FOR OFFICIAL USE ONLY
JAU/CAET/PFE/PHET/2023/1

AICRP ON POST - HARVEST ENGINEERING AND TECHNOLOGY

JUNAGADH CENTRE

ANNUAL REPORT

(2021-2022)

PEANUT SAUCE

AICRP ON POST - HARVEST ENGINEERING AND TECHNOLOGY
COLLEGE OF AGRICULTURAL ENGINEERING & TECHNOLOGY
JUNAGADH AGRICULTURAL UNIVERSITY
JUNAGADH – 362 001 (GUJARAT)

OFFICIAL USE ONLY

ANNUAL REPORT
2021- 2022

ALL INDIA COORDINATED RESEARCH PROJECT (ICAR)

ON

POST-HARVEST ENGINEERING AND TECHNOLOGY

JUNAGADH CENTRE

To be presented
at
ICAR-Central Plantation Crop Research Institute,
Kudlu, P. O. Kasaragod-671124, Kerala

During
20-22 February, 2023

AICRP on Post-Harvest Engineering and Technology
Department of Processing and Food Engineering
College of Agricultural Engineering & Technology
Junagadh Agricultural University
JUNAGADH – 362001

FOREWORD

Post-harvest engineering and technology is the one of the mechanism for processing of agricultural products. This starts are after harvesting of grains as well as fruits and vegetables. This consequences for rduction of post-harvest losses, enhancement in nourishment to the products. Employment generation villages through storage and processing of farmers' products, reduce poverty and encourage development of other related economic sectors.

The Junagadh centre added effectively processing of groundnut by establishing agro processing centres, storage of groundnut pods and kernels. Utilization of groundnut for other product is also important. In view of the shortage of capital, an arrangement of custom hiring service facility was provided to the farmers in meeting the requirements for onion storage. These findings of research work became useful to farmers, industries and entrepreneurs.

As per the necessity of this state, this centre has worked regularly and cutting-edge technologies related to feed block making machine, solar dryer cum green house, peanut butter, coriander dhal milling process, vacuum packaging of mangoes, storage technique for coriander and wheat (seed), onion storage structures, sapota cleaner, pectin extraction, enzyme extraction, spice processing etc. for the benefit of farmers and processing industries. However, in view of the recent trends, still much remains to be done for value addition to groundnut, spices and onion. This centre has space for laboratory work, office room, analytical facilities, etc., but due do continuous expansion and with a view to impart training and accommodate precious and sensitive instruments / equipments purchased/developed so far, this centre need a separate building / space for better sitting and laboratory arrangements, for which necessary efforts are being made to fulfill the same at university level.

The financial assistance delivered by the ICAR under the AICRP on Post-Harvest Engineering and Technology is appreciatively admitted. I am sure the Junagadh centre will provide significantly to fulfill the requirement of the agro processing industries and the life prosperous of the farmers of the state.

13 February, 2023
Junagadh

(N. K. Gontia)
Principal & Dean
College of Agril.Engg.& Technology
JAU, Junagadh

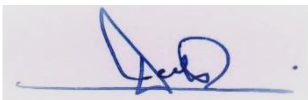
ACKNOWLEDGEMENT

All India ICAR Co-ordinated Research Project on Post-harvest Engineering and Technology is functioning at Junagadh Agricultural University, Junagadh since 1980. This report is the concern of true efforts and hard work of concerned research scientists. Value addition and post-harvest technology are accepted as needful section liable for welfare of the farmers.

The All India Coordinated Research Project on Post-Harvest Engineering and Technology staff wish to convey their sincere acknowledgements to Dr. V. P. Chovatiya, Vice Chancellor Junagadh Agricultural University, Junagadh; for their highly support in the activities of the scheme. We here by definite our solemn thanks to Dr. H. M. Gajipara, Director of Research, for able monitoring of the scheme work and Sh. S. K. Jethani, Comptroller Junagadh Agricultural University, Junagadh for undertaking financial matters promptly. We hereby affirmative our honest thanks to Dr. N. K. Gontia, Principal & Dean, College of Agricultural Engineering & Technology, Junagadh for able nurturing of the scheme work.

The staff members of the scheme pleasingly discriminate the financial assistance received by ICAR to run the scheme absolutely. The constructive approach and esteemed remark of Dr. S. N. Jha, Deputy Director General (Engineering) and Dr. K. Narsaih, Assistant Director General (PE) ICAR, New Delhi are gratefully recognized. We express our most earnest thanks to Dr. S. K. Tyagi, Project Coordinator, AICRP on Post-Harvest Engineering and Technology, Central Institute of Post-Harvest Engineering & Technology, Ludhiana for their inspiring direction, harmonization as well as their keen attentiveness in the activities of the scheme.

We are also thankful to all the staff members of the Department of Processing and Food Engineering for their support and taking due interest in the activities of the scheme work.



January 13, 2023
Junagadh

(M. N. Dabhi)
Research Engineer
for Scheme Staff

C O N T E N T S

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

ALL INDIA CO-ORDINATED RESEARCH PROJECT (ICAR)

ON

POST HARVEST ENGINEERING AND TECHNOLOGY SCHEME
JUNAGADH AGRICULTURAL UNIVERSITY

JUNAGADH CENTRE

GENERAL INFORMATION

1.	**Title of the scheme**	:	All India Co-ordinated Research Project (ICAR) on Post Harvest Engineering and Technology
2.	**ICAR sanction No. & Date**	**:**	1(41)/PHT/2006/XI Plan/1010998, dtd. 21.3.2009 (PC letter No.)
3.	**Date of commencement**	**:**	April, 1980
4.	**Date of completion**	:	The scheme is sanctioned for the 12th Five Year Plan
5.	**Sanctioned grant for the Year 2020-2021 for which this report is presented**	:	Rs**. 99,83,510**/- (ICAR+State)

6. Staff position in the scheme

Sr. No.	Designation	No. of posts			Name of the incumbent	Present Scale of pay	Date of joining / vacant
		S	F	V			
1.	Research Engineer	1	1	-	Dr. M. N. Dabhi	131400-217100	01.09.2016
2.	Asstt. Bio-Chemist	1	1	-	Vacant	57700-182400	31.03.2022
3.	Asstt. Entomologist	1	1	-	Prof. D. V. Khanpara	131400-217100	16.06.1922
4.	Asstt. Food Microbiologist	1	1	-	Prof. A.M. Joshi	68900-205500	18.02.2009
5.	Asstt. Res. Engineer (ASPE)	1	1	-	Prof. P. R. Davara	68900-205500	01.01.2011
6.	Asstt. Process Engr. (Testing & Eva.)	1	-	1	Vacant	57700-182400	23.07.2020
7.	Senior Tech. Asstt.	1	1	-	Er. H. R. Sojaliya	39900-126600	14.02.2012
8.	Investigator	1	1	-	Er. B. A. Karangiya	38090 (fixed)	08.06.2022
9.	Draftman (Mech.)	1	1	-	Shri R. V. Bokhiriya	31340 (fixed)	01.01.2021
10.	Craftman-I (Welder)	1	1	-	Shri V. S. Kava	25500-81100	01.11.2014
11.	Craftman-II (Fitter)	1	1	-	Shri N. V. Vora	19900-63200	28.12.2008
12.	Craftman-III (Tinsmith)	1	-	1	Vacant	19900-63200	1.07.2016
13.	Senior Mechanic	1	1	-	Shri A. P. Zezariya	29200-92300	26.07.2018

7. Expenditure Statement for the year 2021-2022 (Upto March, 2022)

Head-wise breakup of Receipts, Expenditure and Closing Balances for the financial year 2021-22 (ICAR share)
Period : 01-04-2021 to 31-03-2022

Sr. No.	Budget Head	Opening balance as on 01-04-2021 Rs.	Receipts during the previous years Rs.	Total opening balance as on 01-04-2021 Rs. (3+4)	Grant received during the year 2021-22 Rs.	Revalidated amount of Unspent Balances of 2020-21, Rs.	Total grant Rs. (6+7)	Expenditure incurred for the councils share during the year 2021-22 Rs.	Closing balance at the end of the year 2021-22 as on 31-03-2022 Rs. (6-7)
1	2	3	4	5	6	7	8	9	10
1	Pay and Allowances	16,74,465.00	94,00,000.00	--	1,10,74,465.00	93,92,710.50	16,74,465.00	7,289.50	16,74,465.00
2	Travelling Allowance	3,19,210.00	20,000.00	--	3,39,210.00	-	3,19,210.00	20,000.00	3,19,210.00
3	Recurring Contingencies (Including HRD)	1,91,247.00	11,00,000.00	--	12,91,247.00	5,61,204.75	1,91,247.00	5,38,795.25	1,91,247.00
4	Non recurring contingencies	1,42,137.81	5,00,000.00	--	6,42,137.81	85,875.00	1,42,138.00	4,14,124.81	1,42,137.81
	Total, Rs.	**23,27,059.81**	**1,10,20,000.00**	--	**1,33,47,059.81**	**1,00,39,790.25**	**23,27,060.00**	**9,80,209.56**	**23,27,059.81**

8. Technical Programme

Sr.No.	Code No.	Title
1	PH/JU/85/1	Establishment of Agro Processing Centre training and demonstration of technologies (Operational research project on Agro Processing Centres)
4	PH/JU/2020/01	Standardization of process technology for preparation of peanut sauce and peanut wadi (Chunks).
5	PH/JU/2022/01	Processing of green tender sorghum.
6	New Investigation - I	Optimization of process parameters for protein extraction from peanut through fermentation.
7	New Investigation - II	Development of peanut based extruded product suitable for fasting
8	New Investigation - III	Management of insect pest of storage wheat in bin by ozone.

Investigation No. : 1

1.1 Scheme code No. : PH/JU/85/1

1.2 Title of Investigation: Establishment of Agro Processing Centre training and demonstration of technologies (Operational research project on Agro Processing Centres)

1.3 Name of Investigators: 1. Dr. M. N. Dabhi
2. Prof. P. R. Davara

1.4 Objectives

1. Survey of selected villages to identify the available agro-processing equipment.
2. To transfer the developed and improved agro-processing equipment to the selected village to give value added product.
3. To evaluate the techno-economic feasibility of the agro-processing centre.

1.5 Justification

Migration from the village to the cities not only disturbs the rural based economy but also causes a saturated and explosive urban population growth. The dire need of the hour is to prevent this migratory trend from villages to cities, so as to increase the activities concerned with farming thereby increase food production. This could be prevented by stabilizing industries in the proximity of the source of raw materials or near the vicinity of consumption catchment's area to avoid higher transportation cost. This will help the village to become self-sufficient in production, processing and consumption of raw materials produce by them. More job opportunities would also be created, resulting in more income generation.

1.6 Date of start: April - 2012

1.7 Date of completion: Continue

1.8 Past Work done

Major equipment installed at agro processing centres were used for their operational work. In this period, oil milling, spice milling, groundnut decorticating, groundnut threshing, cleaning and grading of wheat were taken up. The detailed operational performance data and expenditure incurred, income obtained along with profit / loss were determined.

1.9 Progress of work

Agro processing centers were visited for monitoring the progress made by the centers. Loej, Virol, and Tadka pipaliya centre has also deposited installment for the year 2020-21. The detailed operational performance data and expenditure incurred, income obtained along with profit / loss were determined and presented in Table: 1.1.

Table 1.1 : Operational performance and income from the processed products

S. N.	Activities	Raw material processed (kg)	Finished material produced (kg)	Expenditure incurred (Rs.)	Income (Rs.)	Net income (Rs.)
	Tadaka Pipaliya Agro Processing Centre					
1	Oil milling (groundnut)	75300 kg	-	188250 (@ 2.5 Rs./kg.)	376500 (@ 5Rs./kg.)	188250
2	Cleaning and grading of wheat,	7200 kg	-	-	7200 (@ 1 Rs/kg.)	7200
3	Groundnut decortication (manually)	-	_	_	410 (@ 20Rs/day x 2 nos.)	410
4	Sesame processing	320 kg	-	9600	16800	9600
5	Groundnut threshing	-	-	-	36600 (@600Rs./hr; Total 61 hrs.)	36600
6	Pulse mill	450 kg	-	900	4500	3600
7	Spice milling	310 kg	-	620	3100	2480
	Loej Agro Processing Centre					
1	Oil milling (groundnut)	115000 kg	-	287500 (@ 2.5 Rs./kg.)	575000 (@ 5 Rs./kg.)	287500
2	Cleaning and grading of wheat,	3500 kg	-	-	3500 (@ 1Rs./kg.)	3500
	Virol Agro Processing Centre					
1	Oil milling (groundnut)	135000 kg	-	337500 (@ 2.5 Rs./kg.)	675000 (@ 5 Rs./kg.)	337500
2	Cleaning and grading of wheat,	4300kg	-	-	4300 (@ 1 Rs./kg.)	4300
3	Spice milling	1320 kg Chilly 307 kg turmeric 123 kg cumin Total 1750	-	5250	17500	12250
	Panchal Vikas Mandal, Chotila					
1.	Oil milling (groundnut)	7300 kg	-	18250 (@ 2.5 Rs./kg.)	36500 (@ 5Rs./kg.)	18250

1.10 Conclusion:

Agro Processing Centres are running very well for utilization of processing machinery and processing of farmers produce at village level.

1.11 Future plan of work

The experiment will be continued.

PROJECT – 1

Title : Value Chain on groundnut

ANNEXURE -VI

INDIAN COUNCIL OF AGRICULTURAL RESEARCH

CHECKLIST FOR SUBMISSION OF FINAL RESEARCH PROJECT REPORT (RPP-III)

(For Guidelines Refer ANNEXURE – XI (F))

1. Institute Project Code : PH/JU/2018/02
2. Investigators as approved in RPP-I, If any change attach IRC proceedings:

Principal Investigator	Co-PI
Dr. P. R. Davara	Prof. A. M. Joshi, Dr. M. N. Dabhi, Dr. P. J. Rathod

3. Any change in objectives and activities No
   (If yes, attach IRC proceedings)

1.	Date of Start & Date of Completion (Actual). If any extension granted enclose IRC proceedings		01-02-2020	31-01-2023
2.	Whether all objectives met		Yes	Yes
3.	All activities completed		Yes	Yes
4.	Salient achievements/major recommendations included		Yes	Yes
5.	Annual Progress Reports (RPP-II) submitted	1st Year	Yes	Yes
		2nd Year	Yes	Yes
6.	Reprint of each of publication attached		Yes	Yes
7.	Action for further pursuit of obtained results indicated		Yes	Yes
8.	Report presented in Divisional seminar (enclose proceedings & action taken report)		Yes	Yes
9.	Report presented in Institute seminar (enclose proceedings & action taken report)		Yes	Yes
10.	IRC number in which the project was adopted		IRC No:	
11.	Any other Information			

4. Signature:

P. R. Davara Principal Investigator	**Prof. A. M. Joshi** Co-PI	**M. N. Dabhi** Co-PI	**Dr. P. J. Rathod** Co-PI

HOD/PD/I/c.

ANNEXURE - VII

INDIAN COUNCIL OF AGRICULTURAL RESEARCH

FINAL RESEARCH PROJECT REPORT (RPP- III)

(For Guidelines Refer ANNEXURE – XI(G))

PROJECT REPORT (RPP- III)

1. Institute Project Code : PH/JU/2018/02
2. Project Title : Standardization of process technology for preparation of peanut sauce and peanut wadi (Chunks).
3. Key Words : Peanut, defatted peanut, peanut sauce, peanut wadi,
4. (a) Name of the Lead Institute : College of Agril. Engg. & Technology
(b) Name of Division/ Regional Center/ Section : AICRP on PHT, Junagadh
5. (a) Name of the Collaborating Institute(s) : -
(b) Name of Division/ Regional Center/ Section of Collaborating Institute(s) : -
6. Project Team(Name(s) and designation of PI, CC-PI and all project Co-PIs, with time spent)

Sr. No.	Name, designation and institute	Status in the project (PI/CC-PI/ Co-PI)	Time to be spent (%)	Work components to be assigned to individual scientist
1.	Dr. P. R. Davara, Assistant Research Engineer, AICRP on PHET, Dept. of Processing and Food Engg., College of Agril. Engg. & Tech., Junagadh Agril. University, Junagadh	PI	60%	1. Review collection/literature survey 2. Designing of the experiment 3. Procurement of raw materials 4. Procurement of microbial cultures and chemicals required to conduct the research trials 5. Quality analysis of the raw materials 6. Preliminary trials for production of peanut sauce and peanut wadi 7. Final trials for development of peanut sauce and peanut wadi using defatted peanut flour/kernels as per the different treatments 8. Physico-chemical and sensory analysis of the products 9. Data collection and its analysis 10. Optimization of process parameters based on the experimental data 11. Report writing

2.	Prof. A. M. Joshi Assistant Microbiologist, AICRP on PHET, Dept. of Processing and Food Engg., College of Agril. Engg. & Tech., Junagadh Agril. University, Junagadh	Co-PI-I	15%	1. To assist the PI during fermentation process for peanut sauce 2. To assist the PI to carry out the microbiological analysis of the peanut sauce
3.	Dr. M. N. Dabhi, Research Engineer, AICRP on PHET, Dept. of Processing and Food Engg., College of Agril. Engg. & Tech., Junagadh Agril. University, Junagadh	Co-PI-III	15%	To assist the PI in taking administrative approvals as and when needed to carry out the different project related activities
4.	Dr. P. J. Rathod Assistant Biochemist, AICRP on PHET, Dept. of Bio-Technology, JAU, Junagadh	Co-PI-III	10%	1. To assist the PI to carry out biochemical analysis of the product

7. Priority Area : Post Harvest Technology

8. Project Duration: Three years Date of Start : 01-02-2020

Date of Completion : 31-01-2023

9.

a. Objectives :

1. To develop a process technology for preparation of peanut sauce and peanut wadi.
2. To study the effect of process parameters on different quality and sensory parameters of peanut sauce and peanut wadi.
3. To standardize the process parameters for preparation of peanut sauce and peanut wadi.

b. Practical utility :

1. The process technology for the production of peanut sauce and peanut wadi will be standardized.
2. The new peanut based fermented product and texturized protein product will be developed.
3. The process technology for production of nutrient rich peanut sauce and peanut wadi can be made available to the commercial players and food processors.
4. The proposed process technology will suggest the proper byproduct utilization of peanut for the preparation of value added product.
5. The process parameters for the preparation of peanut sauce and peanut wadi will be optimized.

10. Final Report on the Project (materials and methods used, results and discussion, objective wise achievements and conclusions)

10.1 Preparation of peanut sauce

10.1.1 Chemical process (Acid hydrolysis method)

10.1.1.1 Materials and methods (Acid hydrolysis method)

❖ **Raw material**

- **Defatted peanut kernel and wheat**

Defatted peanut kernel and wheat are the basic raw materials required in the preparation of peanut sauce.

Defatted peanut kernel **Wheat**

Plate 2.1. Defatted peanut kernel and wheat selected for peanut sauce preparation.

