Template/Pro forma for Submission

NMHS-Himalayan Institutional Project Grant

NMHS-FINAL TECHNICAL REPORT (FTR)

Demand-Driven Action Research and Demonstrations

NMHS Reference No.:	GBPNI/NMHS-2017-18/SG19

Date of Submission:	1	7	1	1	2	0	2	2
	d	**d**	**m**	**m**	**y**	**y**	**y**	**y**

PROJECT TITLE (IN CAPITAL)

Technological Interventions and Their Application for Sustainable Livelihood of Women Folk Involved in the Production of Various Traditional Milk-based Fermented Foods of Himalayan Belt of J&K

Project Duration: *from* (**28.03.2018**) *to* (**31.12.2021**).

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

Demand-Driven Action Research Project

DSL: Date of Sanction Letter							
2	8	0	3	**2**	**0**	**1**	**8**
d	d	m	m	y	y	y	y

DPC: Date of Project Completion							
3	1	1	2	**2**	**0**	**2**	**1**
d	d	m	m	y	y	y	y

Part A: Project Summary Report

1. Project Description

i.	Project Reference No.	GBPNI/NMHS-2017-18/SG19
ii.	Type of Project	Medium Grant
iii.	Project Title	**Technological Interventions and Their Application for Sustainable Livelihood of Women Folk Involved in the Production of Various Traditional Milk-based Fermented Foods of Himalayan Belt of J&K**
iv.	State under which Project is Sanctioned	**Jammu & Kashmir**
v.	Project Sites (IHR States covered) (Maps to be attached)	Himalayan Belt of Jammu and Kashmir including the sites Leh, Ladak, Kargil, Gurez, Pahalgam, Kupwara etc.
vi.	Scale of Project Operation	Local
vii.	Total Budget/ Outlay of the Project	0.49 (in Cr)
viii.	Lead Agency	NATIONAL MISSION ON HIMALAYAN STUDIES (NMHS) G.B. Pant National Institute of Himalayan Environment and Sustainable Development (GBPNIHESD)
	Principal Investigator (PI)	Dr. Adil Gani
	Co-Principal Investigator (Co-PI)	1. Prof. F. A. Masoodi 2. Dr. Idrees. A. Wani 3. Dr. Asima Jan
ix.	Project Implementing Partners	Department of Food Science and Technology, University of Kashmir, Hazratbal, Srinagar, India.

	Key Persons / Point of Contacts with Contact Details, Ph. No, E-mail	1. Dr. Adil Gani Coordinator/Sr. Assistant professor, Dept of Food Science and Technology, University of Kashmir. Cell no.: 7006599755 Email: adil.gani@gmail.com 2. Dr. Naseer Ahmad Bhat, Post-doctorate Fellow, Dept of Food Science and Technology, University of Kashmir. Cell no.: 7006205647 Email: bnaseerahmad03@gmail.com

2. Project Outcomes

2.1. Abstract

In the current stream of development, especially in the food-processing sector, factors like the role and impact of sustained technologies in the production, organized market, market linkages and value addition have an important impact on the decisions made by both producers and consumers. There is thus tremendous need for the scientific interventions in the manufacture, storage, and market linkages for the traditional dairy products of the Himalayan belt of Jammu and Kashmir. As, most of these regions are untouched by the recent developments in the mainstream dairy sector. Value chain describes the full range of activities that are required to bring a product from conception, through the different phases of production involving a combination of physical transformations, input of various producer services, and delivery to final consumers. Though there are studies that analyse value chains and dairy development but none of those analyze the scientific interventions for mechanized processing of the traditional dairy products of J&K Himalayas. Traditionally the women of the tribes of the region produce high value dairy products for home consumption and informal market with little knowledge about their prices, grades, standards and food safety. But these women lack the training and entrepreneurial skills. A major gap identified is the lack of mechanized process, proper storage and market linkages, which deprive these high value products to enter in the demanding market of foods with health benefits. The study aimed to explore the role of scientific interventions for economic development of the tribal women folk involved in the production of traditional dairy products of Himalayan region of Jammu and Kashmir. In addition, the implementation of developed scientific methodology by demonstrating the process to the concerned stakeholders was also done. Thus the overall proposal focused at improving the livelihood and social status of underprivileged gender of the tribal population of the Himalayan belt of Jammu and Kashmir.

The major change that was observed in the *krad*i and *chhurpi* samples after the addition of sea buckthorn leaves was the improvement in their nutraceutical potential. The total flavonoids and total phenolic contents were significantly increased. Antioxidant properties were also highly enhanced. The *kradi* and *chhurpi* samples showed considerable anti-diabetic, anti-obesity and anti-proliferative properties after enrichment with sea buckthorn leaves. Thus, the fortification of traditional dairy products like *kradi* and *chhurpi* or other milk-based fermented foods with saffron and sea buckthorn leaves can be done to develop functional foods with health promoting properties which may be consumed during long harsh winters, by the people living in colder regions of the world. Furthermore, the developed products may have increased shelf-life with desirable organoleptic properties. It is an important approach to the diversity of traditional fermented milk products like *chhurpi*, *kudan* and *kradi*. The mechanization of the processes increased the production rate, decreased the labor and time, thereby decreasing the overall production cost of the products.

2.2. Objective-wise Major Achievements

S. No.	Objectives	Major achievements (in bullets points)
1.	To standardize and mechanize the process methodology for the product (*kalari. chhurpi*, and *kudaan*) using response surface methodology (RSM)	a. Standardized and mechanized production process of cheese using RSM. b. The optimum processing parameters i.e. Incubation time, incubation temperature, inoculum concentration and drying time for cheese preparation were obtained. **c.** The paper was published in **Applied Food Research.** d. The prototype for the mechanised production of *chhurpi* and *kradi* has been designed e. A patent of the Semi-automatic Kradi making machine (prototype) was filed (Indian Patent No. 202211057391).
2.	To evaluate the quality of each product with respect to their chemical composition, microbiology, bioactivity and sensorial properties	a. Fortification of Himalayan cheese (kradi) with saffron for enhancing its nutraceutical potential. The paper has been published in the Journal of Food Bioscience b. Isolation and identification of the lactic acid bacteria from Kradi cheese. The paper has been published in the journal of LWT_Food Science and Technology. c. Extraction of protein from churpi of yak milk origin: Size reduction, nutraceutical potential and as a wall material for resveratrol. The paper was published in Food Bioscience.

3.	To develop the packaging material from available resources of their localities to extend the shelf-life of the traditional products.	a. A packaging film made of bee wax and pine needle extract has also been developed. The paper has been published in Ultrasonics Sonochemistry.
4.	To demonstrate the standardized methodology and edible film development to the women folk of the nomadic tribes involved in the production of kalari, churpi, and Kudan	a. A workshop was successfully conducted and tribal women were given demonstration regarding the use and benefits of using the designed prototype and developed technology. b. The plan was to distribute some prototypes to the local tribal people but due to lack of funds and time we could not distribute the prototypes.

2.3. Outputs in terms of Quantifiable Deliverables*

S. No.	Quantifiable Deliverables*	Monitoring Indicators*	Quantified Output/ Outcome achieved	Deviations made, if any, & Reason thereof:
1.	To standardize and mechanize the process methodology for the Churpi using RSM. And mechanisation of the process of Kradi	a. The standardization process for product development was carried using response surface methodology (RSM) software. At the initial stage the standardization process for the development of Churpi was carried. The statistical program used for analysing the data was Design Expert 9.0.3. Central composite design (CCD) was used to study the effect of four independent variables which were inoculum concentration (X1), incubation time (X2), incubation temperature (X3) and	a. Standardized and mechanized production process of churpi using RSM. The optimum processing parameters i.e. Incubation time, incubation temperature, inoculum concentration and drying time for Churpi preparation were obtained. The churpi sample with the incubation time, incubation temperature, inoculum concentration and drying time of 26 h, 25 °C, 50 g and 24 h respectively, was found to have greater potential with respect to all the sensory	

		drying time (X4). The parameters were run into a package program and a total of 30 experimental settings were obtained and yield (Y1), firmness (Y2), acidity (Y3) and sensory analysis (Y4) were expressed as dependent variables. These variables were expressed as a function of independent variables. Experimental data was fitted to second order polynomial to express yield, firmness, acidity and sensory analysis of chhurpi as a function of independent variables. Two dimensional response surface contour plots were generated by keeping two variable constant while varying the other two in the second order polynomial model. Statistical analysis was performed at 5% level of significance. The 30 combinations that were obtained by using RSM were	attributes, yield, acidity and texture. The sensory, chemical and instrumental data of the churpi was the best when compared with all the other developed Churpi samples. b. The prototype that has been designed was used for the preparation of traditional fermented milk products including kradi and chhurpi. The time required for making kradi and chhurpi by conventional method takes almost 12 hrs. The churning of the butter from the fermented milk (Dahi) takes 3-4 h. However, the prototype designed churns the milk in 15 minutes thereby saving time as well as energy to a large extent. The tribal people were given a demonstration of the designed prototype.	

