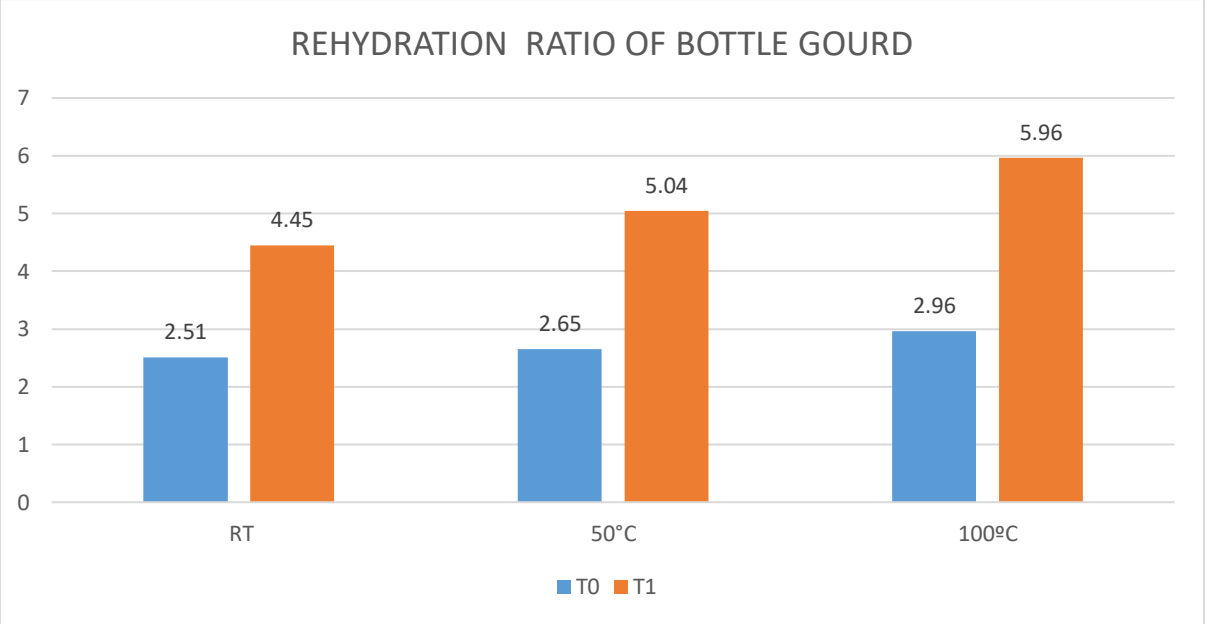
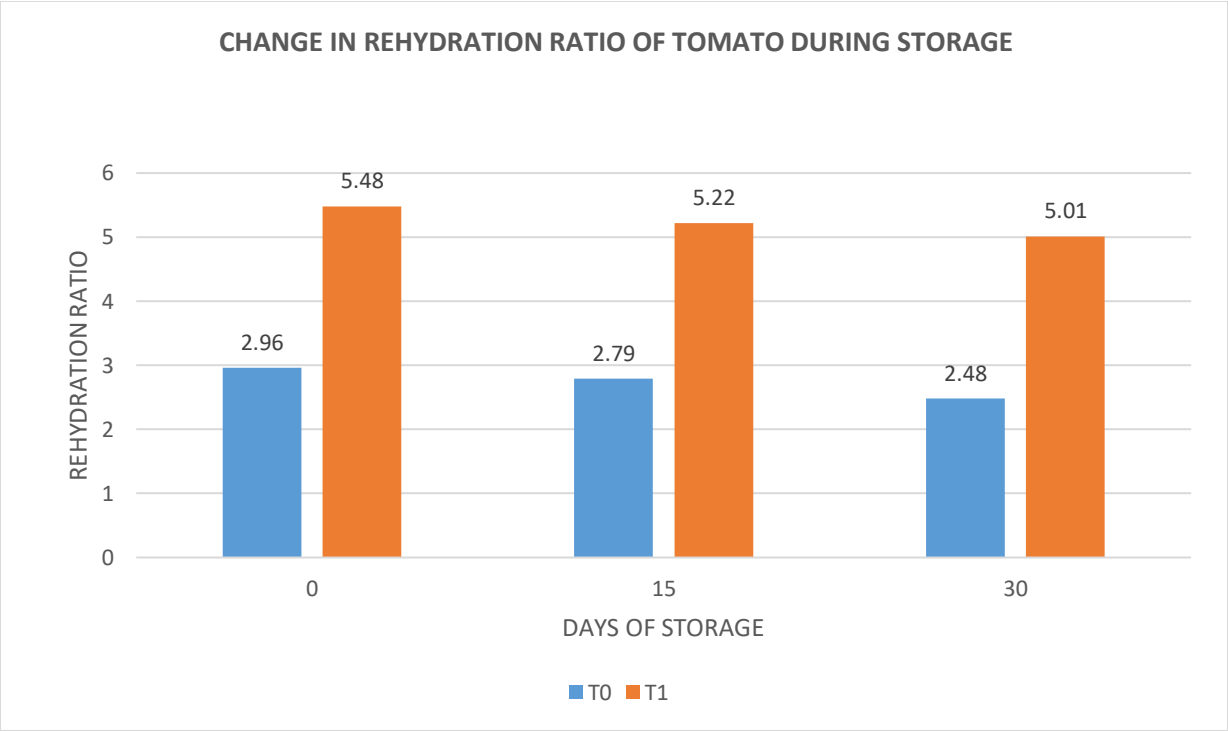