❖ **Methodology**

- **Roasting of wheat**

The wheat grains were heated by using induction heating coil at 150℃ for 30-45 s under normal atmospheric pressure. Roasted wheat was then cracked into 4 to 5 pieces per kernel accompanied by some amount of smaller particles of wheat flour.

Plate 2.2. Roasting of wheat for preparation of peanut sauce through acid hydrolysis method.

- **Soaking of defatted peanut kernel**

Soaking of defatted kernels was done to increase the moisture content of kernels up to 60% (wb).

Plate 2.3. Soaking of defatted peanut kernel.

- **Experimental procedure**

The experimental setup for the heating of the suspension is shown in the Plate 2.4. The modified process flow chart for the preparation of peanut sauce through acid hydrolysis is presented in the Fig. 1.

Plate 2.4. Experimental setup for preparation of peanut sauce through acid hydrolysis method.

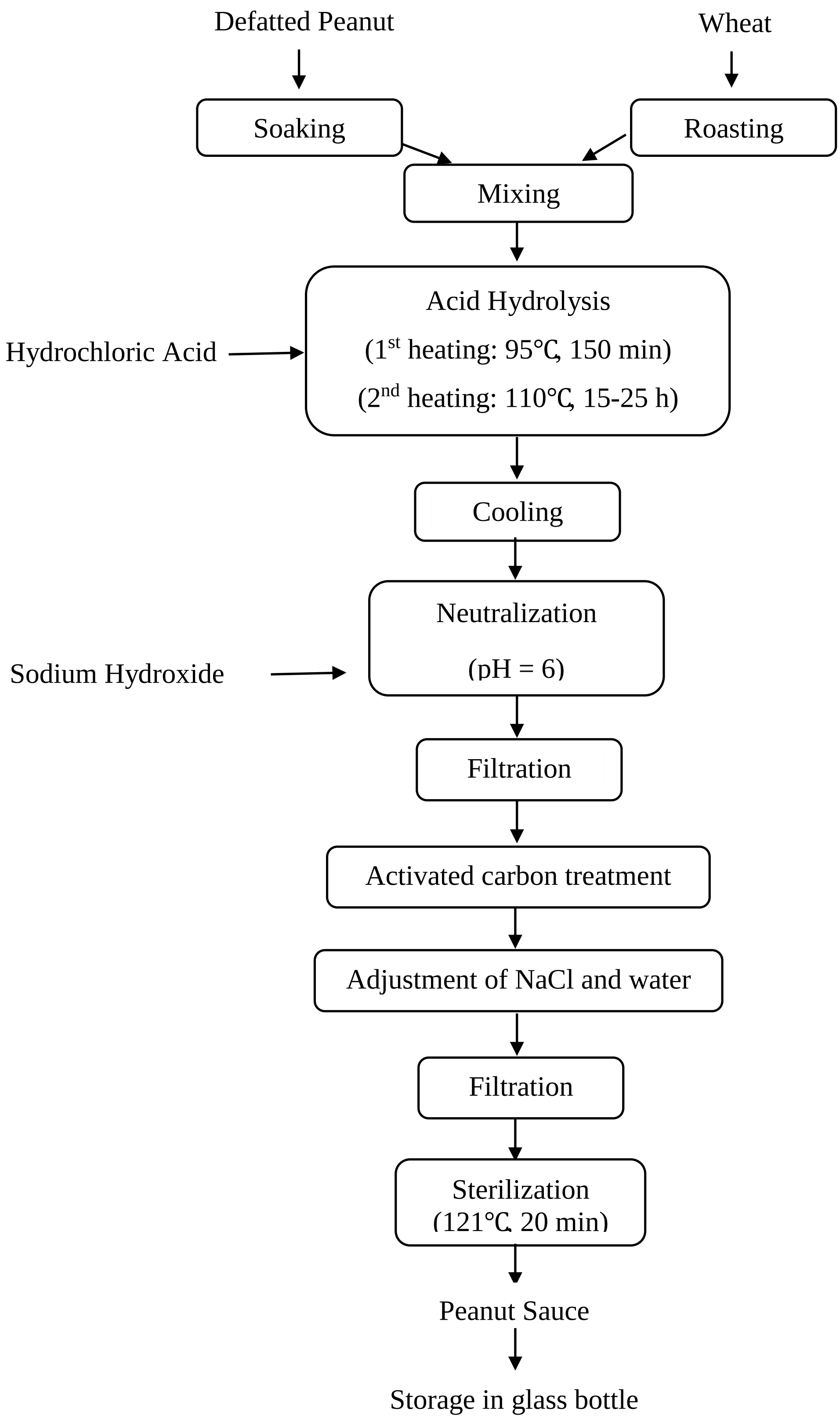


Fig. 2.1 Modified process flow chart for preparation of peanut sauce using acid hydrolysis method (Lee and Khor, 2015).

- **Experimental design**

The experiment was designed as per the Central Composite Rotatable Design (CCRD) of Response Surface Methodology (RSM).

Table 2.1. Coded and uncoded values of independent parameters.

Parameters		Coded variables				
		-1.682	**-1**	**0**	**+1**	**+1.682**
Defatted peanut kernel (%)	(X_1)	10	26	50	74	90
Acid concentration (%)	(X_2)	15	17	20	23	25
Hydrolysis time (h)	(X_3)	15	17	20	23	25

Table 2.2. Matrix of experimental central composite rotatable design for peanut sauce preparation.

Treatment No.	Type	Coded variables			Uncoded variables		
		X_1	X_2	X_3	Defatted peanut level (%w/w)	Acid concentration (%)	Hydrolysis time (h)
1	Fact	-1	-1	-1	26	17	17
2	Fact	1	-1	-1	74	17	17
3	Fact	-1	1	-1	26	23	17
4	Fact	1	1	-1	74	23	17
5	Fact	-1	-1	1	26	17	23
6	Fact	1	-1	1	74	17	23
7	Fact	-1	1	1	26	23	23
8	Fact	1	1	1	74	23	23
9	Axial	-1.682	0	0	10	20	20
10	Axial	1.682	0	0	90	20	20
11	Axial	0	-1.682	0	50	15	20
12	Axial	0	1.682	0	50	25	20
13	Axial	0	0	-1.682	50	20	15
14	Axial	0	0	1.682	50	20	25
15	Center	0	0	0	50	20	20
16	Center	0	0	0	50	20	20
17	Center	0	0	0	50	20	20
18	Center	0	0	0	50	20	20
19	Center	0	0	0	50	20	20
20	Center	0	0	0	50	20	20

❖ **Observations recorded**

Sr. No.	Parameter	Method	Reference
Biochemical parameters of defatted peanut and wheat			
1	True protein (%)	Spectrophotometric method	Lowry *et al.* (1951)
7	Total sugar (%)	Phenol sulphuric acid method	Dubois *et al.* (1956)
8	Reducing sugar (%)	Nelson Somogyi method	Somogyi (1952)
9	Oil (%)	Soxhlet method	AOAC (2005)

Quality Analysis of peanut sauce			
1. Physical parameters			
1	Viscosity (cP)	Using viscometer	Ranganna (2000)
2	Specific gravity	$\frac{Density\ of\ peanut\ sauce}{Density\ of\ water}$	Judoamidjojo *et al* (1985)
2. Biochemical parameters			
1	True protein (%)	Spectrophotometric method	Lowry *et al.* (1951)
2	Total Nitrogen (g/kg)	Micro Kjedahl method	AOAC (2005)
3	Free amino acid (mg/ml)	Spectrophotometric method	Moore and Stein (1984)
4	Total sugar (%)	Phenol sulphuric acid method	Dubois *et al.* (1956)
5	Reducing sugar (%)	Nelson Somogyi method	Somogyi (1952)
6	Total Phenol (mg/100g)	Spectrophotometric method	Malick and Singh (1980)
7	Salt content (ppm)	TDS (Total Dissolved Solids) method	Ranganna (2000)
8	Titrable acidity (%)	Titration method	Ranganna (2000)
9	Total Soluble Solids (˚Brix)	Digital refractometer	Nyasordzi *et al*. (2013)
3. Sensory parameters			
1	Colour	9-point hedonic scale method (Amerine et al., 1965)	
2	Taste (Saltiness, Pungency, Umami)		
3	Flavour/odour/aroma		
4	Overall acceptability		

❖ **Optimization and validation of process variables**

The optimization of process variables was carried out by using Design Expert version 10 software. The optimum values of the selected variables were analyzed by the response surface contour plots and also by solving the regression equation. The optimum conditions obtained through response surface analysis were verified by conducting the experiments in triplicate. The average experimental value of different response variables were used to check the validity and adequacy of the predicted models.

10.1.1.2 Results and Discussion (Acid hydrolysis method)

❖ **Proximate composition of defatted peanut kernel and wheat**

Table 2.3. Proximate composition of defatted peanut kernel and wheat.

Parameters	Average value	
	Defatted peanut kernel	**Wheat**
Moisture (%)	3.80	13.10
True protein (%)	29.00	12.90
Fat (%)	20.33	2.34
Carbohydrates (%)	2.35	67.80
Fiber (%)	14.20	10.65
Ash (%)	5.32	1.80

❖ **Physical, biochemical and sensory characteristics of peanut sauce**

The samples of peanut sauce obtained by different treatments using acid hydrolysis method are shown in Plate 5.

Plate 2.5. Samples of peanut sauce obtained by different treatments using acid hydrolysis method.

Table 2.4. Physical properties of peanut sauce prepared through acid hydrolysis method.

Treatment no.	Defatted peanut (%)	Acid Concentration (%)	Hydrolysis Time (h)	Viscosity (cP)	Sp. Gravity
1	26	17	17	1.30	1.19
2	74	17	17	1.19	1.19
3	26	23	17	1.15	1.19
4	74	23	17	1.01	1.20
5	26	17	23	1.01	1.16
6	74	17	23	1.03	1.19
7	26	23	23	1.49	1.19
8	74	23	23	1.33	1.21
9	10	20	20	1.18	1.19
10	90	20	20	1.01	1.21
11	50	15	20	1.30	1.21
12	50	25	20	1.31	1.22
13	50	20	15	1.27	1.21
14	50	20	25	1.16	1.20
15	50	20	20	1.41	1.20
16	50	20	20	1.45	1.22
17	50	20	20	1.44	1.21
18	50	20	20	1.45	1.20
19	50	20	20	1.44	1.21
20	50	20	20	1.43	1.21

Table 2.5. Biochemical properties of peanut sauce prepared through acid hydrolysis method.

Treatment no.	Defatted peanut (%)	Acid Conc. (%)	Hydrolysis Time (h)	True Protein (%)	Total N_2 (g/kg)	Free AA (mg/ml)	Total Sugar (%)	Reducing Sugar (%)	Total Phenol (%)	Salt (ppm)	Titratable Acidity (%)	TSS (°Brix)
1	26	17	17	*1.18*	1.07	27.10	3.41	0.280	*4.25*	22.21	*1.15*	38.5
2	74	17	17	3.24	1.98	28.90	2.93	0.273	4.73	19.58	1.18	36.0
3	26	23	17	*1.65*	1.91	17.40	3.84	0.533	*4.58*	24.55	*1.51*	38.2
4	74	23	17	3.46	2.01	24.90	1.78	0.229	4.83	26.01	1.50	37.7
5	26	17	23	1.69	1.19	18.90	2.87	0.172	5.37	18.70	1.36	30.4
6	74	17	23	3.88	1.88	28.20	1.68	0.690	5.97	19.58	1.28	34.8
7	26	23	23	2.75	1.98	14.40	3.89	0.329	5.34	21.63	1.71	38.7
8	74	23	23	4.15	2.04	27.20	1.29	0.610	5.52	25.43	1.73	38.7
9	10	20	20	1.35	1.37	13.80	4.23	0.347	4.79	22.21	1.39	35.5
10	90	20	20	3.99	1.75	26.60	1.49	0.575	5.51	22.80	1.40	35.2
11	50	15	20	2.76	1.57	22.90	2.08	0.337	3.99	20.09	1.03	37.8
12	50	25	20	3.47	1.81	14.70	2.29	0.461	4.75	25.72	1.78	43.5
13	50	20	15	2.49	1.17	30.50	2.87	0.271	5.93	22.80	1.40	40.5
14	50	20	25	3.38	1.05	22.50	1.64	0.499	5.41	20.84	1.62	35.2
15	50	20	20	3.21	1.35	22.80	2.31	0.538	4.77	23.67	1.39	36.4
16	50	20	20	3.29	1.67	23.40	2.61	0.533	5.95	22.50	1.39	37.9
17	50	20	20	3.04	1.59	23.52	2.71	0.518	5.43	21.92	1.41	36.8
18	50	20	20	2.99	1.66	22.20	2.34	0.481	5.05	22.80	1.40	37.6
19	50	20	20	3.27	1.61	23.10	2.12	0.486	5.29	23.09	1.43	37.2
20	50	20	20	3.11	1.58	23.70	2.59	0.523	5.88	22.21	1.38	38.0

Table 2.6. Sensory characteristics of peanut sauce prepared through acid hydrolysis method.

Treatment no.	Defatted peanut (%)	Acid Concentration (%)	Hydrolysis Time (h)	Colour	Taste	Flavour	Overall acceptability
1	26	17	17	6.39	6.45	6.50	7.21
2	74	17	17	6.31	6.00	6.00	6.61
3	26	23	17	6.50	6.09	6.52	6.88
4	74	23	17	6.66	6.06	6.10	6.91
5	26	17	23	7.00	7.66	7.00	6.42
6	74	17	23	6.78	7.00	6.90	7.09
7	26	23	23	7.13	6.94	6.80	6.91
8	74	23	23	7.00	7.13	6.50	7.21
9	10	20	20	7.02	7.44	7.30	6.45
10	90	20	20	6.59	6.91	7.10	6.66
11	50	15	20	6.85	7.06	7.10	7.03
12	50	25	20	6.88	6.94	6.98	7.13
13	50	20	15	6.25	6.15	6.11	7.08
14	50	20	25	7.06	6.78	6.40	6.85
15	50	20	20	6.79	6.43	6.34	6.79
16	50	20	20	6.75	6.32	6.29	6.76
17	50	20	20	7.09	6.66	6.69	6.98
18	50	20	20	6.84	6.84	6.38	6.82
19	50	20	20	6.72	6.22	6.28	6.95
20	50	20	20	7.05	6.86	6.74	6.89

Table 2.7. Analysis of variance (ANOVA) and regression coefficients for response surface quadratic model of physical properties of peanut sauce prepared through acid hydrolysis method.

Source	Viscosity (cP)	Specific gravity
Intercept	1.44	1.21
Linear terms		
A (X_1)	-0.0501**	0.0070*
B (X_2)	0.0348*	0.0064*
C (X_3)	0.0003	-0.0035
Interaction terms		
AB (X_1X_2)	-0.0268	0.0005
AC (X_1X_3)	0.0132	0.0055
BC (X_2X_3)	0.1388***	0.0054
Quadratic terms		
A^2 (X_1^2)	-0.1215***	-0.0067*
B^2 (X_2^2)	-0.0473**	-0.0016
C^2 (X_3^2)	-0.0786**	-0.0047
Indicators for model fitting		
R^2	0.9506	0.7366
Adj-R^2	0.9062	0.4995
Pred-R^2	0.6264	-0.7828
Adeq Precision	12.2360	6.9070
F-value	21.39	3.11
Lack of fit	S	S
C.V. %	4.02	0.8294

A or X_1= Defatted peanut kernel, B or X_2= acid concentration, C or X_3= hydrolysis time, ***Significant at $p<0.001$, **Significant at $p<0.01$, *Significant at $p<0.05$, NS = Non-significant

Table 2.8. Analysis of variance (ANOVA) and regression coefficients for response surface quadratic model of biochemical properties of peanut sauce prepared through acid hydrolysis method.

Source	True protein (%)	Total nitrogen (%)	Free amino acid (mg/ml)	Total sugar (%)	Reducing sugar (%)	Total phenol (%)	Salt content (%)	Titratable acidity (%)	TSS (°Brix)
Intercept	3.16	1.57	23.07	2.44	0.5136	5.393	22.70	1.40	37.36
Linear terms									
A (X_1)	0.872***	0.176*	3.88***	-0.801***	0.064***	199.00	0.329	-0.001	0.066
B (X_2)	0.236***	0.162*	-2.42***	0.019	0.036***	89.16	1.98***	0.21***	1.70***
C (X_3)	0.325***	-0.006	-1.69***	-0.315***	0.064***	215.92	-0.754**	0.08***	-1.22**
Interaction terms									
AB (X_1X_2)	-0.130	-0.180*	1.15*	-0.374**	-0.067***	-82.71	0.877**	0.008	-0.3
AC (X_1X_3)	-0.034	-0.032	1.60**	-0.156	0.139***	6.66	0.731**	-0.01	0.925
BC (X_2X_3)	0.082	0.010	1.03*	0.169	-0.016	-113.98	0.000	0.014	1.35*
Quadratic terms									
A^2 (X_1^2)	-0.201**	0.060	-0.691	0.205**	-0.023**	-80.88	-0.107	-0.004	-0.983*
B^2 (X_2^2)	-0.044	0.106	-1.19**	-0.0337	-0.044***	-356.8*	0.034	-0.002	0.891*
C^2 (X_3^2)	-0.107*	-0.099	1.54***	-0.009	-0.049***	104.38	-0.349	0.036**	-0.099
Indicators for model fitting									
R^2	0.979	0.739	0.966	0.957	0.987	0.584	0.953	0.982	0.884
Adj-R^2	0.960	0.504	0.935	0.919	0.976	0.210	0.911	0.966	0.779
Pred-R^2	0.870	-0.765	0.762	0.797	0.948	-1.100	0.798	0.873	0.155
Adeq Precision	25.098	6.526	19.789	19.431	34.350	5.067	15.760	27.544	13.073
F-value	51.24	3.14	31.58	24.89	86.13	1.56	22.65	61.28	8.46
Lack of fit	NS	S	S	NS	NS	NS	NS	S	S
C.V. %	5.86	14.00	5.39	9.20	5.11	9.82	2.71	2.44	3.23

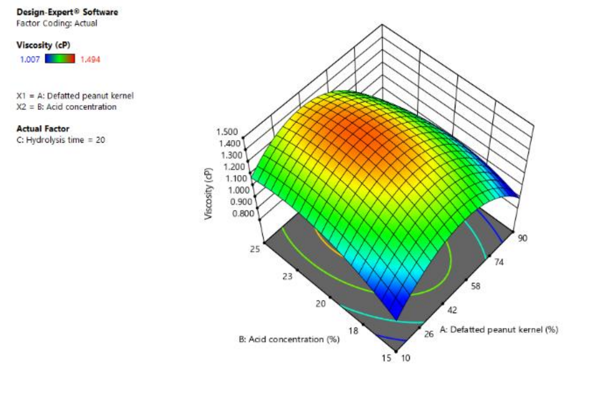
A or X_1= Defatted peanut kernel, B or X_2= acid concentration, C or X_3= hydrolysis time, ***Significant at $p<0.001$, **Significant at $p<0.01$, *Significant at $p<0.05$, S = Significant, NS = Non-significant

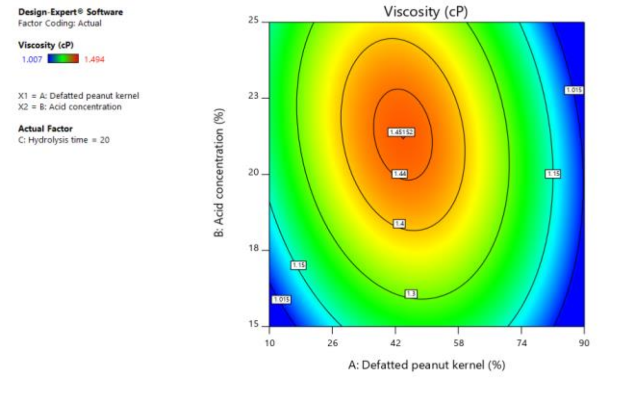
Table 2.9. Analysis of variance (ANOVA) and regression coefficients for response surface quadratic model of sensory characteristics of peanut sauce prepared through acid hydrolysis method.