		prepared in the Food processing lab under hygienic conditions and were analysed for % yield, acidity, firmness and sensory characteristics. The mechanization process has also been completed now and the prototype has been designed.		
2.	To evaluate the quality of each product with respect to their chemical composition, microbiology, bioactivity and sensorial properties	a. The product was analysed for physicochemical, antioxidant and medicinal properties. The moisture, protein, fat and ash contents of kradi cheese samples were in between 31.76-38.95%, 27.88-28.21%, 6.89-7.13% and 1.14-1.52%, respectively. The enriched kradi showed considerably high ‘a’ and ‘b’ values as compared to control. The HPLC analysis revealed that kradi had the highest crocin content (3.08-5.67 µg/g) than the safranal content (0.45-1.07 µg/g). Total phenolic content and antioxidant	a. Fortification of Himalayan cheese (kradi) with saffron for enhancing its nutraceutical potential. The kradi cheese was enriched with saffron powder (25 mg, 50 mg, 75 mg and 100 mg of saffron/50 g of cheese). The product was analyzed for physicochemical, antioxidant and medicinal properties. b. Characterization and value addition of the dried cheese (Chhurpi) was done by fortifying it with different concentrations of sea buckthorn leaves. Different concentrations of the sea buckthorn	

		activity of enriched kradi was highly improved due to the presence of saffron secondary metabolites. The enriched kradi had desirable organoleptic properties compared to control. b. The results of the study revealed that addition of SBL (1.5%, 2.5% and 3.5%) to chhurpi significantly ($p < 0.05$) changed its color and texture. The total flavonoids and total phenolic contents of the chhurpi samples were also significantly ($p < 0.05$) increased from 0.05-4.63 mg catechin equivalents/g and 7.55-63.04 mg GAE/g, respectively. Enriched chhurpi showed significant ($p < 0.05$) increase in anti-obesity, anti-diabetic and anti-proliferative properties. The organoleptic of enriched chhurpi samples were modified considerably and gained maximum scores as compared to control.	leaf powder (1.5, 2.5 and 3.5%) were added to chhurpi samples. The physicochemical, antioxidant, antidiabetic and sensory properties of the Chhurpi samples enriched with sea buckthorn leaves were evaluated. Antioxidant properties were evaluated by using different assays such as DPPH radical scavenging assay, reducing power and inhibition of lipid peroxidation. Total phenolic content was also determined. The antidiabetic activity was determined by measuring the inhibitory activity of enriched chhurpi samples against α-glucosidase. c. To isolate and identify the lactic acid bacteria from Kradi cheese. Further the sample was subjected to simulated gastric digestion. The study was carried out to evaluate probiotic potential of the isolated	

		The FT-IR spectra revealed that intensity of the peaks between 3400-3200 cm-1 and 1200-800 cm-1 of the enriched chhurpi samples increased significantly. c. Kradi cheese showed presence of a potent probiotic strain i.e., Lb. plantarum with high hydrophobicity and antimicrobial activity. During simulated gastrointestinal digestion the overall bioactivity of the product enhanced profoundly up to 320 min of digestion and did not change further with increased time. This revealed the potential of released bioactive peptides to maintain their activity and resist further hydrolysis, which otherwise might have resulted in their compromised activity. Therefore, Kradi cheese can be used as potent source of probiotics and bioactive peptides to alleviate many lifestyle	LAB from Kradi and the effect of simulated gastrointestinal digestion on its bioactivity. The water-soluble peptide extract generated during the transit were collected and evaluated for antioxidant (DPPH radical scavenging activity, ABTS radical scavenging activity, Inhibition of lipid peroxidation and reducing power), and antimicrobial properties.	

		related diseases including diabetes, hypertension, cancers, etc.		
3.	To develop the packaging material from available resources of their localities to extend the shelf-life of the traditional products.	The packaging film by using bee wax and pine needle extract has been successfully developed.	a. The demonstration of the standardized and mechanized processes for the development of traditional cheeses was given to tribal people of the Anantnag district. Some of the other regions Including Ladakh, Gurez etc. will be covered in the upcoming days. b. The demonstration of the packaging film has not been given to the local people of the valley and will be given in the upcoming days as we have planned to visit the areas in the next week.	
4.	To develop the packaging material from available resources of their localities to extend the shelf-life of the traditional products.	The PI and his team visited district Anantnag of J&K where a workshop was conducted. The tribal people were invited and a demonstration of the designed prototype was given by the PI and his team. The people were full satisfied with the	a. The demonstration of the standardized and mechanized processes for the development of traditional cheeses was given to tribal people of the Anantnag district. Some of the other regions Including Ladakh, Gurez etc. were also covered.	

		designed prototype. We are planning to make some more prototypes and distribute among the tribal people (Women folk) and receive their feedback.		

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

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

S. No.	Particulars	Number/ Brief Details	Remarks/ Attachment
1.	New Methodology developed	NA	
2.	New Models/ Process/ Strategy developed	The prototype for the mechanised production of cheese (*kradi*)	
3.	New Species identified	NA	
4.	New Database established	NA	
5.	New Patent, if any	A patent of the Semi-automatic Kradi making machine (prototype) was filed (Indian Patent No. 202211057391).	
	I. Filed (Indian/ International)	One (Indian)	
	II. Granted (Indian/ International)		
	III. Technology Transfer(if any)		
6.	Others (if any)	NA	

3. Technological Intervention

S. No.	Type of Intervention	Brief Narration on the intervention	Unit Details (No. of villagers benefited / Area Developed)
1.	Development and deployment of indigenous technology	Standardized method for the production of cheese (*chhurpi*) was developed under hygienic conditions. In addition, a prototype for the mechanised production of cheese (*kradi, chhurpi*) was designed. The traditional fermented dairy products like *kradi*, *chhurpi*, etc. which are mostly consumed by the people living in higher Himalayan regions of J&K. The production of these products are gender specific activities in which women have an important role and stake in the value chain of these traditional cheeses. In many households women receive the payments through middlemen. The *kalari* or *chhurpi* thus brings women of the household the only cash income that she receives. It is the women's skills and labor that goes in the production of these cheeses and they are the sole proprieties' for the sale of the produce. But these women lack the training and entrepreneurial skills. The main problems in making this cheese are that, it is highly time-consuming, and as of now, the process is not standardized for industrial production. The electricity-powered kradi making machine designed mimics the artisan cheese making process in a scientific way to improve the efficiency and decrease the time consumed of the cheese making process itself. The machine does pasteurization, incubation and churning in the same chamber itself so that the machine is portable and can be used by the tribal people and as a household appliance. The machine can operate with a minimum of 5 L to a maximum of 10 L of milk. The milk chamber is indirectly heated using a water jacket, which is heated using	The demonstration of the prototype and the standardized method for the production of *chhurpi or kradi* was given to more than 200 tribal men and women.

		an immiscible heating element placed at the bottom of the water jacket. A thermocouple is placed in the chamber to determine the temperature of the water jacket so that the temperature of the milk, for pasteurization and incubation can be determined and controlled using the temperature controller. The pasteurization time can be determined based on the set temperature	
2.	Diffusion of High-end Technology in the region	The tribal people were ready to use the designed prototype for the cheese production. We had decided to distribute the some designed prototypes among the tribal people of different regions but due tyo lack of funds we couldn't.	
3.	Induction of New Technology in the region	NA	
4.	Publication of Technological / Process Manuals	A number of papers have been published in high impact journals. In addition a Patent of the designed prototype has also been filed.	
	Others (if any)		

4. New Data Generated over the Baseline Data

S. No.	New Data Details	Status of Existing Baseline	Additionality and Utilisation New data
1.	A standard and mechanised process for the development of cheese was developed.	The traditional procedure used for the development of cheese is very unhygienic and requires lot of energy and labour.	The new method developed will reduce the cost, time and energy required for the production of traditional cheese products.

5. Demonstrative Skill Development and Capacity Building/ Manpower Trained

S. No.	Type of Activities	Details with number	Activity Intended for	Participants/Trained			
				SC	**ST**	**Woman**	**Total**
1.	Workshops	**01**	**Demonstration of designed prototype**			**40-50**	**45**

2.	On Field Trainings	**05**	**Mechanise the process of cheese production by using standard technology.**		**40**	**40-60**	**80-100**
3.	Skill Development	**04**	**Trained manpower for the production of traditional cheese products.**				
4.	Academic Supports		**NA**				
	Others (if any)						

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

NA

7. Project Stakeholders/ Beneficiaries and Impacts

S. No.	Stakeholders	Support Activities	Impacts
1.	Gram Panchayats		
2.	Govt Departments (Agriculture/ Forest)		
3.	Villagers		
4.	SC Community		
5.	ST Community	The nomadic people Gujjar and Bakarwals which are involved in the production of *kradi, chhurpi and Kudan will be able to use the standard technology developed and thus increase the production of these products which will help in improving their livelihood.*	
6.	Women Group	The women were given training on mechanised production of *kradi* which will increase their source of income and reduce the time and labour	
	Others (if any)		

8. Financial Summary (Cumulative)

S. No.	Financial Position/Budget Head	Funds Received	Expenditure/ Utilized	% of Total cost
I.	Salaries/Manpower cost	1372879	1372720	28.00
II.	Travel	244450	244450	4.99
III.	Expendables &Consumables	780000	780000	15.92