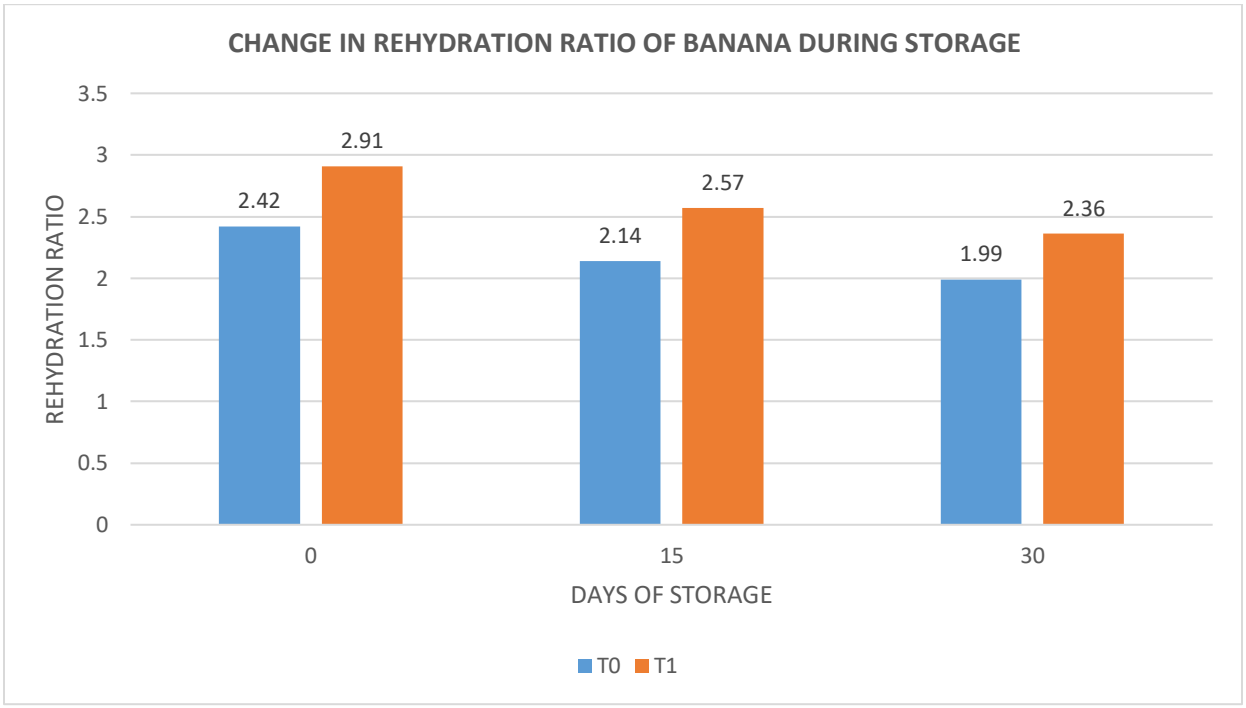