Source	Colour	Taste	Flavour	Overall acceptability
Intercept	6.87	6.56	6.46	6.83
Linear terms				
A (X_1)	-0.0727	-0.1348	-0.1213	0.0412
B (X_2)	0.0630	-0.0799	-0.0499	0.0658
C (X_3)	0.2499***	0.3800***	0.1880	0.0355
Interaction term				
AB (X_1X_2)	0.0413	0.1587	-0.0150	-0.0262
AC (X_1X_3)	-0.0537	0.0012	0.0650	0.1887
BC (X_2X_3)	-0.0138	-0.0363	-0.0900	0.0888
Quadratic terms				
A^2 (X_1^2)	-0.0342	0.1699	0.1976	-0.0740
B^2 (X_2^2)	-0.0130	0.1081	0.1410	0.1116
C^2 (X_3^2)	-0.0873*	-0.0811	-0.1365	0.0480
Indicators for model fitting				
R^2	0.8546	0.7727	0.7473	0.4597
Adj-R^2	0.7237	0.5681	0.5199	-0.0265
Pred-R^2	0.4706	-0.1897	-0.4304	-3.0991
Adeq Precision	9.3233	8.5149	7.9577	3.6221
F-value	6.53	3.78	3.29	0.9455
Lack of fit	NS	NS	NS	Significant
C.V. %	2.05	4.60	3.94	4.36

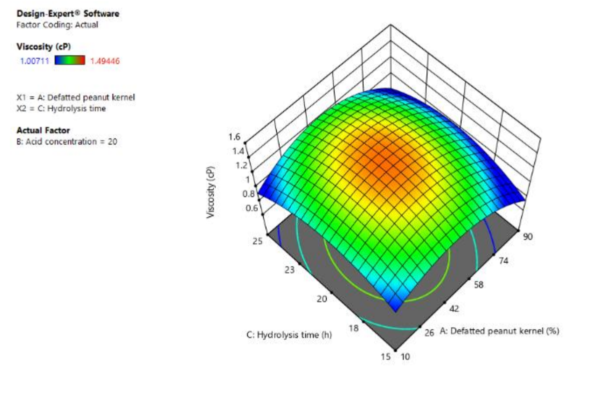
A or X_1= Defatted peanut kernel, B or X_2= acid concentration, C or X_3= hydrolysis time, ***Significant at $p<0.001$, **Significant at $p<0.01$, *Significant at $p<0.05$, NS = Non-significant

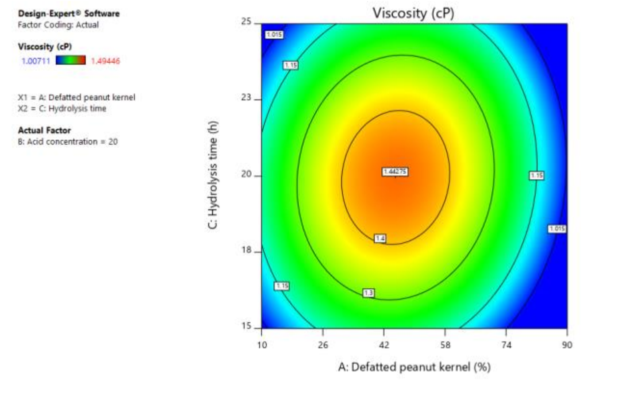
❖ Response Surface Analysis (Acid hydrolysis method)



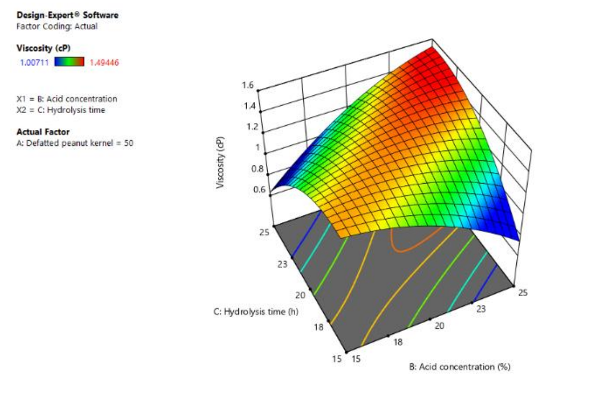


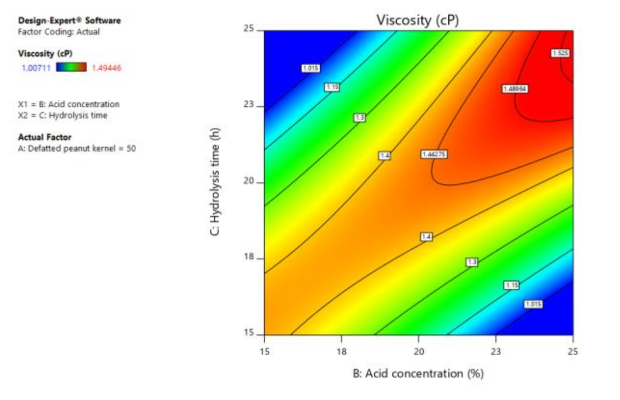
The viscosity was increased as the percentage of defatted peanut kernel increased from 10% to 44% and again decreased with further increase in percentage of defatted peanut kernel up to its maximum level, i.e. 90%. The viscosity was observed to be increased up to the acid concentration of 21.32% and with further increase in the acid concentration it was observed to be decreased. The predicted maximum viscosity (1.45 cP) was obtained at the combination of 44% defatted peanut kernel and 21.32% acid concentration.





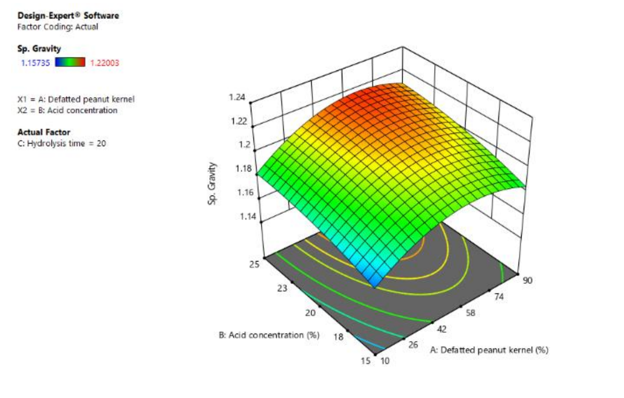
The viscosity of peanut sauce was increased as the percentage of defatted peanut kernel increased from 10% to 45.01% and again decreased with further increase in percentage of defatted peanut kernel up to its maximum level, i.e. 90%. The viscosity increase with increase in hydrolysis time at certain level, i.e. 19.97 h and again decrease with further increase in hydrolysis time. The predicted maximum viscosity (1.44 cP) at the combination of 45.01% defatted peanut kernel and 19.97 h hydrolysis time.

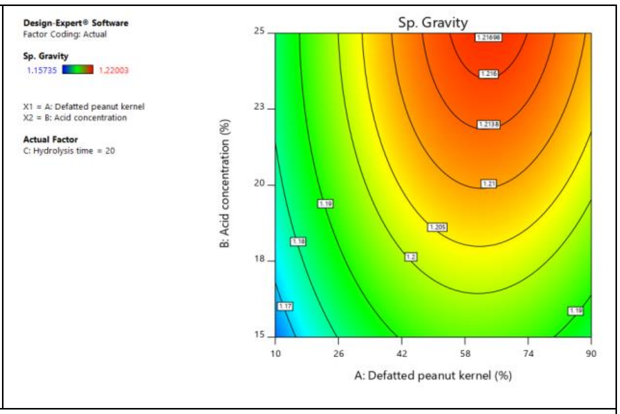




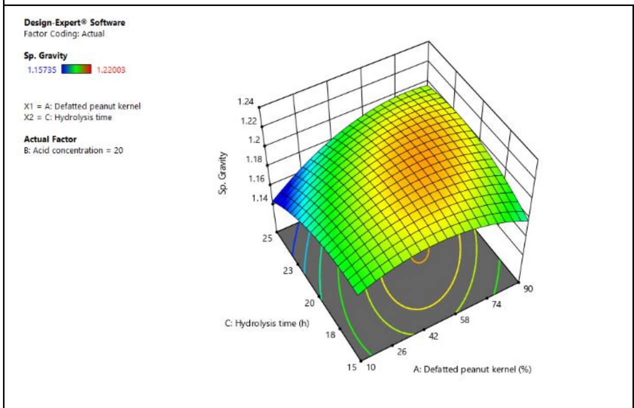
The viscosity of peanut sauce was increased with increased in hydrolysis time up to certain level, i.e. 24.43 h and decreased further with increase in hydrolysis time up to its maximum level, i.e. 25 h At the combination of 25% acid concentration and 24.43 h hydrolysis time, the maximum predicted viscosity was observed (1.54 cP).

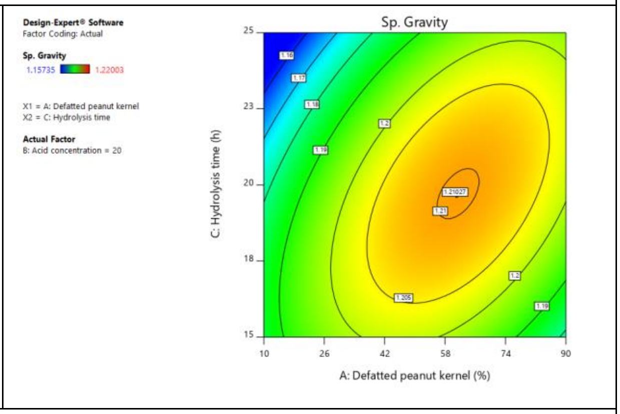
Fig. 2.2. Effect of different process parameters on viscosity of peanut sauce (Acid hydrolysis method)



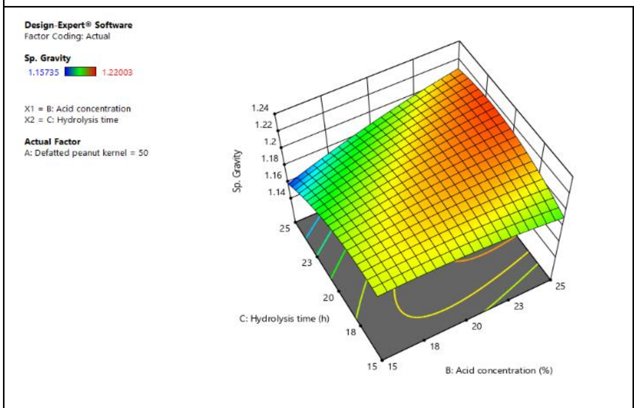


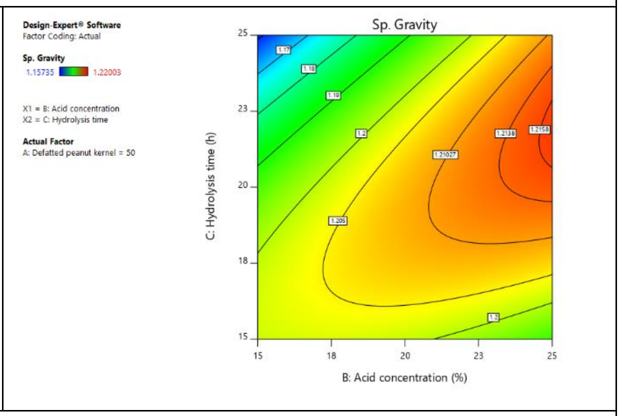
The specific gravity was increased as the percentage of defatted peanut kernel increased from 10% to 63.92% and again decreased with further increase in percentage of defatted peanut kernel up to its maximum level, i.e. 90%. The specific gravity was also found to be increased with an increase in acid concentration up to maximum level i.e. 25%. The predicted maximum specific gravity (1.22) was obtained at the combination of 63.92% defatted peanut kernel and 25% acid concentration.





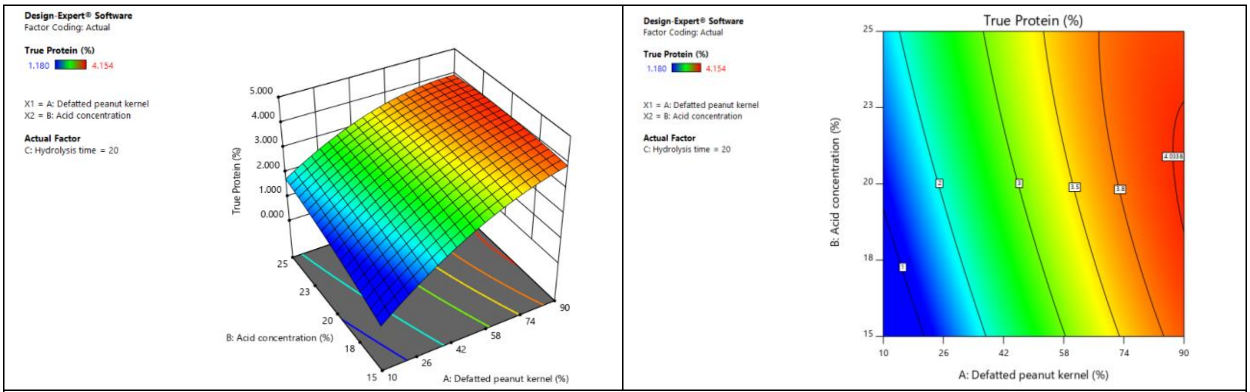
The specific gravity of peanut sauce was increase with increased in defatted peanut kernel from 10% to 61.36% and again decreased with further increase in percentage of defatted peanut kernel up to its maximum level, i.e. 90%. In same way the specific gravity of peanut sauce was increased with increased in hydrolysis time up to certain level, i.e. 19.70 h and decreased further with increase in hydrolysis time up to its maximum level, i.e. 25 h. The maximum predicted specific gravity was observed (1.21) at the combination of 61.36% defatted peanut kernel and 19.70 h hydrolysis time.



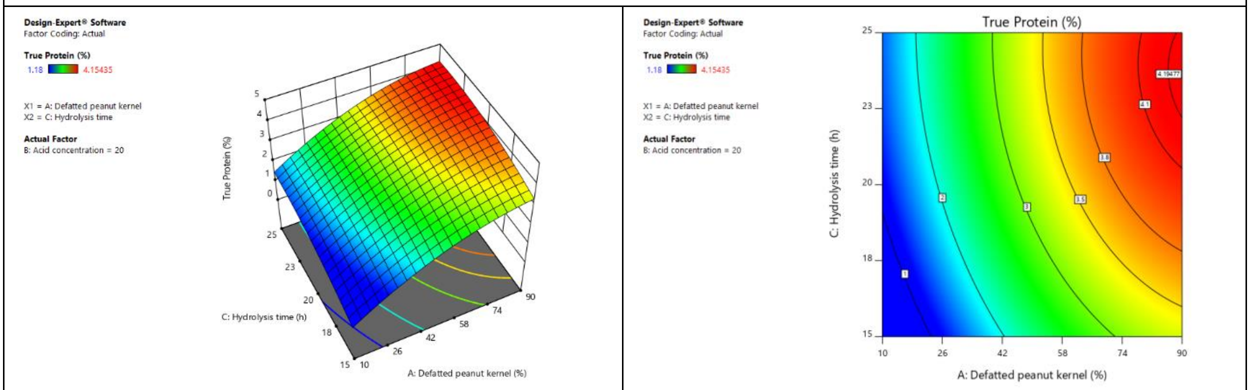


Increase in the specific gravity value was observed with an increase in acid concentration up to 25% and hydrolysis time up to 21.74 h. Beyond this combination, the specific gravity was observed to be decreased. The predicted maximum specific gravity (1.22) was obtained at the combination of 25% acid concentration and 21.74 h hydrolysis time.

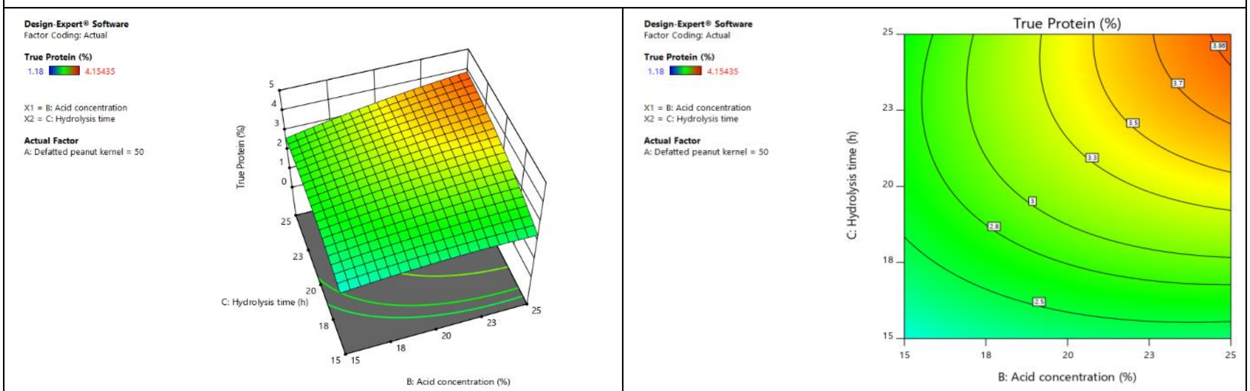
Fig. 2.3. Effect of different process parameters on specific gravity of peanut sauce (Acid hydrolysis method)



True protein of peanut sauce was increased with an increase in defatted peanut kernel up to its maximum value, i.e. 90% and In other axis the true protein of peanut sauce was increased with increased in acid concentration up to certain level, i.e. 20.72% and decreased further with increase in acid concentration up to its maximum level, i.e. 25%. The maximum predicted true protein of peanut sauce was observed (4.06%) at the combination of 90% defatted peanut kernel and 20.72% acid concentration.