IV.	Contingencies	207000	207000	4.22
V.	Activities & Other Project cost	217480	217480	4.44
VI.	Institutional Charges	500000	200000	4.08
VII.	Equipments	1262000	1258825	25.69
	Total	4283809	4280634	87.36
	Interest earned			
	Grand Total			

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

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

S. No.	Name of Equipments	Cost (INR)	Utilisation of the Equipment after project
1.	Lyovapor L-200 Freeze Dryer	1122000 INR	The equipment will be utilized for the research purpose.
2.	Milk Homogenizer A1HO100	129380 INR	The equipment will be used by the students and scholars of the University for Research studies.
3.	Cream churner	10620 INR	Research Purpose

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

10. Quantification of Overall Project Progress

S. No.	Parameters	Total (Numeric)	Remarks/ Attachments/ Soft copies of documents
1.	IHR States Covered	*01*	
2.	Project Site/ Field Stations Developed	*Himalayan Belt of Jammu and Kashmir including the sites Leh, Ladak, Kargil, Gurez etc.*	
3.	New Methods/ Modeling Developed		
4.	No. of Trainings arranged	*02*	
5.	No of beneficiaries attended trainings		
6.	Scientific Manpower Developed (Phd/M.Sc./JRF/SRF/ RA):	*12*	
7.	SC stakeholders benefited		
8.	ST stakeholders benefited	*40-50*	
9.	Women Empowered	*25-40*	
10.	No of Workshops Arranged along with level of participation		
11.	On field Demonstration Models initiated	Video and Images.zip	
12.	Livelihood Options promoted		
13.	Technical/ Training Manuals prepared		
14.	Processing Units established	.... (attach photos)	
15.	No of Species Collected		
16.	New Species identified		
17.	New Database generated (Types):		
	Others (if any)		

11. Knowledge Products and Publications:

S. No.	Publication/ Knowledge Products	*Number*		*Total Impact Factor*	*Remarks/* Enclosures
		National	International		
1.	Journal Research Articles/ Special Issue:		05	27.814	Papers.zip
2.	Book Chapter(s)/ Books:				
3.	Technical Reports				
4.	Training Manual (Skill Development/ Capacity Building)				
5.	Papers presented in		01		International

S. No.	Publication/ Knowledge Products	*Number*		*Total Impact Factor*	*Remarks/* Enclosures
		National	International		
	Conferences/Seminars				Conference on interface between agriculture, food, chemical and biological sciences
6.	Policy Drafts/Papers				
7.	Others:				

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

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

Particulars	Recommendations
Utility of the Project Findings	The fortification of traditional dairy products like kradi and chhurpi or other milk-based fermented foods with saffron and sea buckthorn leaves can be done to develop functional foods with health promoting properties which may be consumed during long harsh winters, by the people living in colder regions of the world,. Furthermore, the developed products may have increased shelf-life with desirable organoleptic properties. It is an important approach to the diversity of traditional fermented milk products like chhurpi, kudan and kradi. The mechanization of the processes increased the production rate, decreased the labour and time, thereby decreasing the overall production cost of the products
Replicability of Project	As milk and milk products are widely consumed across the globe, their fortification with bioactive compounds from plant sources can be a promising strategy. The fortification of dairy products with active ingredients will not only increase the nutritional content but also promote the health of consumers. In addition, the antioxidants present will help to improve their shelf life to some extent. The prototype designed can be used by the people to develop the traditional cheese products in a very cost-effective manner.

Exit Strategy	The successful implementation of the technology in the rural households will sustain the results achieved in the project because the production process of the traditional cheeses will be sustained rather the production process will increase by implementing the project results. There is strong hope that the results achieved will sustain till the new technological developments in the production of these traditional dairy products will take place.

(**PROJECT PROPONENT/ COORDINATOR**)

(Signed and Stamped)

(**HEAD OF THE INSTITUTION**)

(Signed and Stamped)

Place: Srinagar
Date: 28-11-2022

PART B: PROJECT DETAILED REPORT

The Detailed report should include an Executive Summary and it should have separate chapters on (i) Introduction (ii) Methodologies, Strategy and Approach (iii) Key Findings and Results (iv) Overall Achievements (v) Project's Impacts in IHR (vi) Exit Strategy and Sustainability (vii) References and (viii) Acknowledgement (It should have a mention of financial grant from the NMHS, MoEF&CC)

Further, description of Technical Activities, List of Trainings/ Workshops/ Seminars with details of trained resources, list of New Products developed under the project, Manual of Standard Operating Procedures (SOPs) developed, Technology developed/Transferred etc should be enclosed as Appendix.

1 EXECUTIVE SUMMARY

The Executive Summary of the project should not be more than 3–5 pages, covering all essential features in precise and concise manner as stated in Part A (Project Summary Report) and Part B (Comprehensive Report).

In the current stream of development, especially in the food-processing sector, factors like the role and impact of sustained technologies in the production, organized market, market linkages and value addition have an important impact on the decisions made by both producers and consumers. There is thus tremendous need for the scientific interventions in the manufacture, storage, and market linkages for the traditional dairy products of the Himalayan belt of Jammu and Kashmir. As, most of these regions are untouched by the recent developments in the mainstream dairy sector. Value chain describes the full range of activities that are required to bring a product from conception, through the different phases of production involving a combination of physical transformations, input of various producer services, and delivery to final consumers. Though there are studies that analyze value chains and dairy development but none of those analyse the scientific interventions for mechanized processing of the traditional dairy products of J&K Himalayas. Traditionally the women of the tribes of the region produce high value dairy products for home consumption and informal market with little knowledge about their prices, grades, standards and food safety. But these women lack the training and entrepreneurial skills. A major gap identified is the lack of mechanized process, proper storage and market linkages, which deprive these high value products to enter in the demanding market of foods with health benefits. The study aimed to explore the role of scientific interventions for economic development of the tribal women folk involved in the production of traditional dairy products of Himalayan region of Jammu and Kashmir. In addition, the implementation of developed scientific methodology by demonstrating the process to the concerned stakeholders was also done. Thus the overall proposal focused at improving the livelihood and social status of underprivileged gender of the tribal population of the Himalayan belt of Jammu and Kashmir.

The major change that was observed in the *krad*i and *chhurpi* samples after the addition of sea buckthorn leaves was the improvement in their nutraceutical potential. The total flavonoids and total phenolic contents were significantly increased. Antioxidant properties were also highly enhanced. The *kradi* and *chhurpi* samples showed considerable anti-diabetic, anti-obesity and

anti-proliferative properties after enrichment with sea buckthorn leaves. Thus, the fortification of traditional dairy products like *kradi* and *chhurpi* or other milk-based fermented foods with saffron and sea buckthorn leaves can be done to develop functional foods with health promoting properties which may be consumed during long harsh winters, by the people living in colder regions of the world,. Furthermore, the developed products may have increased shelf-life with desirable organoleptic properties. It is an important approach to the diversity of traditional fermented milk products like *chhurpi*, *kudan* and *kradi*.

To preserve the flavour and texture of the artisan cheese. The process of traditional cheese making is not altered per see, but the process is mechanized through the invention to improve the efficiency and reduce the time involved in making kradi. The primary audience to buy and use this invention are the nomadic people, so, compactness, portability and low cost were the parameters given high priority while designing the prototype. The mentioned constrains and considerations put the machine developed, in the category of semi-automatic. The invention has a water jacketed milk chamber, where pasteurization, incubation and agitation take place. The outer layer of the water jacket was insulated using glass wool to reduce loss of heat and to prevent the damage of electronic components due to high temperature. The temperature controller is coupled with a thermocouple which is attached to the water jacket, which feeds in real time temperature data to the controller. The output of the controller is connected to a solid-state relay which conducts to the heating element when the temperature drops below the set temperature in the controller. To reduce the temperature of the water in the jacket, water could be injected through the 'water in' valve by connecting to the household water supply (cold water) and the water out valve discards hot water. The lid of the milk chamber is fitted with an agitator which mimics the forward and reverse circulation of traditional churning with increased speed and consistency which is technique employed to convert cream to butter. The speed of agitation is controlled by using pulse width modulation-based speed controller and the direction of rotation is controlled by changing the polarity of the DC motor using solid state relays. The manual work to be carried out in the overall operation are skimming of butter, addition of inoculum and final pressing of cheese. The invention has reduced the overall time required for cheese making, and the temperature-controlled incubation, pasteurization and curdling, along with preventing the degradation of nutrients due to excessive exposure of milk to high temperature.

2 INTRODUCTION

2.1 Background of the Project (max. 500 words)

Small holder dairy farming and its management in hills in general and production of kalari, churpi, and kudan in particular are gender specific activities in which women have an important role and stake in the value chain of these traditional cheeses. In many households women receive the payments through middlemen. The kalari, kudan, or churpi thus brings women of the household the only cash income that

she receives. It is the women's skills and labour that goes in the production of these cheeses and they are the sole proprieties' for the sale of the produce. But these women lack the training and entrepreneurial skills. A major gap identified is the lack of mechanized process, proper storage and market linkages, which deprive these high value products to enter in the demanding market of foods with health benefits. These products are high source of proteins, bioactive peptides and probiotic microorganisms. Their clean, hygienic, mechanized production and storage by the use of suitable infrastructure can fetch a premium price if marketed properly in high-income final markets. The consumers of such markets give preference to non-price critical success factors like hygiene, organic production, and health improving foods. But at present the producers are unaware of these aspects and if the stakeholders will be provided with the developed scientific processing and communicated about the benefits associated with adaption of mechanized processing and other aspects. There would be complete turnaround in the value chains of these traditional dairy products of Himalayan region of Jammu and Kashmir.