Figure 9: Graphs representing rehydration ratio of tomato, banana and bottle gourd dehydrated by sun drying (T0) and vacuum assisted microwave dryer (T1)


CHANGE IN REHYDRATION RATIO OF TOMATO DURING STORAGE
REHYDRATION RATIO
6
5
4
3
2
1
0
5.48
5.22
5.01
2.96
2.79
2.48
0
15
30
DAYS OF STORAGE
T0
T1


CHANGE IN REHYDRATION RATIO OF BANANA DURING STORAGE
REHYDRATION RATIO
3.5
3
2.5
2
1.5
1
0.5
0
2.42
2.91
2.14
2.57
1.99
2.36
0
15
30
DAYS OF STORAGE
T0
T1

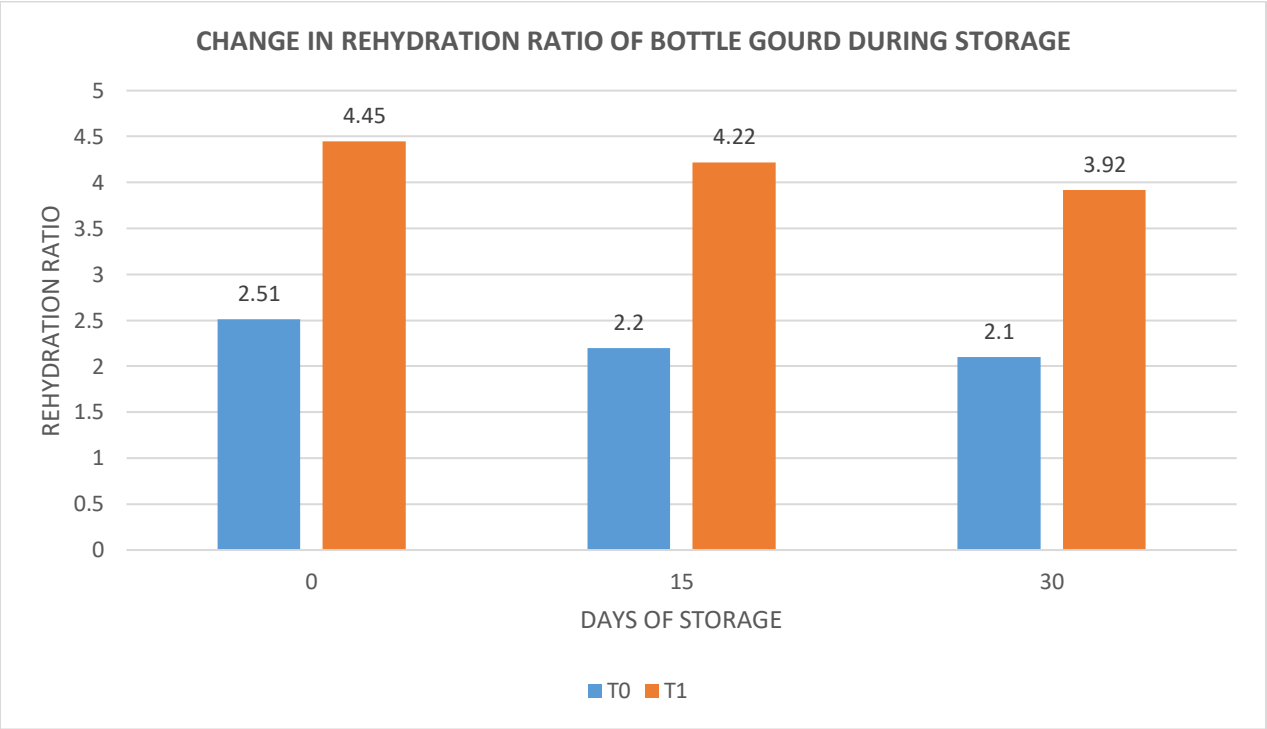


Figure 10: Graphs representing change in rehydration ratio of tomato, banana and bottle gourd dehydrated by sun drying (T0) and vacuum assisted microwave dryer (T1) during storage

Table 1: Sensory Evaluation of dehydrated products

	Appearance	Colour	Texture	Overall acceptability
Tomato				
T0	6.1±0.77	6.0±0.70	6.1±0.79	6.1±0.46
T1	9.0±0.00	8.5±0.45	8.8±0.31	8.81±0.22
Banana				
T0	6.61±0.86	5.94±0.79	6.1±0.70	6.37±0.53
T1	8.22±0.58	8.05±0.55	8.94±0.15	8.40±0.31
Bottle Gourd				
T0	6.38±0.65	6.22±0.88	6.44±0.57	6.35±0.48
T1	8.44±0.40	8.50±0.43	8.83±0.24	8.59±0.21

*Based on 9 point Hedonic scale

Figure 11: Preparation of Fermented vegetable products using Solid State Fermenter

INSTANT TOMATO MIX

Recipe (per 100g)

Vacuum assisted Microwave dried tomato powder – 100g

1.25 L water

150 mL oil

20 g salt

2 g starch

4g onion powder

2g garlic powder

1g cumin

0.5g clove

0.5gcardamom

0.5 g cinnamon

0.5g black pepper

Spices and powder provided as premix

Add water and oil and cook to desired consistency