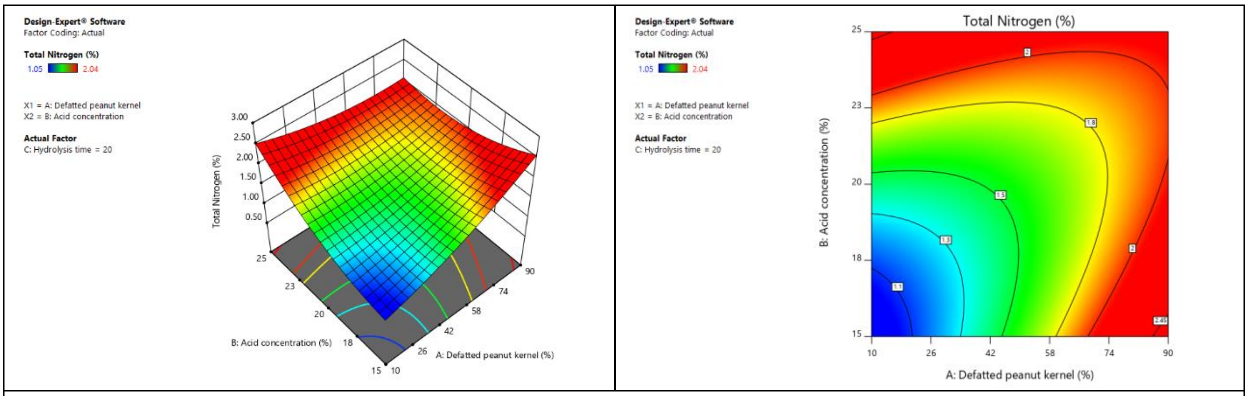


The true protein of peanut sauce was increase with increased in defatted peanut kernel up to its maximum value, i.e. 90% and increase in true protein with increased in hydrolysis time up to certain level, i.e. 23.74 h and decreased further with increase in hydrolysis time up to its maximum level, i.e. 25 h. The true protein of peanut sauce was proposed to be maximum (4.22%) at 90% defatted peanut kernel and 23.74 h hydrolysis time. Beyond this combination, the true protein of peanut sauce was observed to be decreased.

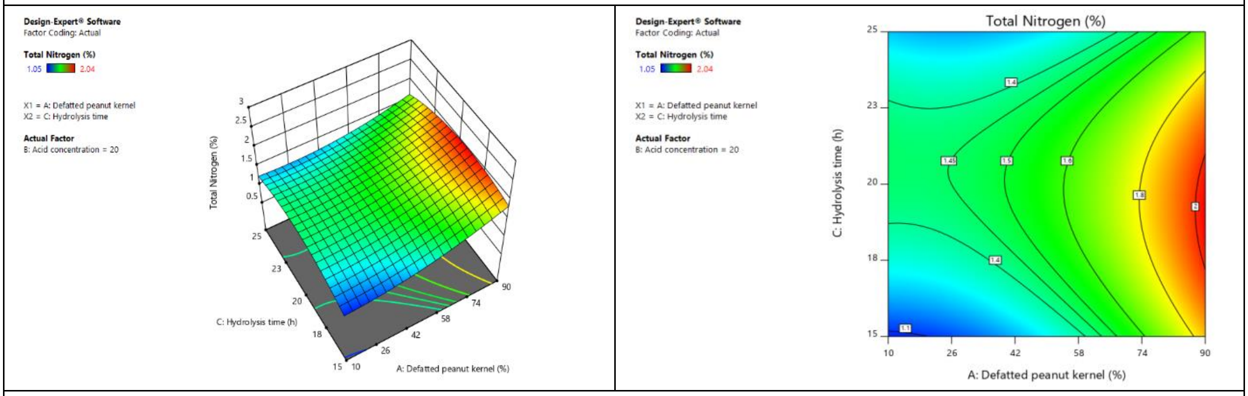


The increase in true protein was observed as the percentage of acid concentration increased up to its maximum level i.e. 25%. In the same way true protein value was also found to be increased with an increase in hydrolysis time up to its maximum level i.e. 25 h. The predicted maximum true protein (3.91%) was obtained at the combination of 25% acid concentration and 25 h hydrolysis time.

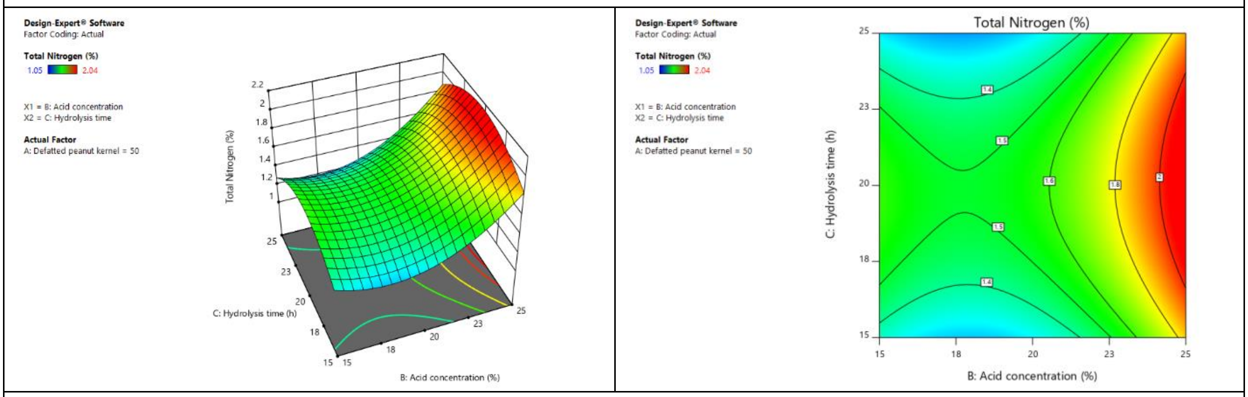
Fig. 2.4. Effect of different process parameters on true protein of peanut sauce (Acid hydrolysis method)



The total nitrogen of peanut sauce was increased with an increase in defatted peanut kernel up to maximum level, i.e. 90%. The total nitrogen content of peanut sauce also increase with increased in acid concentration up to its maximum level, i.e. 25%. The predicted maximum total nitrogen (2.57%) was obtained at the combination of 90% defatted peanut kernel and 15% acid concentration.

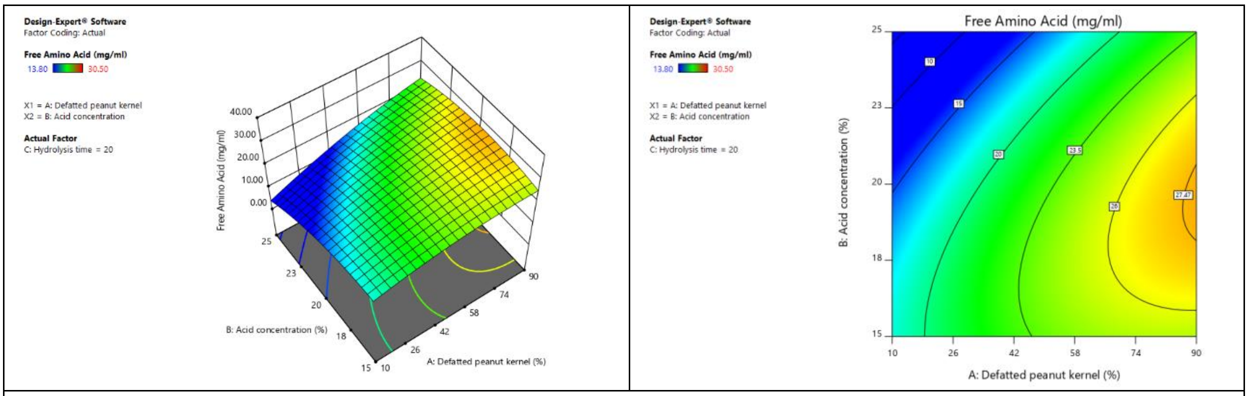


Total nitrogen was observed to be increased as the defatted peanut kernel was increased up to maximum level, i.e. 90%. The total nitrogen was also increased with an increase in hydrolysis time up to certain level, i.e. 19.08 h and decreased further with increase in hydrolysis time up to its maximum level, i.e. 25 h. The maximum predicted value (2.04%) of total nitrogen was found at the combination of 90% defatted peanut kernel and 19.08 h hydrolysis time.

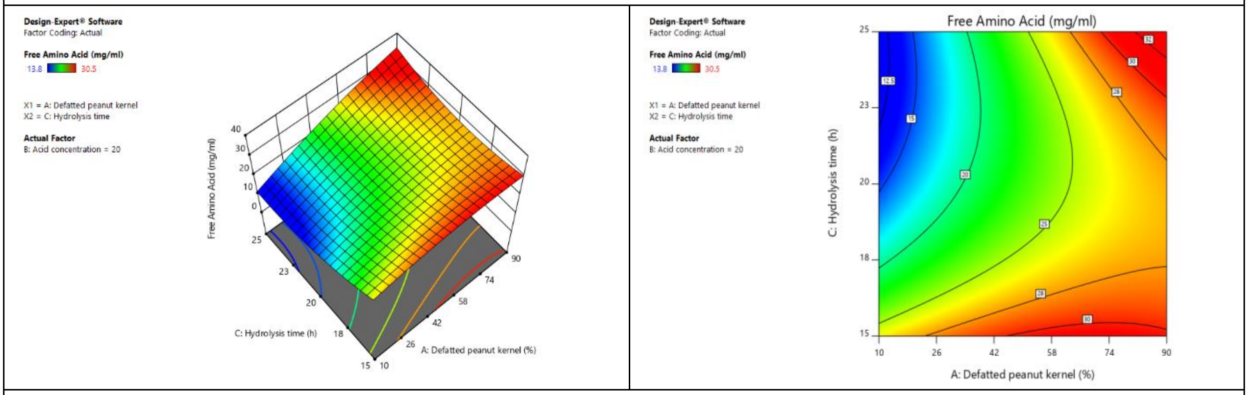


There was an increase in total nitrogen content with an increase in acid concentration up to its maximum level, i.e. 25%. Increased in total nitrogen content with an increase in hydrolysis time up to certain level, i.e. 20.17 h and decreased further with increase in hydrolysis time up to its maximum level, i.e. 25 h. At the combination of 25% acid concentration and 20.17 h hydrolysis time, the total nitrogen content was predicted maximum 2.14%.

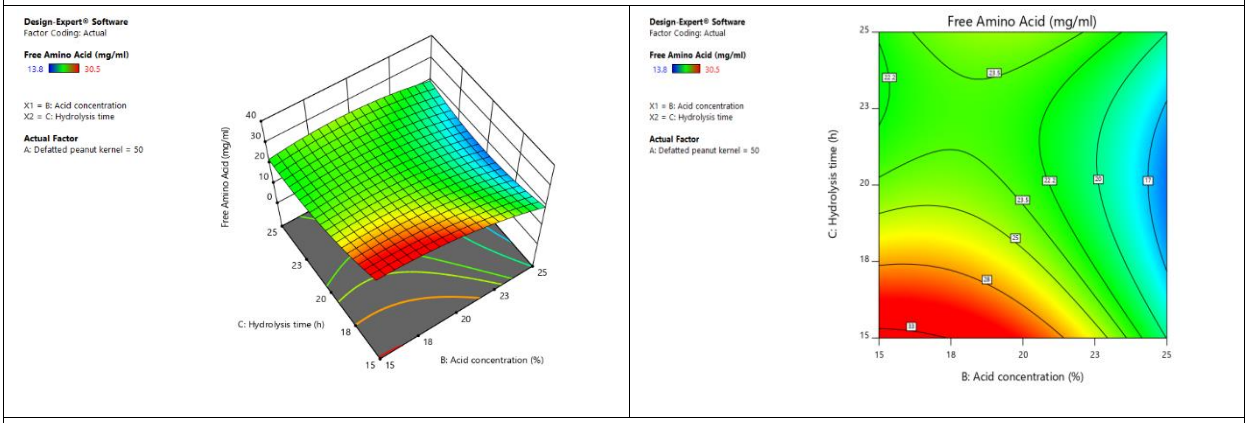
Fig. 2.5. Effect of different process parameters on total nitrogen of peanut sauce (Acid hydrolysis method)



The incremented effect of free amino acid up to 90% defatted peanut kernel and 19.38% acid concentration was observed. Beyond this combination, the free amino acid was observed to be decreased. The predicted maximum free amino acid (27.68 mg/ml) was found at 90% defatted peanut kernel and 19.38% acid concentration.

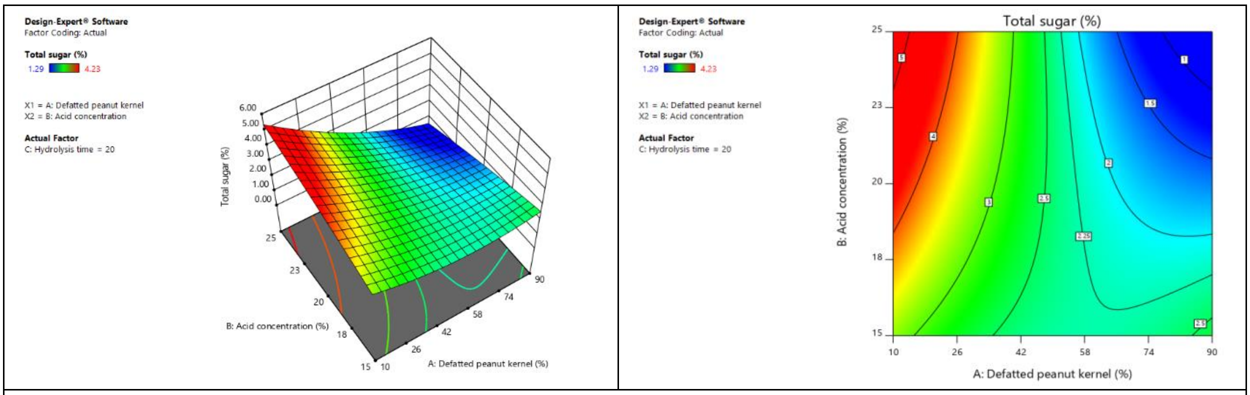


It could be observed from the contour graph, that the free amino acid was increased with an increase in defatted peanut kernel up to 90% and hydrolysis time up to 25 h. The predicted maximum free amino acid (33.62 mg/ml) was found at 90% defatted peanut kernel and 25 h hydrolysis time.

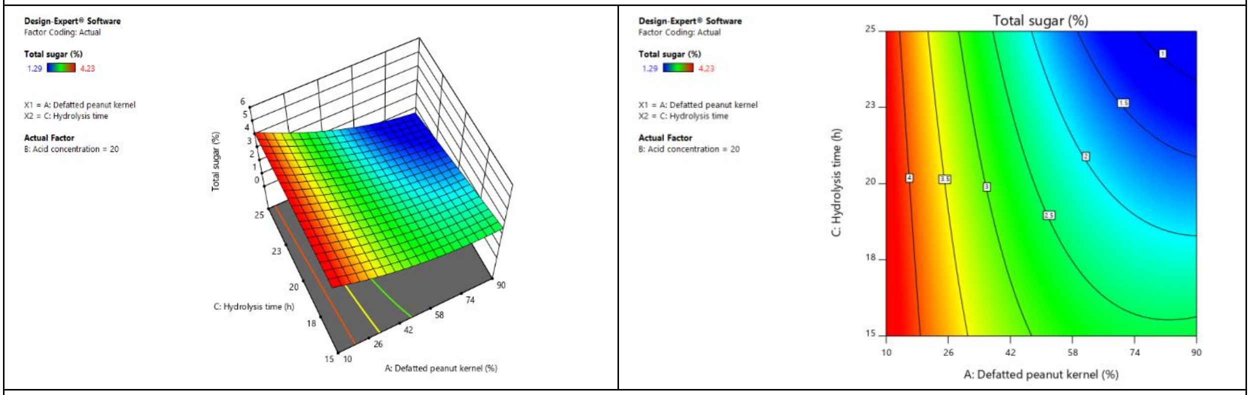


The free amino acid was found to be decreased as the acid concentration and hydrolysis time was increased up to 25% and 23.32 h, respectively. The predicted maximum free amino acid (33.83 mg/ml) was found at 15% acid concentration and 15 h hydrolysis time.

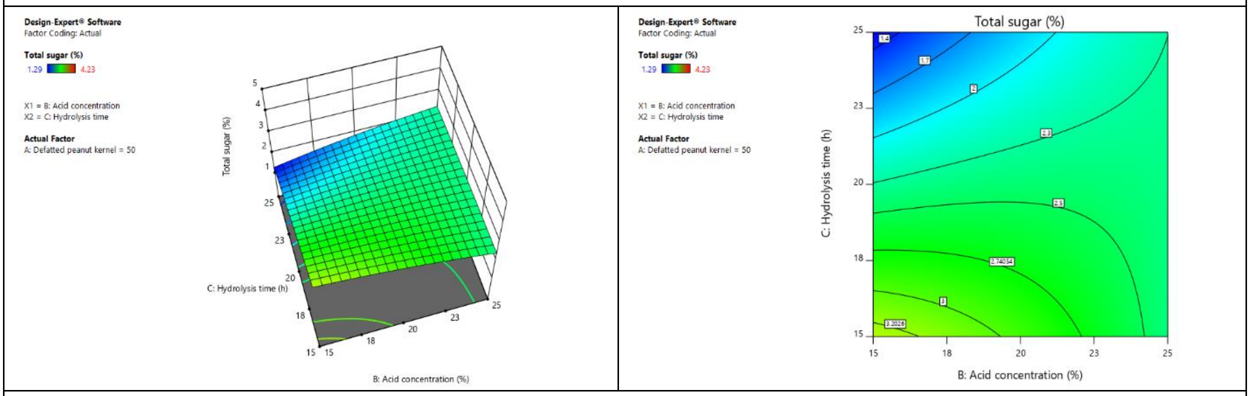
Fig. 2.6. Effect of different process parameters on free amino acid content of peanut sauce (Acid hydrolysis method)



The total sugar was observed to be increased up to maximum acid concentration of 25%. The predicted maximum total sugar (5.35%) was obtained at the combination of 10% defatted peanut kernel and 25% acid concentration and expected minimum total sugar (0.56%) was found at 90% defatted peanut kernel and 25% acid concentration.

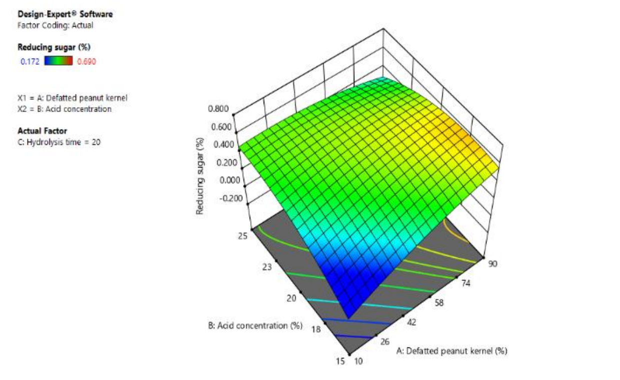


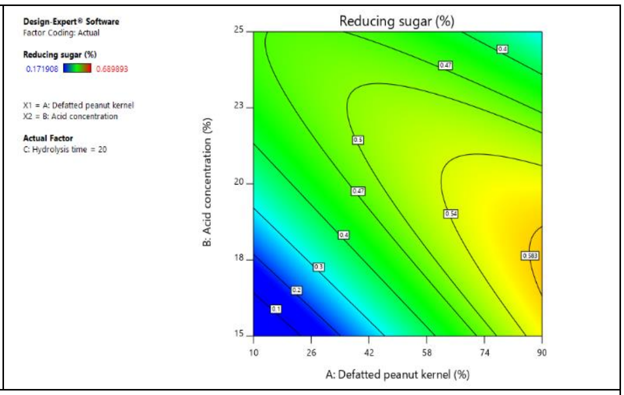
The total sugar also slightly decreased with increase in hydrolysis time up to its maximum level, i.e. 25 h. The predicted maximum total sugar of peanut sauce (4.42%) was found at the combination of 10% defatted peanut kernel and 15 h hydrolysis time and expected minimum sugar content (0.69%) was found at 90% defatted peanut kernel and 25 h hydrolysis time.