2.2 Overview of the Major Issues to be Addressed (max. 1000 words)

The production of *kalari*, *churpi*, and *kudan* are gender specific activities in which women have an important role and stake in the value chain of these traditional cheeses. In many households women receive the payments through middlemen. The kalari, kudan, or churpi thus brings women of the household the only cash income that she receives. It is the women's skills and labour that goes in the production of these cheeses and they are the sole proprieties' for the sale of the produce. But these women lack the training and entrepreneurial skills. A major gap identified was the lack of mechanized process, proper storage and market linkages, which deprive these high value products to enter in the demanding market of foods with health benefits. Since remote hills in J&K, which are the production centres of these traditional dairy products, are not attractive for large industrial unit setup. So awareness among the locals about the scientifically designed and mechanized process will benefit the women folk by boosting their economy, reducing their poverty and improving their social status. The approximate population that will be benefitted directly or indirectly in terms of economy is 3950000 and the general public will be benefitted with associated health benefits of the products after their consumption.

Economic development is often attributed to successful implementation of policy and scientific approaches. Conversely in areas where development is still a dream policy making and lack of scientific interventions are blamed for all the failures. The proposal aimed to explore the role of scientific interventions for economic development of the tribal women folk involved in the production of traditional dairy products of Himalayan region of Jammu and Kashmir. It aimed at the implementation of developed scientific methodology by demonstrating the process to the concerned stakeholders. Thus the focus was at improving the livelihood and social status of underprivileged gender of the tribal population of the Himalayan belt of Jammu and Kashmir.

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

The optimization of each of the product will provide optimum quality products. The successful process in terms of increased yield and quality will be chosen as the standardized process for further communication of the stakeholders. Mechanization of the processes increased the production rate, decreased the labor and time that may ultimately lead to decreased production cost. The compositional analysis will help in determining the storage and packaging requirements of the cheese products studied. Since Water activity (aw) has its most useful application in predicting the growth of bacteria, yeasts and molds. Thus determination of water activity will provide an idea about the possible microbial contamination of these products. Determination of microbial flora is expected to validate the traditional products as a source of probiotic microorganisms. The use of bee wax and pine needles for the development of active packaging is expected to increase the shelf life of the traditional products with maintained quality and safety. Since the materials are readily available in Himalayan region of J&K, their accessibility to the population associated with the production of these traditional cheeses is expected to be is easy. Hence the use of green products in packaging of these products is also expected to conserve the environment of the Himalayan region of J&K.

The demonstration of the processes developed may lead to the implementation of these innovations in the traditional dairy product manufacturing. Also for effective functioning and implementation of technology, it is important to exchange information among the stakeholders and the implementation of the technology may help in increasing the production and improve the quality and safety of the products. The implementation of the process is based on the engagement of the women involved in the production of the traditional cheeses of J&K. The women will participate in training programs and workshops where they get educated about the benefits of scientifically standardized and mechanized processes.

There is no kradi making machine available in the market. The generic cheese making machines available in the market is also available only in commercial scale. Also, in commercial scale the cheese making machines operates in multiple batches and are not completely mechanised either. In the developed kradi making machine the entire process is carried out in a single process, the device is compact and is suitable for house hold application. Also, the machine is easy to use and can be operated even by a layman. Kradi is a unique Himalayan cheese so there are no machines available in the overseas market. The machine if made available can be used commercially especially by the tribal women which are involved in the production of traditional cheese products like *kradi*, *chhurpi, Kudan etc.*

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

Project Objectives	Target Deliverables
• To standardize and mechanize the process methodology for each of the product (kalari. chirpi, and kudaan) using response surface methodology (RSM); • To evaluate the quality of each product with respect to their chemical composition, microbiology, bioactivity and sensorial properties; • To develop the packaging material from available resources of their localities to extend the shelf life of the traditional products; • To demonstrate the standardized methodology and edible film development to the women folk of the nomadic tribes involved in the production of kalari, churpi, and kudan.	• Value chain development with market linkages for dairy products with mechanization of process. • New packaging material based on local produce like bee wax and pine needle to improve shelf life of products; • Field model for capacity building of >100 nomadic women on new technology.

3 METHODOLOGIES, STARTEGY AND APPROACH

3.1 Methodologies used for the study (max. 1000 words)

Methodology (in brief):

Project objective 1: To standardize and mechanize the process methodology for each of the product (kalari. chirpi, and kudaan) using response surface methodology (RSM).

A. Methodology:

1. Preparation of Chhurpi

Chhurpi was prepared by following the procedure of Panda et al. (2016).

2. Yield

3. Texture

Firmness of the dried chhurpi was determined by using TA.XT Plus, texture analyser (Stable MicroSystems, Vienna Court, UK).

4. Acidity

Titratable acidity was determined by using the standard AOAC (1990) method.

5. Sensory analysis

6. Proximate analysis

The proximate composition (moisture, protein, ash, and fat) was determined by using standard AOAC (1990) method.

7. Fourier transform infrared (FTIR) spectroscopy

The structural characterization of chhurpi was done by using FTIR-ATR (Cary 630 FTIR, Agilent Technologies, Virginia, USA).

8. Differential scanning calorimetry

The thermal analysis of chhurpi was done by using differential scanning calorimeter (DSC822, Mettler-Toledo, Neuchatel, Switzerland).

9. Experimental design and statistical analysis

Experimental design of the study was established by using Response Surface Methodology (RSM). The statistical program used for analyzing the data was Design Expert 9.0.3. Central composite design (CCD) was used to study the effect of four independent variables including inoculum concentration (X1), incubation time (X2), incubation temperature (X3) and drying time (X4).

B. Mechanization of the process

Methodology: The prototype was designed and was used for the preparation of traditional fermented milk products including kradi and chhurpi.

Project objective 2: To evaluate the quality of each product with respect to their chemical composition, microbiology, bioactivity and sensorial properties.

A. Value addition of kradi and its characterization

Methodology:

2.2. Preparation of Kradi

Kradi cheese was prepared in the processing plant of the Department of Food Science & Technology, University of Kashmir, India. Milk was inoculated (previous batch dahi) after cooling to 38-40 ℃. The inoculated milk was then kept for fermentation in an incubator at 25 ℃ for 24 h. After fermentation, the dahi was churned to release butter leaving acidified butter milk. The butter milk was equally divided into five batches. All the batches of milk were then heated at 55-60 ℃ for coagulation. The cheese obtained was then kneaded and stretched to give a shape of round disc which is known as kradi.

2.3. Extraction of the kradi cheese

The procedure followed by Mushtaq et al. (2019) was used for the extraction of kradi cheese samples

2.4. Physicochemical characterization of kradi cheese

2.4.1. Chemical composition

2.4.2. Peroxide value

2.4.3. Texture

2.4.4. Color

2.4.5. FTIR (Fourier transform infrared) spectroscopy

The structural characterization of the kradi cheese samples was performed by using FTIR (Cary 630 FTIR, Agilent Technologies, Virginia, USA).

2.5. Total flavonoid content

The total flavonoid content of kradi cheese samples was measured by using the Dowd method as followed by Krishnaiah et al. (2012

2.6. Quantification of Crocin and Safranal in kradi by HPLC

2.7. Total phenolic content

Total phenolic content of the kradi cheese samples was measured by using the method of Mushtaq et al. (2015).

2.8. Antioxidant activity

2.8.1. DPPH (1,1-diphenyl-2-picrylhydrazyl radical) radical scavenging activity

The DPPH radical scavenging activity of the kradi cheese was determined by following the procedure of Li et al. (2007).

2.8.2. Reducing power

The reducing power was measured as per the procedure described by Bhat et al. (2019)

2.8.3. Inhibition of lipid peroxidation

Inhibition of Lipid peroxidation values of the kradi cheese samples were measured by following the method of Wright et al. (1981).

2.9. Anti-obesity assay

2.9.1. Pancreatic lipase inhibition activity

The colorimetric method of M. Ahmad et al. (2019) was used to determine the inhibitory activity of kradi cheese samples against pancreatic lipase.

2.9.2. Cholesterol esterase inhibition activity

The inhibition activity of kradi cheese against cholesterol esterase enzyme was determined by using a colorimetric method of M. Ahmad et al. (2019).

2.10. Antidiabetic inhibition activity

2.10.1. α-Glucosidase inhibition assay

α-Glucosidase inhibition activity was performed by using the procedure of Chen et al. (2014).

2.10.2. α-Amylase inhibition assay

2.11. Anti-proliferative assay

The MTT assay followed by Sayari et al. (2016) was used to determine the anticancer activity of Kradi cheese samples. The cells HEK-T, HELA and U-2 OS at desired concentration were incubated for 24 h at 37 ℃ with 50 µL of aqueous extract of each sample.