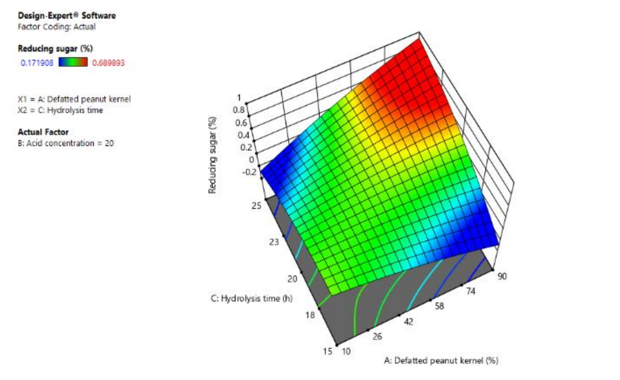
The total sugar of peanut sauce was decreased with increased in acid concentration and hydrolysis time up to maximum level, i.e. 25% and 25 h, respectively. At the combination of 15% acid concentration and 15 h hydrolysis time, the maximum predicted total sugar was observed (3.29%). At 15% acid concentration and 25 h hydrolysis time, the minimum total sugar was found (1.29%).

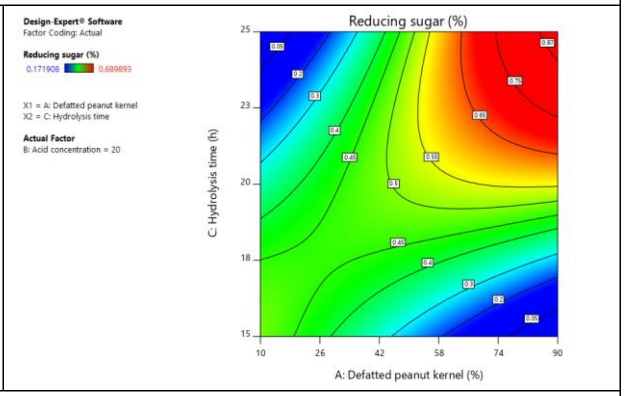
Fig. 2.7. Effect of different process parameters on total sugar of peanut sauce (Acid hydrolysis method)



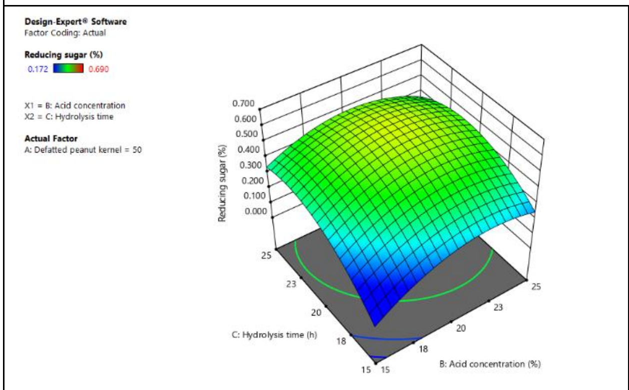


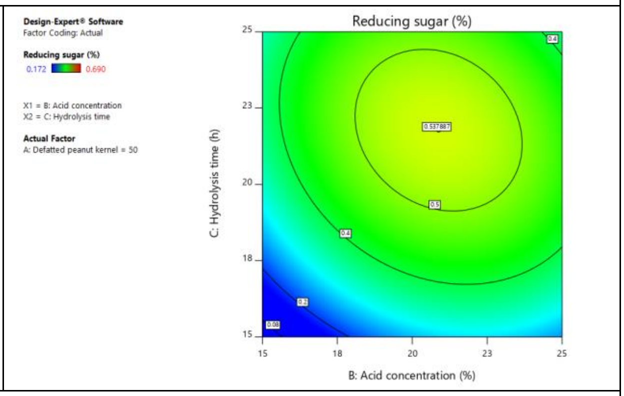
The value of reducing sugar of peanut sauce was increased with an increase in defatted peanut kernel up to maximum level, i.e. 90%. In same way reducing sugar of peanut sauce increased with increased in acid concentration up to its maximum level, i.e. 25%. The predicted maximum reducing sugar (0.590%) was obtained at the combination of 90% defatted peanut kernel and 17% acid concentration.





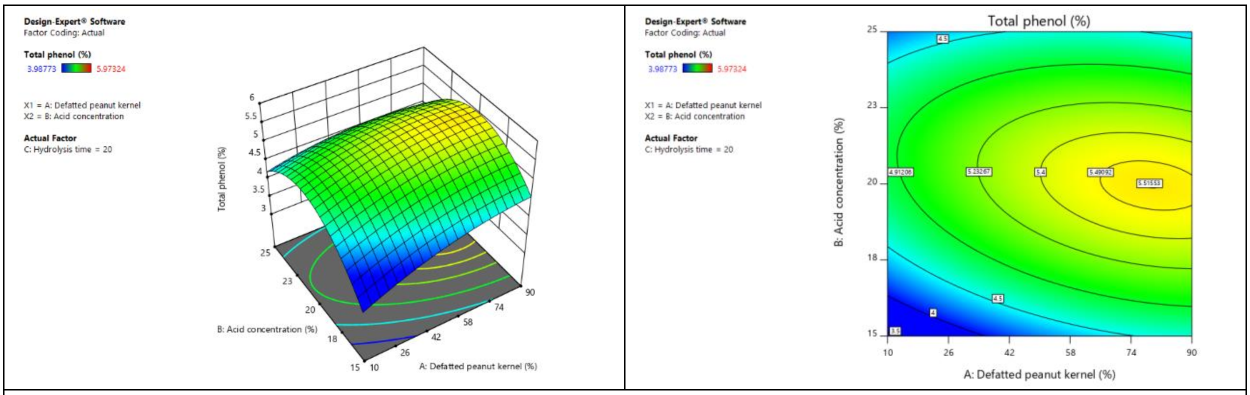
The increase in reducing sugar was observed as the defatted peanut kernel and hydrolysis time were increased relatively up to maximum level, i.e. 90% and 25, respectively. The maximum predicted value (0.916%) of reducing sugar was found at the combination of 90% defatted peanut kernel and 25 h hydrolysis time.



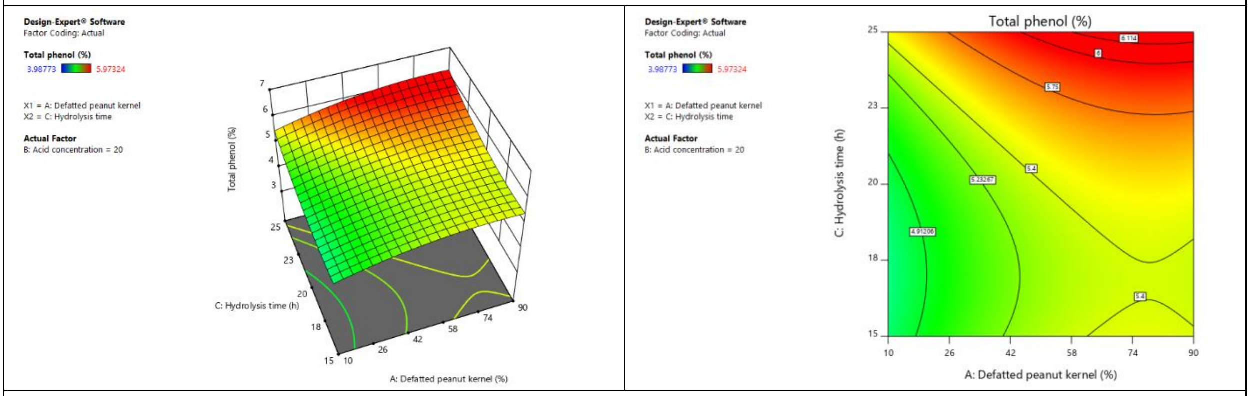


There was increase in reducing sugar with an increase in acid concentration up to certain level, i.e. 20.89% and decreased further with increase in acid concentration up to its maximum level, i.e. 25%. Increased in total nitrogen content with an increase in hydrolysis time up to certain level, i.e. 21.78 h and decreased further with increase in hydrolysis time up to its maximum level, i.e. 25 h. The reducing sugar was predicted maximum 0.538% at the combination of 20.89% acid concentration and 21.78 h hydrolysis time.

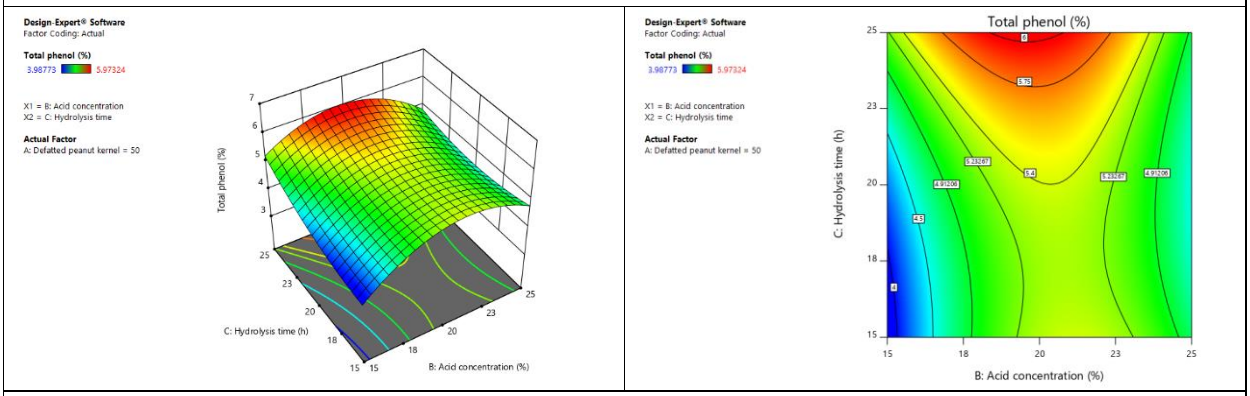
Fig. 2.8. Effect of different process parameters on reducing sugar of peanut sauce (Acid hydrolysis method)



The total phenol content was found to be increased as the percentage of defatted peanut kernel and acid concentration was increased up to 78.92% and 19.98 h, respectively. For this combination of defatted peanut kernel percentage and acid concentration time, the total phenol content of peanut sauce was proposed to be increased up to 5.52%. Beyond this combination, the total phenol content was observed to be decreased.

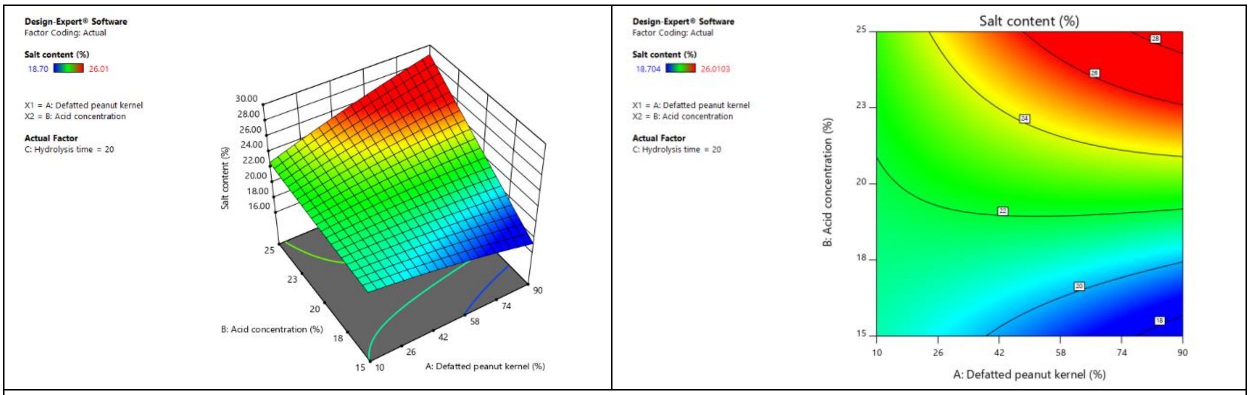


The total phenol was increased with an increase in defatted peanut kernel and hydrolysis time up to 80.97% and 25 h, respectively. At this combination of defatted peanut kernel percentage and hydrolysis time, the total phenol of peanut sauce was expected to be increased up to 6.18%. Beyond this combination, the total phenol content of peanut sauce was found to be decreased.

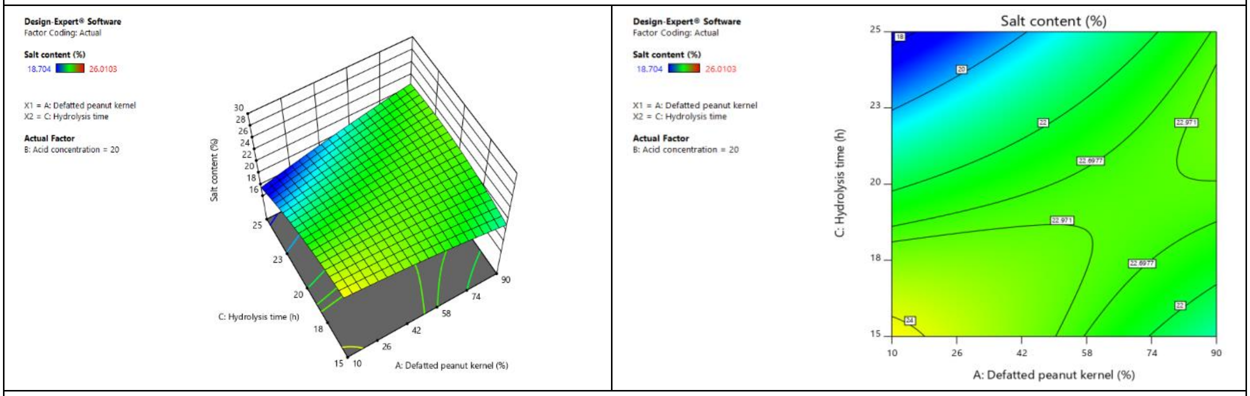


The increase in total phenol was observed as the acid concentration increased up to 19.59% and hydrolysis time up to 25 h. The total phenol at this combination was proposed to be increased up to 6.05%. The total phenol was decreased with further increase in acid concentration and hydrolysis time beyond this combination.

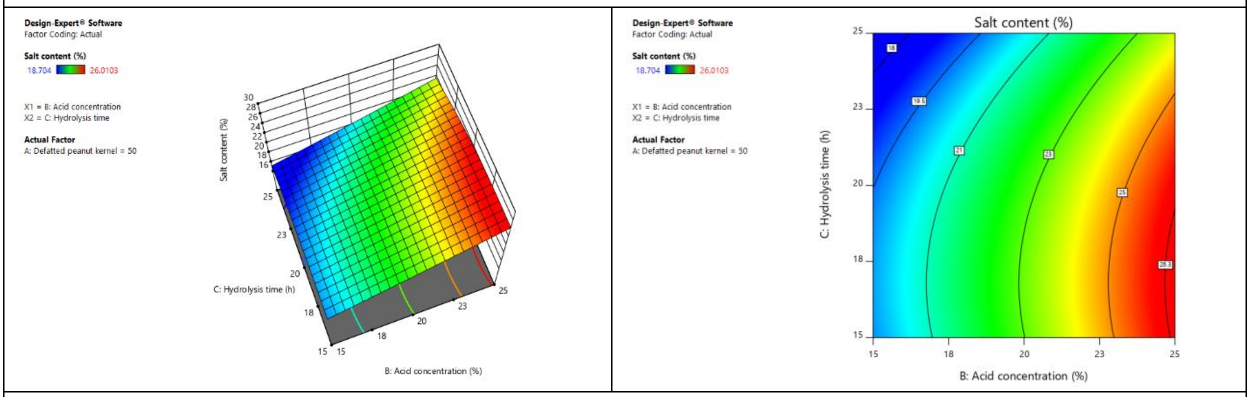
Fig. 2.9. Effect of different process parameters on total phenol content of peanut sauce (Acid hydrolysis method)



The value of salt content of peanut sauce was increased with an increase in defatted peanut kernel and acid concentration relatively up to its maximum level, i.e. 90% & 25% respectively. The predicted minimum salt content (17.26%) was obtained at the combination of 90% defatted peanut kernel and 15% acid concentration and predicted maximum salt content (28.83%) was obtained at 90% defatted peanut kernel and 25% acid concentration.

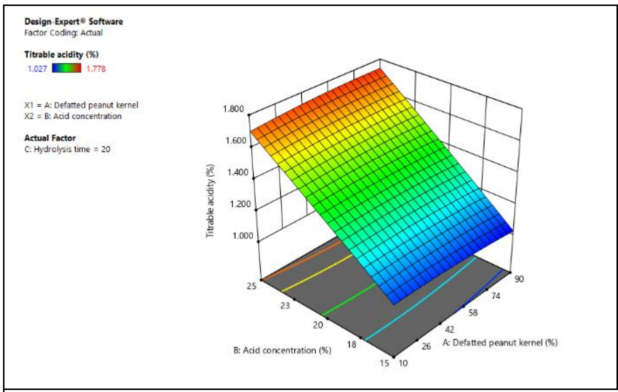


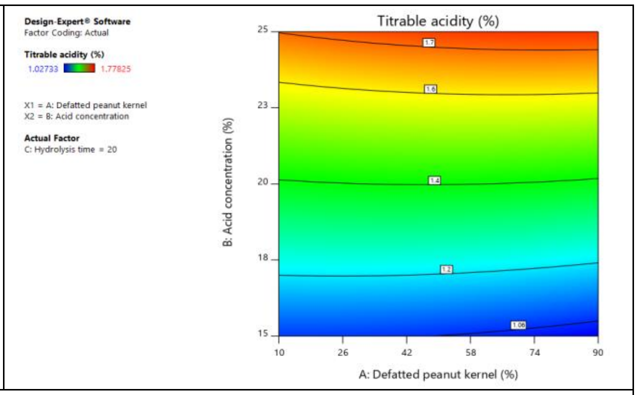
There was a decrease in salt content of peanut sauce as the defatted peanut kernel was increased up to maximum level, i.e. 90%. The salt content was also decreased with an increase in hydrolysis time up to maximum level, i.e. 25 h. The minimum predicted value (17.55%) of salt content was found at the combination of 10% defatted peanut kernel and 25 h hydrolysis time and predicted maximum salt content (24.19%) was obtained at 10% defatted peanut kernel and 15 h hydrolysis time



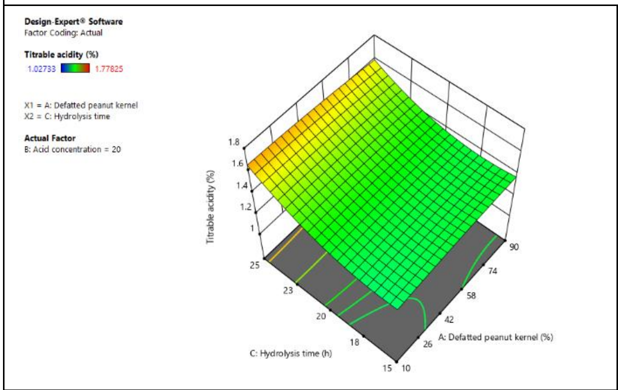
Decrease in salt content was observed with an increase in hydrolysis time up to its maximum level, i.e. 25 h. The salt content of peanut sauce was increased as the increase in acid concentration up to its maximum limit, i.e. 25%. The minimum salt content was predicted (17.25%) at the combination of 15% acid concentration and 25 h hydrolysis time and maximum predicted value of salt content (26.53%) at 25% acid concentration and 15 h hydrolysis time.