B. Value addition of chhurpi and its characterization

Methodology:

2.1. Production of Chhurpi

2.3. Characterization of developed chhurpi

2.3.1. Proximate Analysis

2.3.2. Acidity and pH

2.3.3. Texture Analysis

TAXT Plus, texture analyzer (Stable Micro Systems, Vienna Court, UK) was employed to measure the hardness of the chhurpi samples.

2.3.4. Color

2.3.5. FTIR Analysis

The structural characterization of the samples was done by using FTIR-ATR (Cary 630 FTIR, Agilent Technologies, Virginia, USA

2.7. Quantification of polyphenols in chhurpi by RP-HPLC

2.3.6. Total flavonoid content

2.3.7. Total Phenolic content

2.3.8. Antioxidant properties

2.3.8.1. DPPH radical-scavenging activity

The samples were analyzed for DPPH radical scavenging activity by following the procedure of Brand-Williams et al. (1995).

2.3.8.2. Reducing Power

The reducing power of the cheese samples was estimated by following the procedure of Liu et al., (2018)

2.3.8.3. Lipid peroxidation

Lipid peroxidation value of the cheese samples was determined by following the method of (Wright et al., 1981).

2.3.9. Antidiabetic activity

2.3.9.1. α-amylase inhibition activity

The α-amylase inhibition activity of chhurpi samples was determined as per the method followed by Apostolidis et al. (2007).

2.3.9.2. α-glucosidase inhibition activity

α-glucosidase inhibitory activity of the chhurpi samples was evaluated according to the procedure Apostolidis et al. (2007).

2.3.10. Anti-obesity activity

2.3.10.1. Pancreatic lipase inhibition activity

The pancreatic lipase inhibitory activity was determined by using a colorimetric method followed by (Ahmad et al., 2019).

2.3.10.2. Cholesterol esterase inhibition activity

Cholesterol esterase (CE) inhibitory activity was determined by using a colorimetric method followed by Ahmad et al. (2019).

2.3.11. Anti-proliferative assay

The MTT assay was used to determine the anticancer activity of chhurpi samples (Sayari et al., 2016).

C. Characterization of Kradi

Methodology:

1. Preparation of Kradi
2. Microbiological analysis of cheese

i. Enumeration of different microorganisms

ii. Isolation and identification of lactic acid bacteria from Kradi cheese

3. Antimicrobial activity of LAB isloates

A total of 12 isolates of LAB were screened for antimicrobial activity. Antibacterial activities of LAB isolates were evaluated using the agar-well diffusion assay as previously discussed by Todorov and Dicks (2005) and Diop et al. (2008).

4. Hydrophobicity assay

Hydrophobicity of the isolates was evaluated as described by Tamang et al. (2009).

5. Digestion of Kradi in simulated gastric conditions

Simulated gastro-intestinal digestion was carried according to the prescribed method of Toomer et al. (2013).

6. Nutraceutical potential of Kradi cheese

i. Preparation of the extract (WSPE)

The protocol devised by Rizzello et al. (2005) was used for the preparation of WSPE.

iii. Antioxidant assay

a. DPPH radical scavenging activity

b. ABTS radical scavenging activity

The scavenging activity of WSPE against the ABTS radical (Sigma-Aldrich, USA) was determined by the method described by Re et al. (1999).

c. Inhibition of lipid peroxidation

The antioxidant activity of the WSPE was determined spectrophotometrically with minor modifications to the thiocyanate method (Osawa & Namiki, 1981).

d. Metal chelating activity

The ferrous ion chelating ability of WSPE was determined using the ferrozine method Tang et al. (2002).

e. Reducing power

The reducing power of WSPE was assessed according to the method of Duh et al. (1999).

7. Antidiabetic activity

i. α-glucosidase inhibition activity

The α-glucosidase inhibitory activity of WSPE was determined following previously described of Chen et al. (2014).

ii. α-amylase inhibition activity

8. Anti proliferative MTT assay

9. Antimicrobial activity

Antibacterial ability of WSPE was determined using method previously described by McClean et al. (2014).

10. ACE inhibition activity

ACE-inhibition activity of WSPEs was assayed according to the already described method of Ayyash & Shah, 2011.

Project objective 3: To develop the packaging material from available resources of their localities to extend the shelf-life of the traditional products.

Methodology: The packaging film including bee wax and pine needle extract has been developed. The effect of packaging film on the quality and shelf-life of the cheese will be evaluated in the next few months.

Project objective 4: To demonstrate the standardized methodology and edible film development to the women folk of the nomadic tribes involved in the production of kalari, churpi, and kudan.

Methodology:

The demonstration of the standardized and mechanized processes for the development of traditional cheeses was given to tribal people of the Anantnag district. Some of the other regions Including Ladakh, Gurez etc. were also covered.

3.2 Preparatory Actions and Agencies Involved (max. 1000 words)

NA

3.3 Details of Scientific data collected and Equipments Used (max 500 words)

The standard procedure for obtaining the optimum quality cheese (*kradi, chhurpi*) was developed. The physicochemical, functional, microbiological and nutraceutical characterisation of the developed cheese products was done. In addition a packaging film was developed using Bee wax and pine needles and its characterization. Moreover, in order to mechanise the process of traditional cheese products a prototype was designed which reduced the time, labour and energy required to develop the cheese products.

3.4. Primary Data Collected (max 500 words)

NA

3.5. Details of Field Survey arranged (max 500 words)

NA

3.6. Strategic Planning for each Activities (max. 1000 words)

Activity 1.1 Collection of raw material:

The raw materials for the preparation of *kalari* and *chhurpi* were procured from the respective production areas. The field assistant visited the places and collected the milk and transported under refrigeration conditions to the pilot plant of the Department of Food science and Technology.

Activity 1.2 Experimental designing for the reparation of cheeses:

The research team designed the experiments for the standardization process of the traditional cheeses using the RSM software.

Activity 1.3 Processing of cheese:

The 30 experimental trials designed by RSM software were followed for the production of cheese. The research team performed the experimental trials designed by RSM in the pilot plant of the department.

Activity 2.1 Compositional, structural and textural analysis:

The proximate composition of the optimized cheese produced was evaluated for fat, moisture, protein, ash, pH, water activity by using the standard method of AOAC. Structural analysis was performed using FTIR spectroscopy. Textural analysis was carried out using texture analyzer.

Activity 2.2 Sensory evaluation:

Penal of selected Judges carried out the sensory evaluation of each of the trial in terms of the physical appearance and palatability

Activity 3.1 Value addition of *chhurpi* and kradi:

The cheese such as *chhurpi* and *kradi* were fortified by using different concentrations of sea buckthorn and saffron. The research team evaluated the developed products for physicochemical, structural and nutraceutical properties.

Activity 3.2 Extraction of phenolic compounds from pine needles:

Grinding the pine needles and soaking them in lukewarm water for 24 hours will prepare pine needle extracts. The pine needles were collected and grinded by field assistant. The extraction protocol were followed by the recruited manpower specialized in the field. The water from the extract was removed by keeping the solution under sunshade.

Activity 3.3 Preparation of bee wax with added pine needle extracts:

The collected extract was added to molten bee wax and the traditional cheeses were dipped into the bee wax containing pine needle extract

Activity 3.4 Evaluation of antioxidant and antimicrobial activity of the edible coating:

The quality evaluation of packaging film was done. The antioxidant activity of the edible coating was also evaluated using different antioxidant assays like DPPH radical scavenging activity, lipid peroxidation inhibition activity, metal chelating ability, etc. The experimental work was performed by the recruited manpower under the supervision of the proponents

Activity 3.5 Quality evaluation of the edible-coated cheeses:

The shelf life of coated cheese was determined by the microbiological analysis and oxidation of the proteins and fat present in the cheese. The experimental helped in determining the shelf life of the products when coated with the active edible coating.

Activity 4.1 Organization of workshops and training programs:

The workshops/training programs were conducted in the areas of Jammu, Kashmir and Ladakh where the involvement of the people for production of these traditional products is vast. The proponents, associated and recruited staff, organized the training programs.