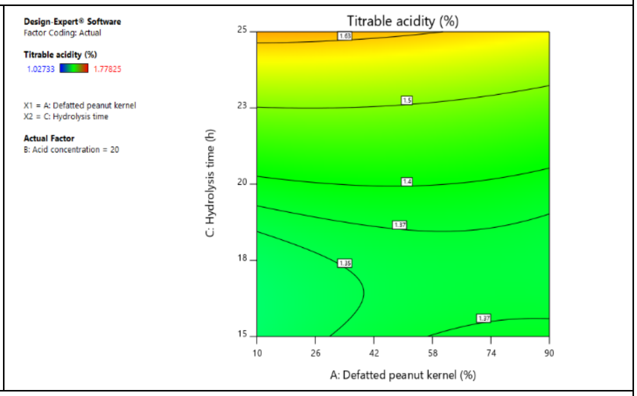
Fig. 2.10. Effect of different process parameters on salt content of peanut sauce (Acid hydrolysis method)



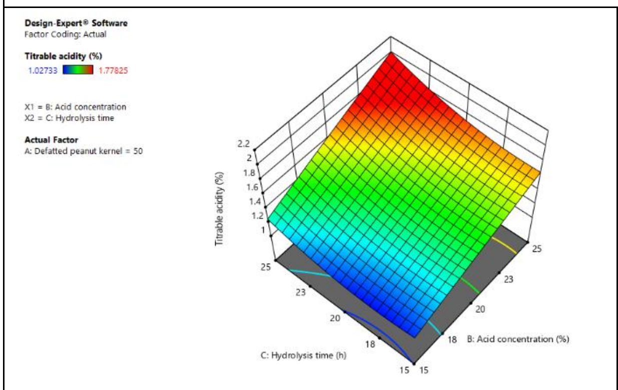


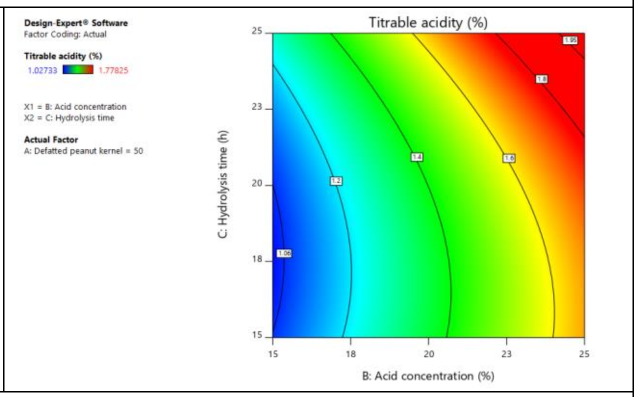
The value of titratable acidity of peanut sauce was increased with an increase in defatted peanut kernel and acid concentration relatively up to its maximum level, i.e. 90% & 25% respectively. The predicted minimum titratable acidity (1.02%) was obtained at the combination of 90% defatted peanut kernel and 15% acid concentration and predicted maximum titratable acidity (1.74%) was observed at 90% defatted peanut kernel and 25% acid concentration.





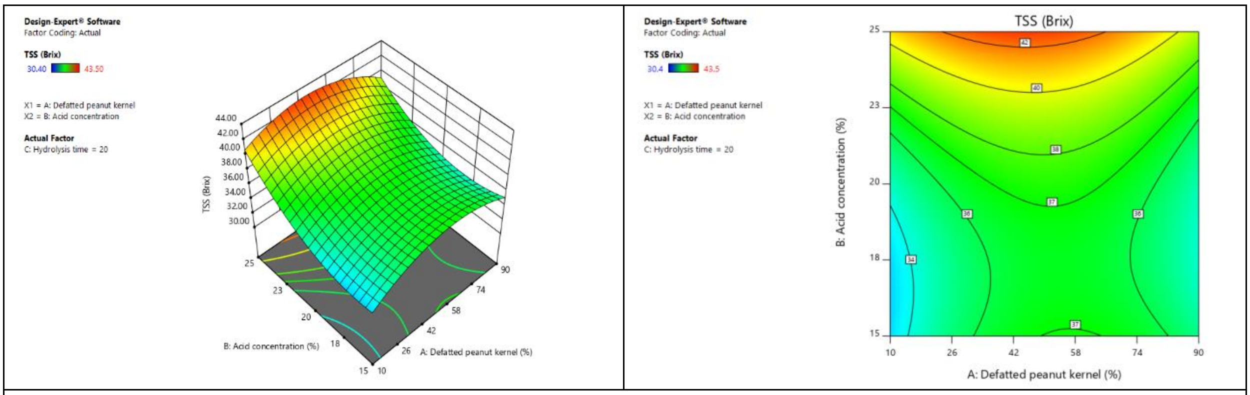
The titratable acidity was increased as the defatted peanut kernel was increased up to maximum level, i.e. 90%. The titratable acidity was also increased with an increase in hydrolysis time up to maximum level, i.e. 25 h. The minimum predicted value (1.33%) of titratable acidity was found at the combination of 10% defatted peanut kernel and 15 h hydrolysis time and predicted maximum value (1.65%) of titratable acidity was found at 10% defatted peanut kernel and 25 h hydrolysis time.



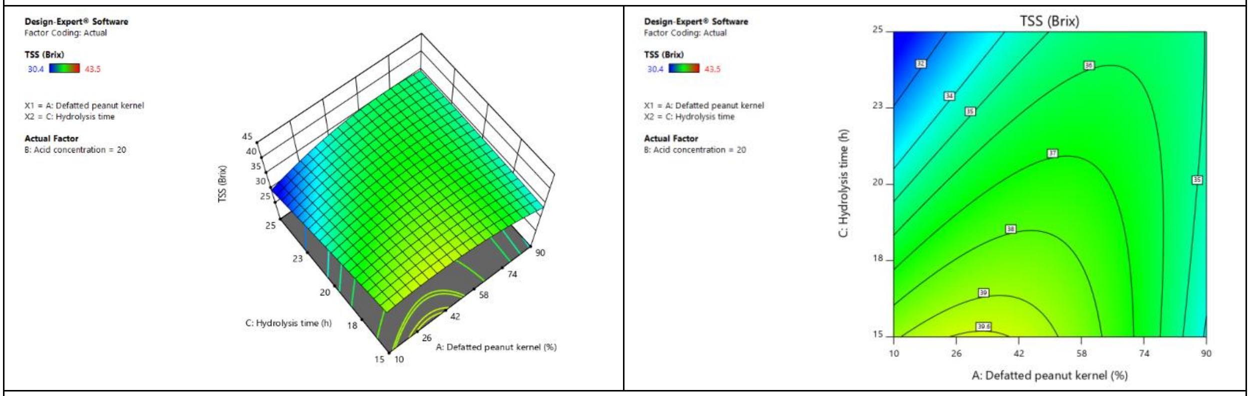


There was increase in titratable acidity with an increase in acid concentration and hydrolysis time relatively up to maximum level, i.e. 25% and 25 h, respectively. The minimum titratable acidity was predicted (1.04%) at the combination of 15% acid concentration and 18 h hydrolysis time and maximum predicted value of titratable acidity (2.01%) was found at 25% acid concentration and 25 h hydrolysis time.

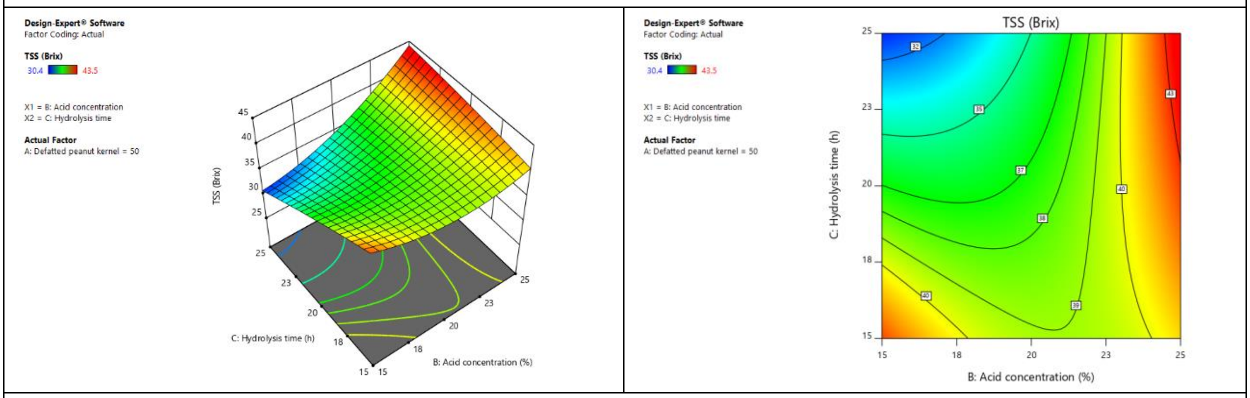
Fig. 2.11. Effect of different process parameters on titratable acidity of peanut sauce (Acid hydrolysis method)



The value of TSS of peanut sauce was increased with an increase in defatted peanut kernel up to certain level, i.e. 44.83% and decreased further with increase in defatted peanut kernel up to its maximum level, i.e. 90%. The value of TSS of peanut sauce was increased with an increase in acid concentration up to its maximum level, i.e. 25%. . The predicted maximum TSS of peanut sauce (42.75 ˚Brix) was obtained at the combination of 44.83% defatted peanut kernel and 25% acid concentration.

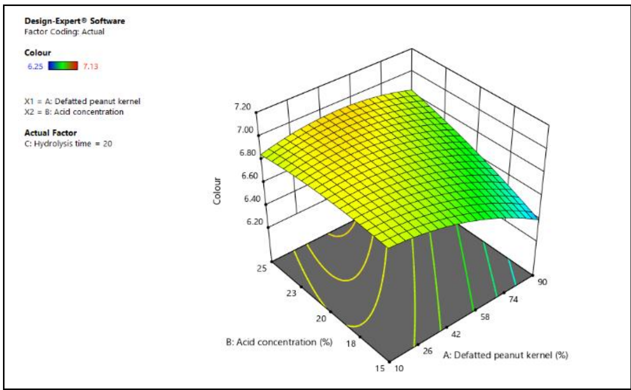


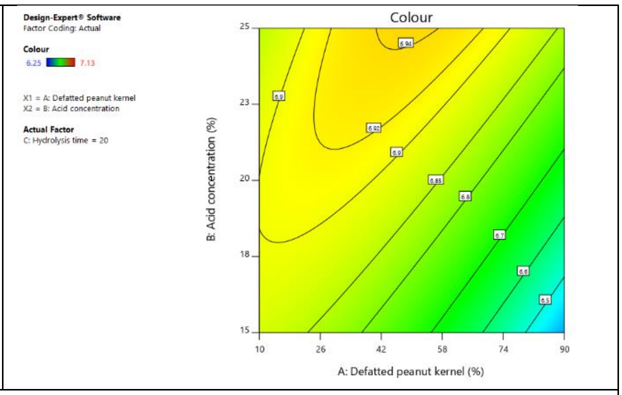
The TSS content of peanut sauce was observed to be increased as the defatted peanut kernel was increased up to certain level, i.e. 32.06% and decreased further with increase in defatted peanut kernel up to its maximum level, i.e. 90%. The TSS was decreased with an increase in hydrolysis time up to maximum level, i.e. 25 h. The maximum predicted value (39.70˚Brix) of TSS was found at the combination of 32.06% defatted peanut kernel and 15 h hydrolysis time.



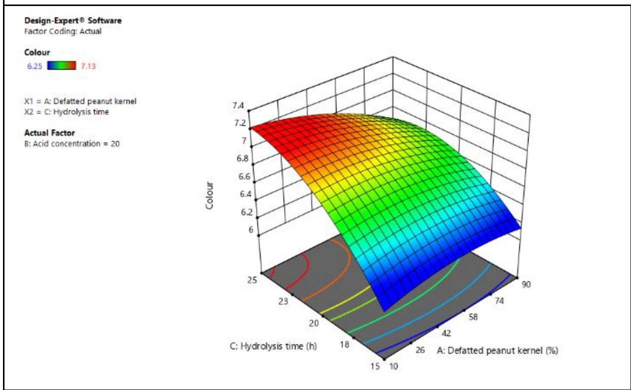
There was increase in TSS with an increase in acid concentration and hydrolysis time relatively up to maximum level, i.e. 25% and 25 h, respectively. The maximum TSS was predicted (44.21 ˚Brix) at the combination of 25% acid concentration and 25 h hydrolysis time. Beyond this combination, TSS content of peanut sauce was found to be decreased.

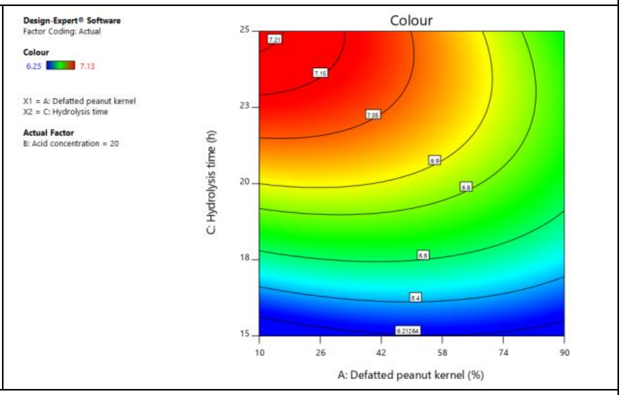
Fig. 2.12. Effect of different process parameters on total soluble solids of peanut sauce (Acid hydrolysis method)



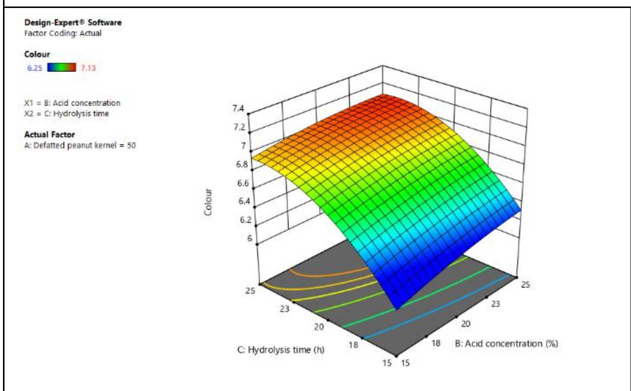


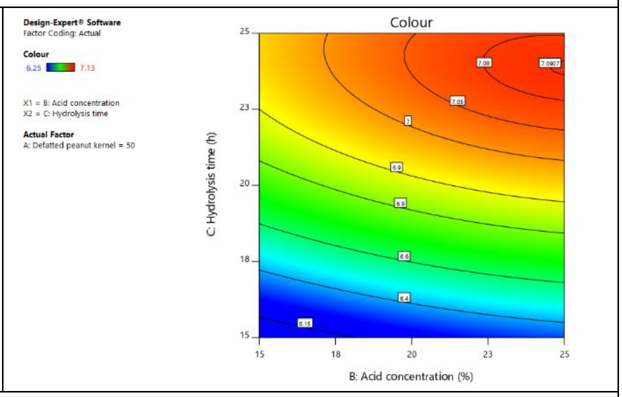
The score of colour was decreased as the percentage of defatted peanut kernel was increased up to its maximum level, i.e. 90%. The sensory score of colour of peanut sauce was increased with increase in acid concentration up to 19.36% and further decreased with increase in acid concentration up to its maximum level, i.e. 25%. The predicted maximum sensory score of colour of peanut sauce (6.94) was found at 48.90% defatted peanut kernel and 25% acid concentration.





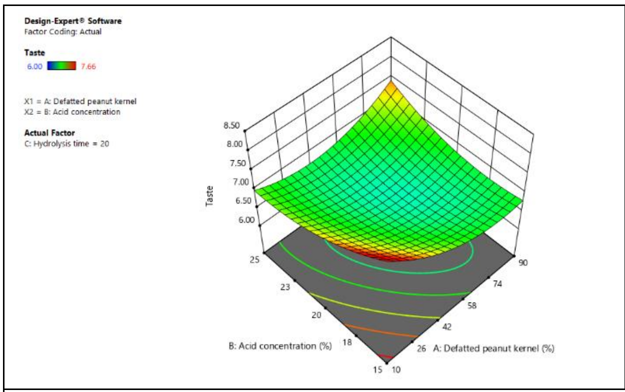
There was increase in sensory score of colour of peanut sauce with an increase in defatted peanut kernel up to 60.52% and further decreased with increase in defatted peanut kernel up to its maximum value, i.e. 90%. The sensory score of colour of peanut sauce was increased with increase in hydrolysis time up to its maximum level, i.e. 25 h. The maximum sensory score of colour of peanut sauce was predicted up to 7.23 at 10 % defatted peanut kernel and 25 h hydrolysis time.

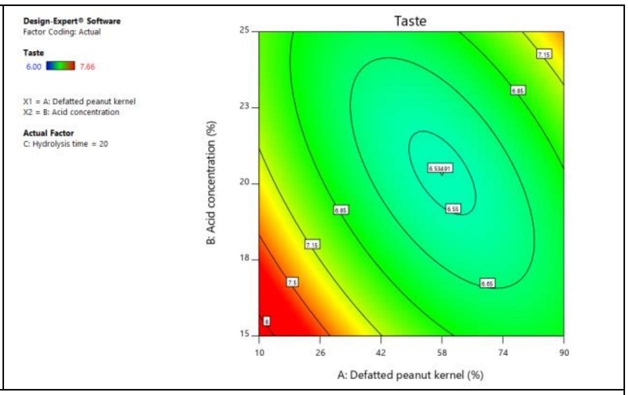




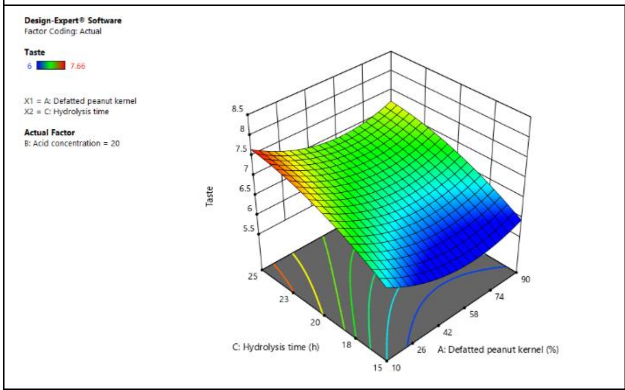
The sensory score of colour of peanut sauce was increased with increase in acid concentration up to its maximum level, i.e. 25%. The sensory score of colour of peanut sauce was increased with increase in hydrolysis time up to its maximum level, i.e. 25 h. Maximum sensory score for colour of peanut sauce was predicted up to 7.09 at 25 % acid concentration and 23.86 h hydrolysis time.

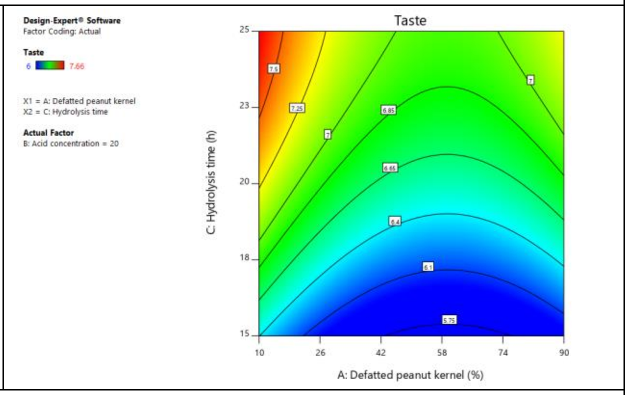
Fig. 2.13. Effect of different process parameters on colour of peanut sauce (Acid hydrolysis method)



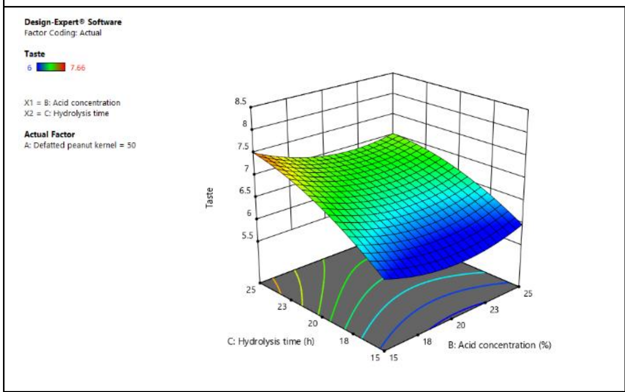


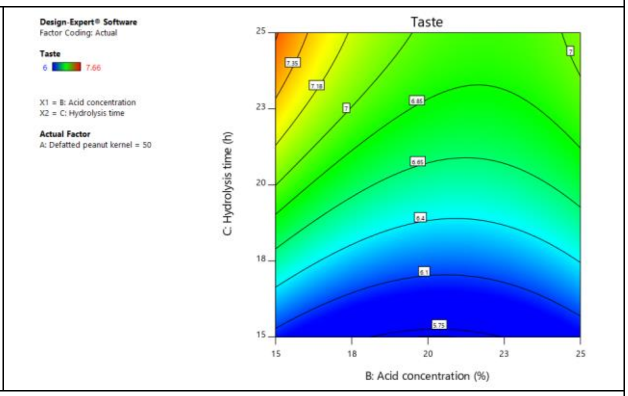
The decremented effect of sensory score of taste up to maximum level of defatted peanut kernel, i.e. 90% and maximum level of acid concentration, i.e. 25% was observed. The predicted maximum tasteful peanut sauce in terms of sensory score (8.15) was found at 10% defatted peanut kernel and 15% acid concentration.





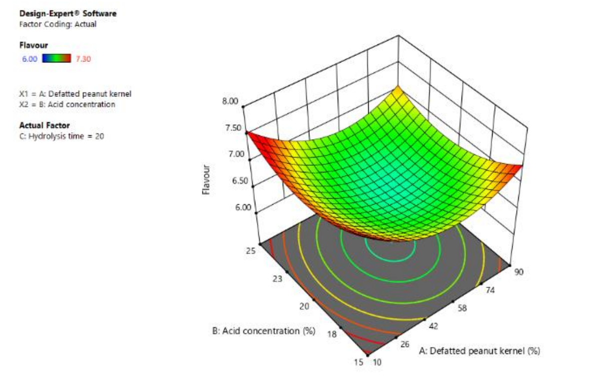
The taste of peanut sauce was decreased with an increase in defatted peanut kernel up to 59.70% and further increased with increase in defatted peanut kernel up to its maximum level, i.e. 90%. The sensory score of taste of peanut sauce was increased with increase in hydrolysis time up to its maximum level, i.e. 25 h. The predicted maximum score of taste of peanut sauce (7.76) was found at 10% defatted peanut kernel and 25 h hydrolysis time.

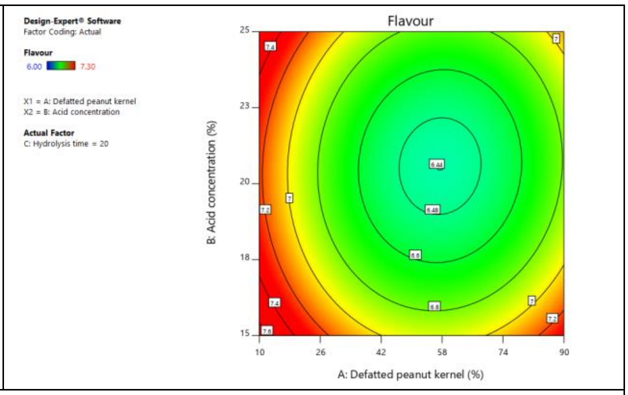




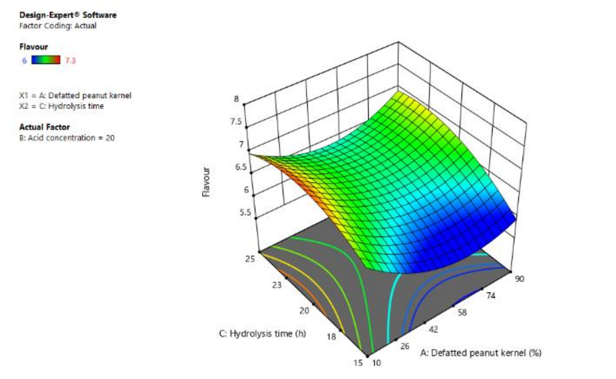
The sensory score of taste of peanut sauce was found to be decreased with increase in acid concentration up to 20.29% and further increased with increase in acid concentration up to its maximum level, i.e. 25%. The sensory score of taste of peanut sauce was increased with increase in hydrolysis time up to its maximum level, i.e. 25 h. The predicted maximum sensory score of taste of peanut sauce (7.51) was found at 15% acid concentration and 25 h hydrolysis time.

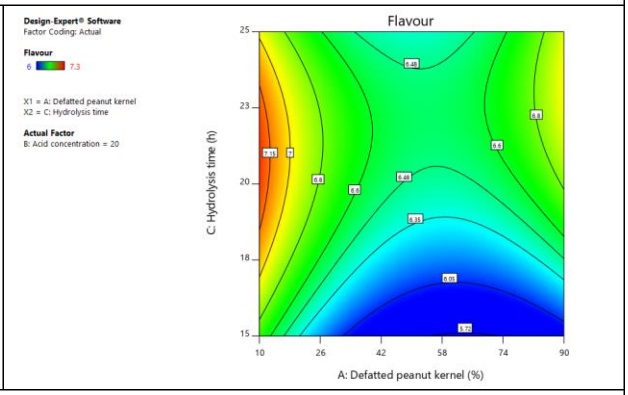
Fig. 2.14. Effect of different process parameters on taste of peanut sauce (Acid hydrolysis method)



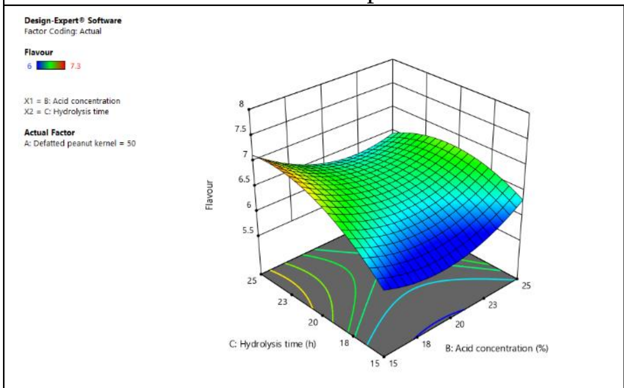


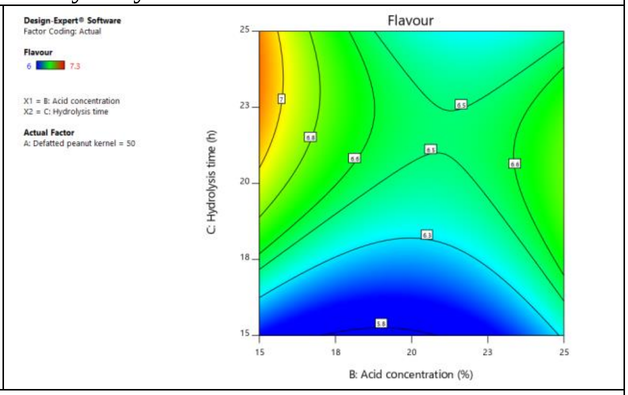
The sensory score of flavour of peanut sauce was decreased with an increase in defatted peanut kernel up to 55.11% and increased with further increase in defatted peanut kernel up to its maximum level, i.e. 90%. Sensory score of flavour of peanut sauce was decreased with increase in acid concentration up to 20.20% and increased with further increase in acid concentration up to its maximum level, i.e. 25%. The predicted maximum sensory score of flavour (7.66) was obtained at the combination of 10% defatted peanut kernel and 15% acid concentration.





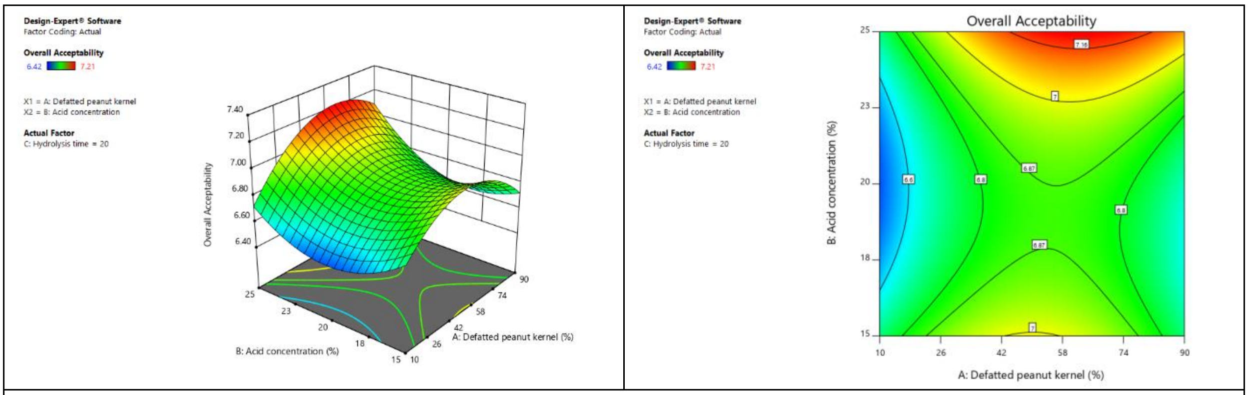
The sensory score of flavour of peanut sauce was decreased as the defatted peanut kernel increased up to certain level, i.e. 63.79% and increased with further increase in defatted peanut kernel up to its maximum level, i.e. 90%. The sensory score of flavour was increased with an increase in hydrolysis time up to certain level, i.e. 20.88 h and decreased with further increase in hydrolysis time up to its maximum level, i.e. 25 h. The maximum sensory score of flavour of peanut sauce was predicted (7.23) at the combination of 10% defatted peanut kernel and 20.88 h hydrolysis.



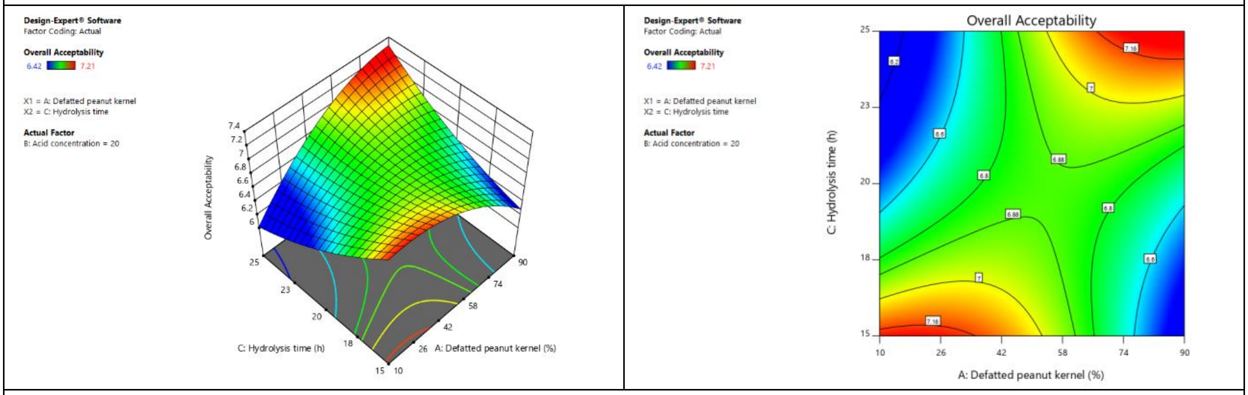


There was decrease in sensory score of flavour of peanut sauce with an increase in acid concentration up to 19.13% and increased with further increase in acid concentration up to its maximum level, i.e. 25%. Increased in sensory score of flavour of peanut sauce with an increase in hydrolysis time up to 23.76 h and decreased with further increase in hydrolysis time up to its maximum level, i.e. 25 h. The maximum predicted value of sensory score of flavour of peanut sauce (7.14) at 15% acid concentration and 23.76 h hydrolysis time.

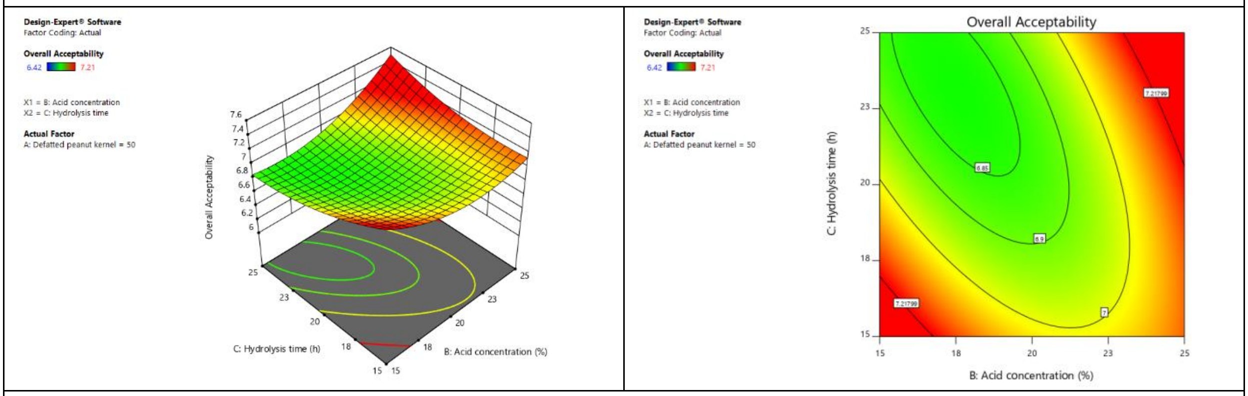
Fig. 2.15. Effect of different process parameters on flavour of peanut sauce (Acid hydrolysis method)



The overall acceptability score of peanut sauce was increased with an increase in percentage of defatted peanut kernel was increased up to 49.88% and decreased with further increase in defatted peanut kernel up to its maximum level, i.e. 90%. Overall acceptability was decreased as increase in acid concentration up to 20% and increased with further increase in acid concentration up to its maximum level, i.e. 25%. The predicted maximum overall acceptability (7.22) was found at 62.81% defatted peanut kernel and 25% acid concentration.



The increase in overall acceptability was observed as the defatted peanut kernel percentage increase up to 19.11% and decreased with further increase in defatted peanut kernel up to its maximum level, i.e. 90%. Sensory score of overall acceptability was decreased with increase in hydrolysis time up to its maximum level, i.e. 25 h. At this combination of 90% defatted peanut kernel and 25 h hydrolysis time, the sensory score of overall acceptability was expected to be increased up to 7.29.



The overall acceptability of peanut sauce was decrease with increased in acid concentration up to 21.10% and further increase in overall acceptability up to its maximum level, i.e. 25%. For hydrolysis time, overall acceptability of peanut sauce was decreased up to 23.47 h and increased further up to its maximum value, i.e. 25 h. Predicted maximum overall acceptability (7.69) was found at 25% acid concentration and 25 h hydrolysis time.

Fig. 2.16. Effect of different process parameters on overall acceptability of peanut sauce (Acid hydrolysis method)

❖ **Optimization and validation of process variables**

The optimum condition for the production of peanut sauce by acid hydrolysis method was determined by the numerical optimization technique, using Design Expert software version 11.

Table 2.10. Constraints, criteria and output for numerical optimization of peanut sauce.

Variables					
Constraint		**Goal**	**Importance**	**Optimum value**	**Experimental value**
Defatted peanut kernel (%)		In the range	3	90.000	90.00
Acid concentration (%)		In the range	3	16.542	16.50
Hydrolysis time (h)		In the range	3	25.000	25.00
Responses					
Constraint	**Goal**	**Importance**	**Predicted value**	**Experimental value**	**Deviation (%)**
Viscosity	None	3	0.50	0.47	6.00
Sp. Gravity	None	3	1.18	1.23	4.24
True protein	Maximum	3	3.99	4.07	2.00
Total nitrogen	Maximum	3	1.94	1.88	3.09
Free amino acid	Maximum	3	30.62	31.76	3.72
Total phenol	Maximum	3	5.97	5.75	3.67
Total sugar	None	3	1.01	1.07	5.94
Reducing sugar	None	3	0.98	0.93	5.10
Salt content	None	3	18.80	18.93	0.69
Titratable acidity	None	3	1.32	1.37	3.79
TSS	None	3	32.14	34.21	6.44
Colour	None	3	6.53	6.69	2.45
Taste	None	3	7.23	7.37	1.94
Flavour	None	3	7.39	7.63	3.25
Overall acceptability	Maximum	3	7.12	7.47	4.91

❖ **Quality comparison developed peanut sauce with different commercial standards**

The important physico-chemical parameters of developed peanut sauce *viz*. Total Soluble Solids, titratable acidity, total nitrogen, specific gravity and salt content were compared with the commercial standards of soy sauce as laid down by different food standardizing authorities like Food Safety and Standards Authority of India (FSSAI), Food and Agriculture Organization (FAO) and United Arab Emirates (UAE) to check its commercial viability (Table 11).