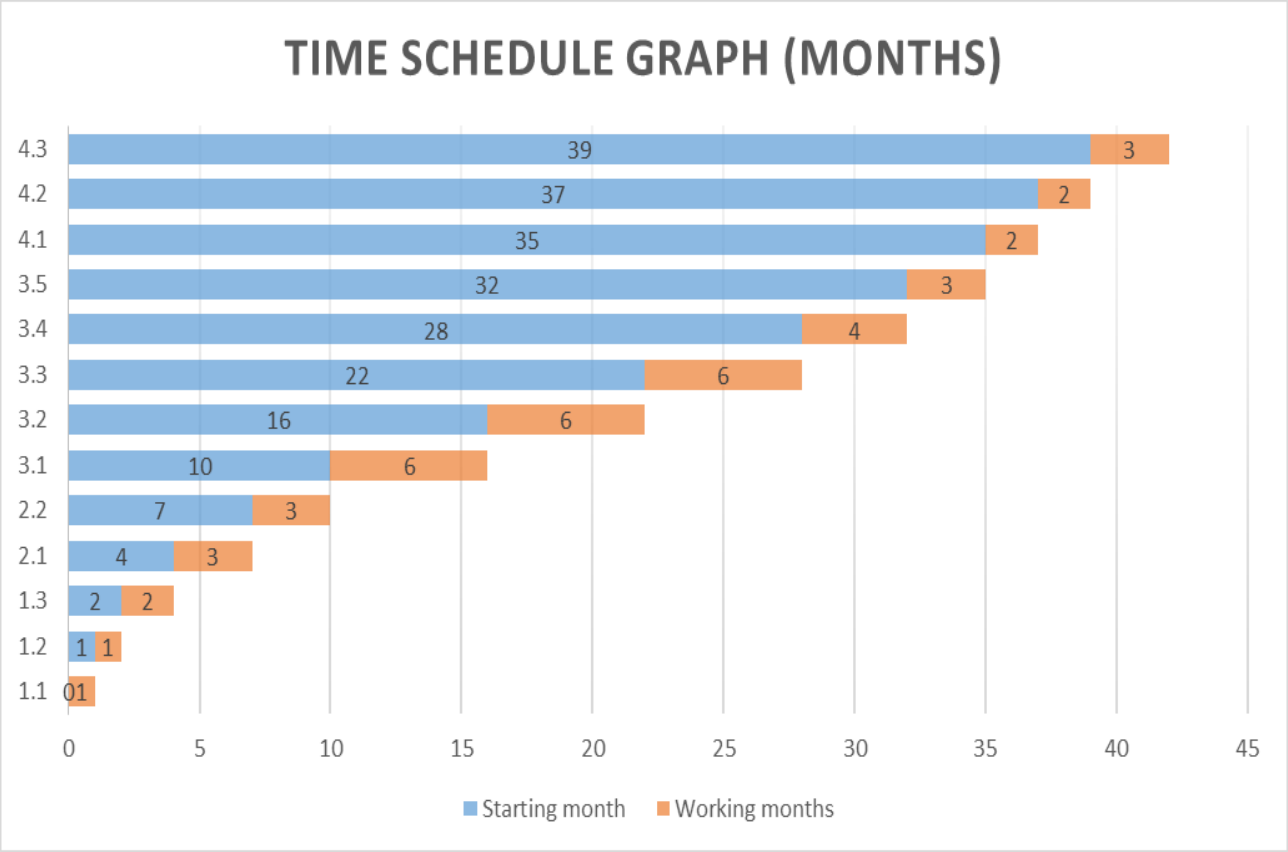
Activity 4.2 Demonstration of the developed and mechanized process:

The mechanized and standardized process was demonstrated to the stakeholders by visiting their places and communicating to them. Each of the places where kalari, and churpi are made were visited and demonstration of the standard mechanization process was given. The visiting places included Udhampur, Rajouri, Poonch, Shopian, Kulgam, Bandipora, Pahalgam, Leh, Kargil, etc.

Activity 4.3 Demonstration of the development of the edible coating:

The process for the development of the edible coating to extend shelf life of these traditional products was demonstrated to the stakeholders. The available resources in the Himalayan belt were exploited for the development of the coating material. Pine needles and bee wax were used for the production of coating with bioactivity

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



4 KEY FINDINGS AND RESULTS

4.1 Major Research Findings (max. 1000 words)

Characterization and value addition of the dried cheese (Chhurpi) was done by fortifying it with different concentrations of sea buckthorn leaves. Different concentrations of the sea buckthorn leaf powder (1.5, 2.5 and 3.5%) were added to chhurpi samples. The physicochemical, antioxidant,

antidiabetic and sensory properties of the Chhurpi samples enriched with sea buckthorn leaves were evaluated. Antioxidant properties were evaluated by using different assays such as DPPH radical scavenging assay, reducing power and inhibition of lipid peroxidation. Total phenolic content was also determined. The antidiabetic activity was determined by measuring the inhibitory activity of enriched chhurpi samples against α-glucosidase. The results revealed that addition of SBL chhurpi significantly changed its color and texture. The total flavonoids and total phenolics of the chhurpi samples also increased significantly. Enriched chhurpi showed increased anti-obesity, anti-diabetic and anti-proliferative properties. The organoleptic characteristics of enriched chhurpi were modified considerably. HPLC analysis confirmed the presence of phenolics (gallic acid, ferulic acid and vanillic acid) and flavonoid compounds (quercetin, kaempferol and isorhamnetin) in SBL.

In another study the effect of saffron addition on the physicochemical, antioxidant and sensory properties of kradi cheese was evaluated. The saffron was added at different concentrations (25 mg, 50 mg, 75 mg and 100 mg). A control without addition of saffron was also taken. The parameters which were evaluated include, proximate composition, color, texture, antioxidant activity and anti-obesity activity anticancer and antidiabetic properties. The product was analyzed for physicochemical, antioxidant and medicinal properties. The HPLC analysis revealed that kradi had the highest crocin content than the safranal content Total phenolic content and antioxidant activity of enriched kradi were highly improved due to the presence of saffron secondary metabolites. The enriched kradi had desirable organoleptic properties compared to the control.

The mechanization of the process has also been carried by designing the prototype for the products. Kradi is a cheese produced by the Gujjar tribes of the Himalayan region. The specialty of the cheese is that it is low in fat content and it also has the potential as the Indian substitute for mozzarella cheese. The main problems in making this cheese are that, it is highly time-consuming, and as of now, the process is not standardized for industrial production. The electricity-powered kradi making machine designed mimics the artisan cheese making process in a scientific way to improve the efficiency and decrease the time consumed of the cheese making process itself. The machine does pasteurization, incubation and churning in the same chamber itself so that the machine is portable and can be used by the tribal people and as a household appliance. The machine can operate with a minimum of 5 L to a maximum of 10 L of milk. The milk chamber is indirectly heated using a water jacket, which is heated using an immiscible heating element placed at the bottom of the water jacket. A thermocouple is placed in the chamber to determine the temperature of the water jacket so that the temperature of the milk, for pasteurization and incubation can be determined and controlled using the temperature controller. The pasteurization time can be determined based on the set temperature. The next stage will be incubation at a lower temperature, for which the temperature of the milk should be reduced. To reduce the temperature, the water jacket can be circulated with cold water by letting cold water enter through the ‘water in’ valve, which has the inlet to the bottom of the chamber. Hot water tends to raise, and the comparatively colder water settles down, so when cold water hits the bottom of the water jacket, the hot

water raises up and exits the chamber through the 'water out' valve. The continuous circulation of cold water at a low flow rate will reduce the temperature of the milk chamber to reduce the temperature to the required, for incubation. Then the temperature settings can be altered in the controller to suit the incubation temperature. Especially for kradi cheese, the butter must be removed before going for coagulation. Thus, the churner coupled with the motor placed over the lid of the chamber is used to churn the fermented milk till the butter floats to the surface. Pulse width modulation-based speed controller is used to regulate the speed, and two solid-state relays and a programmable logic controller is used to change the direction of rotation of agitation. The butter is manually removed, then the coagulant can be added to the buttermilk present in the chamber, and the temperature can be adjusted based on the necessity for incubation. Then the coagulated material is drained, and cheese is prepared. This is the operation of the first prototype manufactured. The material used in this prototype is food grade stainless steel and the entire setup is insulated using glass wool and covered with cladding, to avoid heat loss and decrease energy consumption. The first prototype of the equipment is tested. The cheese produced using the machine had the same properties and better quality than the artisan cheese, produced by the local people involved in cheese making. Drawbacks like high weight and complexity in control were observed. As the next step, a low weight material will be used to build the machine's body, to reduce weight. Using the data collected during standardization of process with the first prototype, a time-temperature control and alarm will be added to the system when developing the cheese making equipment for commercialization.

Currently, there is no complete cheese making machine in the market. Appliances like water kettle and churner are separately available, but temperature control and other standards for cheese making or kradi making is non-existent. In this machine, the entire cheese-making process is carried out in a single process. The machine is compact, any type of cheese can be made with minor adjustments, has the potential to be used as an incubator or pasteurizer alone, and can be used for butter making.

4.2 Key Results (max 1000 words in bullets covering all activities)

The major change that was observed in the kradi and chhurpi samples after the addition of sea buckthorn leaves and saffron was the improvement in their nutraceutical potential. In addition the color of the products was significantly changed and was more attractive as confirmed by carrying the sensory analysis of the developed products. Moreover, the total flavonoids and total phenolic contents were significantly increased after fortification as compared to control. Antioxidant properties were also highly enhanced. The kradi and chhurpi samples showed considerable anti-diabetic, anti-obesity and anti-proliferative properties after enrichment with sea buckthorn leaves and saffron. Thus, the fortification of traditional dairy products like kradi and chhurpi or other milk-based fermented foods with saffron and sea buckthorn leaves can be done to develop functional foods with health promoting properties which may be consumed during long harsh winters, by the people living in colder regions of the world. Furthermore, the developed products may have increased shelf-life with desirable organoleptic properties. It is an important approach to the diversity of traditional fermented milk products like chhurpi, kudan and kradi.

The mechanization of the processes increased the production rate, decreased the labour and time, thereby decreasing the overall production cost of the products.

4.3 Conclusion of the study

Thirty experimental runs according to the CCRD were carried out to study the effect of independent variables on the responses taken in chhurpi preparation. The independent variables showed varying effects on the dependent variables (responses). By using the RSM, optimum values of inoculum concentration 35 g, incubation time 9.85 h, incubation temperature 29.76 °C and drying time 26.05 h for chhurpi preparation were derived in order to obtain the product with optimum yield and desirable organoleptic properties.

The results revealed that the addition of different levels of saffron to the traditional milk product kradi significantly modified its physiochemical, sensory, antioxidant and medicinal properties. The antioxidant properties of the kradi were highly enhanced as compared to the control. Further, the medicinal properties were also significantly improved after the addition of saffron. Thus, saffron can be used as a source of bioactive ingredients for the development of novel functional dairy products with health-promoting properties. In addition, the organoleptic characteristics can also be improved to some extent by fortifying kradi cheese with saffron due to its distinctive flavour and aroma.

Addition of PPE into zein for the development of active packaging resulted in improved functional properties of the film. FTIR analysis showed the possible interactions between PPE polyphenols and zein. Presence of considerable amount of polyphenols in films was responsible for exhibition of wide range of antioxidant and antimicrobial activity. The fruit wastes including pomegranate peel should be considered as low-cost potential ingredients for active packaging industry which otherwise has no other applicability in any form. Film developed has promising role in cheese industry as antimicrobial and antioxidant packaging material to ensure food safety.

The study also explored the use of beeswax and PNE for the enhancement of the self-life and nutraceutical potential of the Himalayan cheese, kradi. The DPPH, metal chelating, alpha-amylase inhibition and antibacterial potential of the coatings increased with the increase in PNE concentration. However, in terms of taste and flavour the panellists marked low scores. Overall, the coatings have a tremendous nutraceutical and self-life characteristics, which could outweigh the negative implications of off odours and characteristic tastes of PNE and beeswax. The designed coatings have great potential to be used in the cheese making industry activity.

The major change that was observed in the chhurpi samples after the addition of SBL was the change in its color and texture. Antioxidant properties were also highly enhanced. The chhurpi samples showed considerable anti-diabetic, anti-obesity and anti-proliferative properties after enrichment with the SBL. It can be concluded from the study that enrichment of chhurpi with SBL or other milk-based fermented foods can be done to develop functional foods with health promoting properties which may be consumed during long harsh winters, by the people living in colder regions of the world,. Furthermore, the

developed products may have increased shelf-life with desirable organoleptic properties. It is an important approach to the diversity of traditional fermented milk products like chhurpi, kudan and kradi.

5 OVERALL ACHIEVEMENTS

5.1 Achievement on Project Objectives [Defining contribution of deliverables in overall Mission (max. 1000 words)]

The process of optimization was successfully carried and the process parameters including incubation time, incubation temperature, inoculum concentration and drying time were obtained in order to produce a traditional cheese with optimum quality and yield. A paper was published on this in the Journal of Applied Food Research. Moreover, the process of the production of the traditional cheese (*chhurpi* and *Kradi*) was mechanised by designing a prototype. The mechanization of the processes increased the production rate, decreased the labour and time, thereby decreasing the overall production cost of the products. An Indian patent of the designed prototype has been filed.

For value addition the cheese including *kradi* and *chhurpi* were fortified with sea buckthorn and saffron. The fortified cheese had significantly high antioxidant and nutraceutical properties as compared to their respective controls. The sensory properties of the fortified products were comparable with the control. Thus, saffron and sea buckthorn can be used as a source of bioactive compounds for enhancing the nutritional as well as nutraceutical potential of cheese thereby increasing the demand of these products in the Indian and International market.

Further, packaging films loaded with bioactive components were prepared for these traditional cheese products so that their storage life can be improved. It was observed that the packaging films significantly inhibited the growth of some harmful microbes and showed prominent antioxidant potential. The designed coatings have great potential to be used in the cheese making industry activity.

In addition, the training programs were successfully conducted wherein the tribal people especially women were given training regarding the mechanised production of cheese. Also, the tribal people were enlightened with the health benefits associated with the wild sea buckthorn, Bee wax, pine needles etc.

5.2 Establishing New Database/Appending new data over the Baseline Data (max. 1500 words, in bullet points)

NA

5.3 Generating Model Predictions for different variables (if any) (max 1000 words in bullets

NA

5.4 Technological Intervention (max 1000 words)

The traditional cheese products such as kradi and chhurpi are rich source of proteins, bioactive peptides and probiotic microorganisms. The mechanised production of these products under clean and hygienic conditions using standard methods will fetch a premium price after proper marketing in high income markets. The consumers mainly prefer non-price critical success factors like hygiene, organic production and health promoting foods. The producers of these products i.e. tribal people especially women are unaware of these aspects and thus these stakeholders were provided the developed

scientific processing techniques and communicated about the benefits associated with standard mechanised processing and other aspects.

5.5 On field Demonstration and Value-addition of Products (max. 1000 words, in bullet points)

The mechanized and standardized process was demonstrated to the stakeholders by visiting their places and communicating to them. Each of the places where kalari, and churpi are made were visited and demonstration of the standard mechanization process was given. The visiting places included Udhampur, Rajouri, Poonch, Shopian, Kulgam, Bandipora, Pahalgam, Leh, Kargil, etc. The people were made aware of the health benefits associated with these products. In addition, the knowledge about the fortification of these products using different local herbs, plant parts etc. was shared for value addition of these products.

5.6 Promoting Entrepreneurship in IHR

The tribal people particularly women, are actively involved in the production of traditional cheese. These cheese are then supplied to the local shops and are sold within two to three days after production as their shelf life is limited to 2-3 days. The use of standard mechanised production of these products will reduce the time, labour and overall cost of the product. Thus, the production of these cheese will increase thereby increasing the source of income for the tribal population. The tribal people may use the designed equipment and set up a small scale plant for the production of these traditional cheese including *kradi* and *chhurpi.* In addition, the designed packaging material cab be to increase the storage life to these products to some extent.

5.7 Developing Green Skills in IHR

The people living in higher regions of J&K can make the use of local herbs for fortification of different locally produced food products. This will not only improve the health of consumers but also promote the consumption of these traditional products and medicinal herbs and plants.

5.8 Addressing Cross-cutting Issues (max. 500 words, in bullet points)

NA

6 PROJECT'S IMPACTS IN IHR

6.1 Socio-Economic Development (max. 500 words, in bullet points)

- The tribal people involved in the production of traditional cheese were given demonstration of standardized process, packaging and storage so that they can earn their living without depending on the opposite gender.
- The mechanization of these products will reduce the labour, time and cost of production thereby increasing the production of these products.

6.2 Scientific Management of Natural Resources In IHR (max. 500 words, in bullet points).

NA

6.3 Conservation of Biodiversity in IHR (max. 500 words, in bullet points)

NA

6.4 Protection of Environment (max. 500 words, in bullet points)

NA

6.5 Developing Mountain Infrastructures (max. 500 words, in bullet points)

NA

6.6 Strengthening Networking in IHR (max. 700 words, in bullet points)

NA

7 EXIT STRATEGY AND SUSTAINABILITY

7.1 How effectively the project findings could be utilized for the sustainable development of IHR (max. 1000 words)

The people living in higher regions of J&K particularly Gujjar and Bakarwals are mainly involved in the production of traditional cheese including *kradi* and *chhurpi* which are by-products of butter. These people usually consume these products during large harsh winters to fulfil their nutritional requirements as there is shortage of food in winters and the regions remain cut from the main city due to heavy snowfall. The standard procedure developed will help in increasing the yield of these products. Moreover, the mechanization of the process will reduce the cost, time and labour required to produce the products. In addition, the developed packaging material might increase the shelf-life of these products to some extent thereby minimising the spoilage of the products. Thus, the developed technology will not only improve the quality of these traditional cheese but also increase their production which will ultimately increase the source of income of the tribal people.

7.2 Efficient ways to replicate the outcomes of the project in other parts of IHR (Max 1000 words)

The standard procedure developed can be used by the people from other parts of IHR for producing traditional cheese. The demonstration regarding the standard procedure, prototype and packaging material should be given to the people living in other parts of IHR so that they can utilize the developed technology for the production of these traditional cheese.

7.3 Identify other important areas not covered under this study needs further attention (max 1000 words)

The designed porotypes should be distributed free to some regions and feedback regarding the same should be collected in order to make improvements in the machine. In addition, more packaging materials should be tested to enhance the shelf-life of the cheese as currently there is no such packaging material which could increase the shelf-life of fresh un-ripened cheese to 2-3 days.

7.4 Major recommendations for sustaining the outcome of the projects in future (500 words in bullets)

- Awareness programmes/training or workshops should held for the people living in higher regions of J&K and Ladakh and knowledge regarding the local available herbs or medicinal plants and traditional dairy products and their health benefits should be disseminated.

- The women who are actively involved in the process of traditional cheese development should be given frequent training regarding the new technologies and programmes developed for enhancing the quality, nutritional and nutraceutical potential of these products.

- The prototype designed for the standard mechanised production of traditional cheese should made available in the market at an affordable price so that the people of below poverty line can purchase it.

- The tribal people should be given training regarding the marketing of these traditional products.

8 REFERENCES/BIBLIOGRAPHY

9 ACKNOWLEDGEMENT

APPENDICES

Appendix 1 – Details of Technical Activities
Appendix 2 – Copies of Publications duly Acknowledging the Grant/ Fund Support of NMHS
Appendix 3 – List of Trainings/ Workshops/ Seminars with details of trained resources and dissemination material and Proceedings
Appendix 4 – List of New Products (utilizing the local produce like NTFPs, wild edibles, bamboo, etc.)
Appendix 5 – Copies of the Manual of Standard Operating Procedures (SOPs) developed
Appendix 6 – Details of Technology Developed/ Patents filled
Appendix 7 – Any other (specify)

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Annexure-I

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

For the Period: 01-04-2018 to 31-12-2021

1.	Title of the project/Scheme/Programme:	**Technological Interventions and their application for sustainable Livelihood of Women Folk Involved in the production of various Milk-based fermented foods of Himalayan bet of J&K.**
2.	Name of the Principle Investigator & Organization:	**Dr. Adil Gani, Dept. 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 the Project:	**GBPNI/NMHS-2017-18/SG-19 Dated: 28.03.2018**
4	Amount brought forward from the previous financial year, quoting the NMHS-PMU, G.B. Pant National Institute of Himalayan Environment, Kosi-Katarmal, Almora, Uttarakhand, Letter No. and Date on which the authority to carry forward the amount was given	**Nil**
5.	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. 41,69,015.00** GBPNI/NMHS-2017-18/SG-19 Dated: 28.08.2018 Dated: 28-09-2020 Dated: 25-10-2021
6.	Total amount that was available for expenditure (Including commitments) incurred during the project period:	**Rs. 41,69,015.00**
7.	Actual expenditure (excluding commitments) incurred during the project period:	**Rs43,57,345.00**
8.	Unspent Balance amount refunded, if any (Please give details of Cheque no. etc.):	**Nil**
9.	Balance amount available at the end of the project:	**Rs. (-)1,88,330.00**
10.	Balance Amount:	**Rs. (-) 57,269.00**
11.	Accrued bank Interest:	**Rs. 1,31,061.00**

Certified that the expenditure of **Rs. 43,57,345.00 (Rupees Forty three lakh fifty seven thousand three hundred forty five only)** mentioned against Sr. No. 6 was actually incurred on the project/scheme for the purpose it was sanctioned.

Date:

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

OUR REF. No.

ACCEPTED AND COUNTERSIGNED

Date:

COMPETENT AUTHORITY
NATIONAL MISSION ON HIMALAYAN STUDIES (GBP NIHE)

Statement of Consolidated Expenditure

[Institution Name here]

Statement showing the expenditure of the period from 01-04-2018 to 31-12-2021
Sanction No. and Date : **GBPNI/NMHS-2017-18/SG-19; Dated: 28.03.2018**
1. Total outlay of the project : Rs. 4,900,000.00
2. Date of Start of the Project : 01-April-2018
3. Duration : 3 Years (Three Years) +09 Months Extension
4. Date of Completion : 31-December-2021
a) Amount received during the project period : Rs. 41,69,015.00
b) Interest earned / accrued during the period : : Rs. 1,31,061.00
c) Total amount available for Expenditure : **Rs. 43,00,076.00**

S.No.	Budget head	Amount Carried forward	Amount received during the year	Other receipts/ interest earned	Amount received + Amount Carried Forward+Interest earned	Actual Expenditure Incurred	Committed Expenditure	Total Expenditure	Amount Balance / Excess Expenditure
I	II	III	IV	V	VI=(III+IV+V)	VII	VIII	IX=VII+VIII	X=(VI-IX)
1	Salaries	₹ 0.00	₹ 13,72,879.00		₹ 13,72,879.00	₹ 13,72,720.00	₹ 46,400.00	₹ 14,19,120.00	-₹ 46,241.00
2	Permanent Equipment	₹ 0.00	₹ 12,62,000.00		₹ 12,62,000.00	₹ 12,58,825.00	₹ 0.00	₹ 12,58,825.00	₹ 3,175.00
3	Consumables	₹ 0.00	₹ 6,65,206.00		₹ 7,80,000.00	₹ 7,76,981.00	₹ 23,840.00	₹ 8,00,821.00	-₹ 20,821.00
4	Contingency	₹ 0.00	₹ 2,07,000.00		₹ 2,07,000.00	₹ 2,07,000.00	₹ 5,000.00	₹ 2,12,000.00	-₹ 5,000.00
5	Travel	₹ 0.00	₹ 2,44,450.00		₹ 2,44,450.00	₹ 2,42,125.00	₹ 0.00	₹ 2,42,125.00	₹ 2,325.00
6	Activities & Other project cost	₹ 0.00	₹ 2,17,480.00		₹ 2,17,480.00	₹ 2,17,280.00	₹ 7,174.00	₹ 2,24,454.00	-₹ 6,974.00
7	Overhead	₹ 0.00	₹ 2,00,000.00		₹ 2,00,000.00	₹ 2,00,000.00	₹ 0.00	₹ 2,00,000.00	₹ 0.00
8	Accrued bank Interest	₹ 0.00	₹ 0.00	₹ 1,31,061.00	₹ 16,267.00	₹ 0.00	₹ 0.00	₹ 0.00	₹ 16,267.00
9	**Total**	**₹ 0.00**	**₹ 41,69,015.00**	**₹ 1,31,061.00**	**₹ 43,00,076.00**	**₹ 42,74,931.00**	**₹ 82,414.00**	**₹ 43,57,345.00**	**-₹ 57,269.00**

Note : An amount of Rs. 1,31,061/- earned/accrued as interest from bank during the F.Y'S (2018-19 Rs.13,285/-, 2019-20 Rs.54,049/-, 2020-21 Rs. 47,460/- & 2021-22 upto Dec 21 Rs. 16,267/- out of that Rs.1,14,794 has been adjusted in consumables head vide order GBPNI/NMHS-2017-18/SG-19/618/326/138/21/166 Dated 28.09.2020,Dated 25.10.2021.

Certified that the expenditure of **Rs. 43,57,345.00 (Rupees Forty three lakh fifty seven thousand three hundred forty five only)** mentioned against Sr. No.12 was actually incurred on the project/ scheme for the purpose it was sanctioned.

Date:

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

OUR REF. No.

ACCEPTED AND COUNTERSIGNED

Date:

COMPETENT AUTHORITY
NATIONAL MISSION ON HIMALYAN STUDIES (GBP NIHE)

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: NMHS-PMU, G.B. Pant National Institute of Himalayan Environment, Kosi-Katarmal, Almora, Uttarakhand.

Sl. No. _____

1. Name of Grantee Institution: Department of Food Science and Technology, University of Kashmir
2. No. & Date of sanction order: GBPNI/NMHS-2017-18/SG-19; Dated: 28.03.2018
3. Amount of the Sanctioned Grant: Rs. 49,00,000
4. Brief Purpose of the Grant: Research Purpose
5. 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
6. Particulars of assets actually credited or acquired Lyovapor L-200 Freeze Dryer, Milk Homogenizer A1HO10 and Cream churner
7. Value of the assets as on: Rs. 12,58,825.00
8. Purpose for which utilised at present Research Purpose
9. Encumbered or not: NA
10. Reasons, if encumbered: NA
11. Disposed of or not: NA
12. Reasons and authority, if any, for disposal: NA
13. Amount realized on disposal: NA
14. Any Other Remarks: NA

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

(Signed and Stamped) **(Signed and Stamped)**

(HEAD OF THE INSTITUTION)

(Signed and Stamped)

Annexure-IV

List or Inventory of Assets/ Equipment/ Peripherals

S. No.	Name of Equipment	Quantity	Sanctioned Cost	Actual Purchased Cost	Purchase Details
1.	Lyovapor L-200 Freeze Dryer,	01	Rs. 12,62,000.00	1122000	Purchased from Buchi Labortechnik AG, CH-9230, Flawil, Switzerland, through E-tendering
2.	Milk Homogenizer A1HO10	01		129380 INR	Purchased from M/S Agro Care Technologies India Private Limited, Mahjoor Nagar, through E-tendering
3.	Cream churner	01		10620 INR	Purchased from M/S Agro Care Technologies India Private Limited, Mahjoor Nagar, through E-tendering

(PROJECT INVESTIGATOR)

(Signed and Stamped)

(FINANCE OFFICER)

(Signed and Stamped)

(HEAD OF THE INSTITUTION)

(Signed and Stamped)

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 "...." 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. Lyovapor L-200 Freeze Dryer,
2 Milk Homogenizer A1HO10
3. Cream churner.

Head of Implementing Organization: Dean Research
Name of the Implementing Organization: University of Kashmir
Stamp/ Seal:
Date: 28-11-2022

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.

Kindly note the further Bank A/c Details as follows:

Name of NMHS A/c:	NMHS GIA General
Bank Name & Branch:	Central Bank of India (CBI), Kosi Bazar, Almora, Uttarakhand 263643
IFSC Code:	CBIN0281528
Account No.:	3530505520 (Saving A/c)

In case of any queries/ clarifications, please contact the NMHS-PMU at e-mail: nmhspmu2016@gmail.com