Table 2.11. Comparison of quality parameters of developed peanut sauce with different commercial standards of soy sauce.

Standard	**Standard of soy sauce**	**Value for developed peanut sauce**
TSS (FSSAI)	Not less than 25˚Brix	34.21˚Brix
Titratable acidity (FSSAI)	Not less than 0.6%	1.37%

Total nitrogen (FSSAI)	Not less than 1%	1.88%
Specific gravity (FAO & UAE standard)	Minimum 1.22	1.23
Salt (FAO & UAE standard)	Min. 10% & Max. 50%	18.93%

10.1.2 Fermentation process

10.1.2.1 Materials and Methods (Fermentation process)

❖ **Raw material**

- **Defatted peanut cake and wheat**

Defatted peanut cake and wheat are the basic raw materials required in the preparation of peanut sauce.

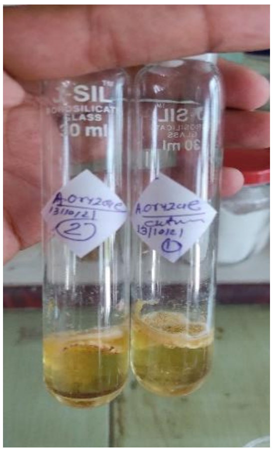
Defatted peanut cake

Wheat

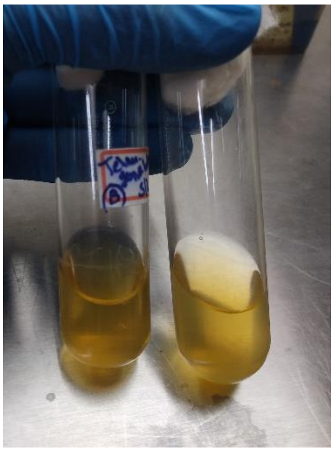
Plate 2.6. Defatted peanut cake and wheat grains used for peanut sauce preparation

- **Microbial cultures**

Three different microbial cultures, *viz. Aspergillus oryzae* (koji mold), *Pediococcus halophilus* (lactic acid bacteria) and *Saccharomyces rouxii* (osmophilic yeast) presently used in the soy sauce production were purposively used in the preparation of fermented peanut sauce.



Aspergillus oryzae



Pediococcus halophilus

Saccharomyces rouxii

Plate 2.7. Stock solution of microbial cultures used in the fermentation process.

❖ Methodology

- **Roasting of wheat**

Roasting of wheat was carried out at 180°C for few minutes till all grains are roasted appropriately and crushed slightly to obtain approximately 4 to 5 pieces per kernel.

Roasted wheat grains

Crushed pieces of roasted wheat

Plate 2.8. Roasting and crushing of wheat preparation of peanut sauce through fermentation process.

- **Soaking of defatted peanut cake**

Soaking of defatted peanut cake was carried out at room temperature for 12 h to attain 60% moisture content followed by autoclaving at 121°C for 30 min.

Defatted peanut cake flour

Sample after soaking

Autoclaving of samples

Sample after autoclaving

Plate 2.9. Soaking and autoclaving of defatted peanut cake flour

- **Peanut sauce preparation**

The process flow chart for the preparation of peanut sauce through fermentation process is presented in the Fig. 2 and the procedural steps are explained in detail as under. The koji fermentation was carried out with 0.1% (w/w) of *Aspergillus oryzae*. It was followed by brine fermentation carried out using lactic acid bacterium and yeast named as *Pediococcus halophiIus* and *Saccharomyces rouxii*, respectively. The fermented peanut sauce was filtered using muslin cloth and pasteurized at 85°C for 15 min for to stop the microbial growth. The pasteurized peanut sauce was again filtered using muslin cloth and stored in the glass bottles. The procedural photographs of the process are given in the Plate 2.9.

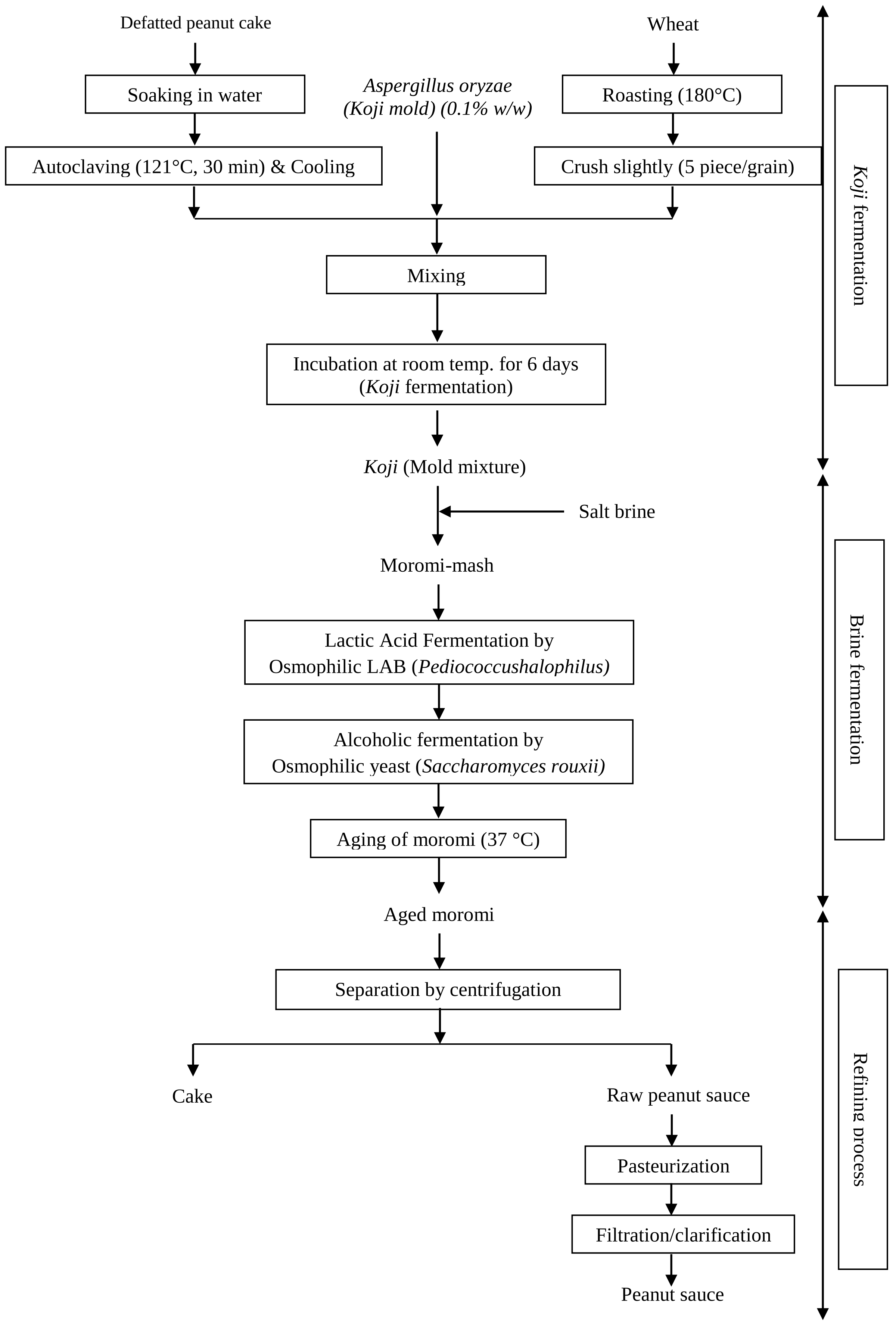


Fig. 2.17. Process flow chart for preparation of peanut sauce (Lee and Khor, 2015)

Mixture of defatted peanut cake flour and roasted wheat powder

Koji mass after koji fermentation

Mixture of koji mass and brine solution

Fermentation of sample

Sample after fermentation

Peanut sauce

Plate 2.10. Preparation of peanut sauce through fermentation process

- **Experimental design**

The experiment was designed as per the Central Composite Rotatable Design (CCRD) of Response Surface Methodology (RSM).

Table 2.12. Coded and uncoded values of independent parameters.

Sr. No.	Parameters	Code	Coded levels				
			-1.414	**-1**	**0**	**+1**	**+1.414**
1	Defatted peanut cake flour (%)	(X_1)	10	21.72	50	78.28	90
2	Brine fermentation time (days)	(X_4)	30	52	105	158	180

Table 2.13. Matrix of experimental central composite rotatable design for peanut sauce preparation

Treatment No.	Type	Coded variables		Uncoded variables	
		X_1	X_2	Defatted peanut cake flour (%)	Brine fermentation time (days)
1	Fact	-1	-1	21.72	52
2	Fact	1	-1	78.28	52
3	Fact	-1	1	21.72	158
4	Fact	1	1	78.28	158
5	Axial	-1.41	0	10.00	105
6	Axial	1.41	0	90.00	105
7	Axial	0	-1.41	50.00	30
8	Axial	0	1.41	50.00	180
9	Center	0	0	50.00	105
10	Center	0	0	50.00	105
11	Center	0	0	50.00	105
12	Center	0	0	50.00	105
13	Center	0	0	50.00	105
14	Center	0	0	50.00	105

❖ **Observations recorded**

Sr. No.	Parameter	Method	Reference
Biochemical parameters of defatted peanut and wheat			
1	True protein (%)	Spectrophotometric method	Lowry *et al.* (1951)
2	Total sugar (%)	Phenol sulphuric acid method	Sadasivam and Manickam (1996)
3	Reducing sugar (%)	Nelson Somogyi method	Sadasivam and Manickam (1996)
4	Oil (%)	Soxhlet method	AOAC (2012)
5	Moisture content (%wb)	Ho air oven method	AOAC (2012)
6	Total carbohydrate	Phenol sulphuric acid method	Dubois *et al.* (1956)
7	Total Ash	Muffle furnace	AOAC (2005)
Quality Analysis of peanut sauce			
1. Physical parameters			
1	Viscosity (cP)	Using viscometer	Ranganna (2000)
2	Specific gravity	$\frac{Density\ of\ peanut\ sauce}{Density\ of\ water}$	Judoamidjojo *et al* (1985)
2. Biochemical parameters			
1	True protein (%)	Spectrophotometric method	Lowry *et al.* (1951)
2	Total Nitrogen (g/kg)	Micro Kjedahl method	AOAC (2005)
3	Free amino acid (mg/ml)	Spectrophotometric method	Moore and Stein (1984)
4	Total sugar (%)	Phenol sulphuric acid method	Dubois *et al.* (1956)

5	Reducing sugar (%)	Nelson Somogyi method	Somogyi (1952)
6	pH	pH meter	Ranganna (2000)
7	Total Phenol (mg/100g)	Spectrophotometric method	Malick and Singh (1980)
8	Salt content (ppm)	TDS (Total Dissolved Solids) method	Ranganna (2000)
9	Titratable acidity (%)	Titration method	Ranganna (2000)
10	Total Soluble Solids (˚Brix)	Digital refractometer	Nyasordzi *et al*. (2013)
3. Microbiological parameters			
1	Total plate count	Standard method	-
2	Lactic acid bacteria	Standard method	-
3	Yeast and mould count	Standard method	-
4. Sensory parameters			
1	Colour	9-point hedonic scale method (Amerine et al., 1965)	
2	Taste (Saltiness, Pungency, Umami)		
3	Flavour/odour/aroma		
4	Overall acceptability		

❖ **Optimization of process variables**

The optimization of process variables was carried out by using Design Expert version 11 software. The optimum values of the selected variables were analyzed by the response surface contour plots and also by solving the regression equation.

10.1.2.2 Results and Discussion (Fermentation process)

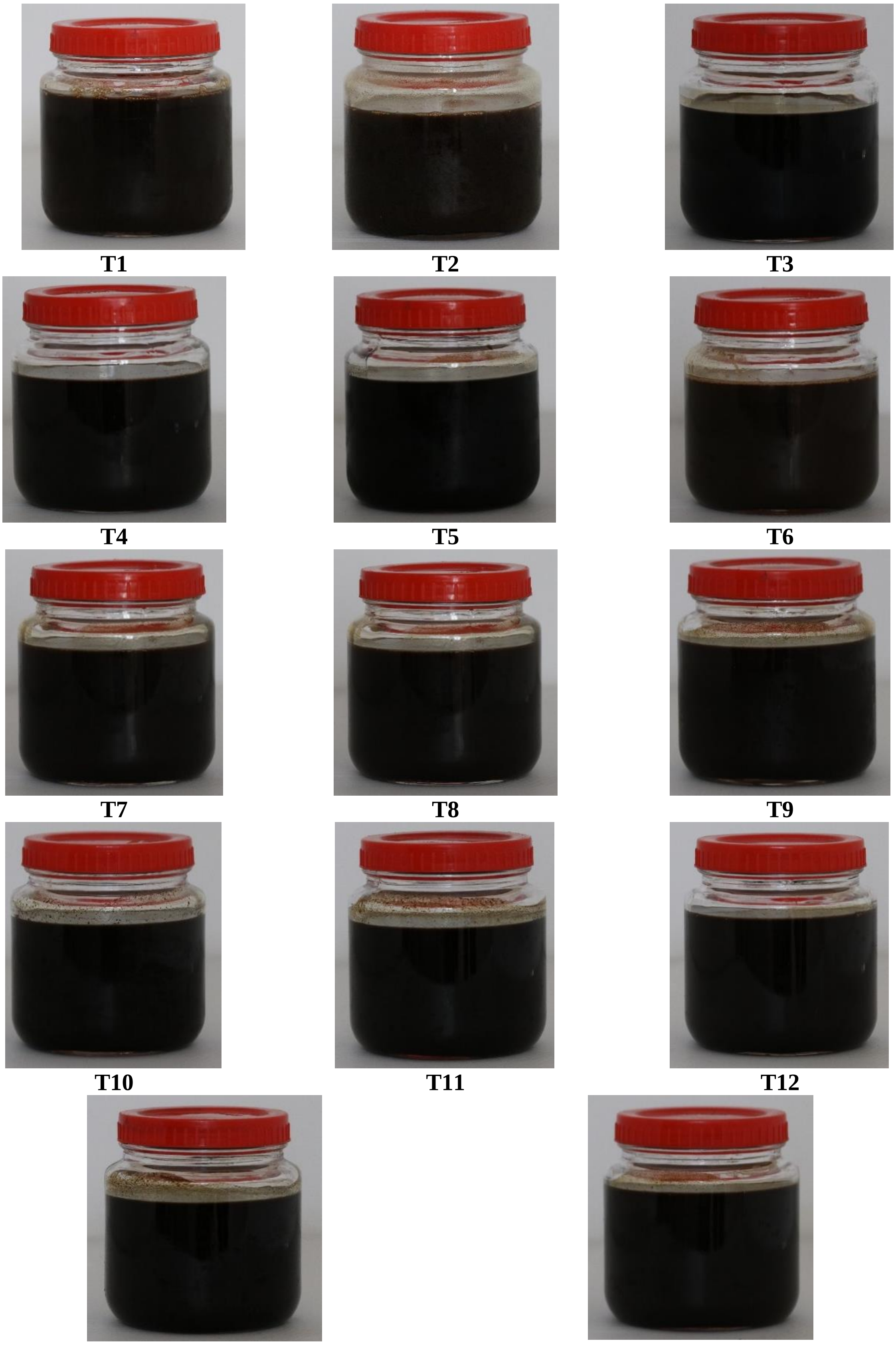
❖ **Proximate composition of defatted peanut cake and wheat**

Table 2.14. Proximate composition of defatted peanut cake and wheat.

Parameters	Average value	
	Defatted peanut cake	**Wheat**
True protein (%)	37.42±0.30	13.44±1.92
Total sugar (%)	5.19±1.21	5.52±1.14
Reducing sugar (%)	0.22±1.04	0.08±1.69
Oil (%)	8.02±1.24	2.56±1.96
Moisture content (%)	8.33±0.26	9.67±0.07
Carbohydrates (%)	14.20	64.72±1.06
Total Ash (%)	4.39±0.54	4.42±1.57

❖ **Physicochemical, microbiological and sensory characteristics of peanut sauce prepared through fermentation process**

Samples of peanut sauce obtained by different treatments using fermentation technology are shown in the Plate 10.



T1 **T2** **T3**

T4 **T5** **T6**

T7 **T8** **T9**

T10 **T11** **T12**

T13 **T14**

Plate 2.11. Samples of peanut sauce obtained by different treatments using fermentation technology

Table 2.15. Physical properties of peanut sauce prepared through fermentation process.

Treatment no.	Defatted peanut cake flour (%)	Brine fermentation time (days)	Viscosity (cP)	Specific gravity
1	21.72	52	2.04	1.1202
2	78.28	52	2.73	1.1389
3	21.72	158	2.25	1.1400
4	78.28	158	2.58	1.1200
5	10.00	105	1.82	1.1084
6	90.00	105	2.94	1.1232
7	50.00	30	2.29	1.1447
8	50.00	180	2.52	1.1400
9	50.00	105	2.13	1.1341
10	50.00	105	2.22	1.1352
11	50.00	105	2.14	1.1320
12	50.00	105	1.95	1.1321
13	50.00	105	2.08	1.1301
14	50.00	105	1.99	1.1373

Table 2.16. Biochemical properties of peanut sauce prepared through fermentation process.

Treatment no.	Defatted peanut cake flour (%)	Brine fermentation time (days)	True Protein (%)	Total N_2 (%)	Free Amino Acids (%)	Total Sugar (%)	Reducing Sugar (%)	pH	Total Phenol (%)	Salt (ppm)	Titratable Acidity (%)	TSS (˚Brix)
1	21.72	52	4.96	0.38	2.780	17.23	1.112	4.78	0.2142	1.67	3.39	36.00
2	78.28	52	5.90	13.36	1.650	3.00	0.899	5.03	0.2356	1.56	3.35	35.00
3	21.72	158	6.52	7.95	3.350	13.21	1.062	4.50	0.2879	1.31	3.57	37.00
4	78.28	158	16.98	15.44	5.090	1.52	0.423	4.93	0.3254	1.46	3.75	36.50
5	10.00	105	4.69	2.35	1.990	17.00	0.912	4.56	0.2546	1.52	2.28	35.00
6	90.00	105	13.22	17.22	2.510	1.47	0.289	5.26	0.3136	1.90	2.88	34.00
7	50.00	30	3.42	5.01	2.110	7.84	1.155	4.85	0.1727	1.26	2.82	37.00
8	50.00	180	12.23	12.32	4.870	5.78	0.795	4.80	0.3256	1.17	4.05	37.50
9	50.00	105	4.53	11.25	3.120	7.21	1.142	4.87	0.3721	1.03	3.38	36.00
10	50.00	105	4.57	11.35	2.620	7.67	1.156	4.70	0.3658	1.05	3.37	37.00
11	50.00	105	4.78	11.12	2.760	6.63	1.178	4.69	0.3546	1.06	3.41	37.00
12	50.00	105	4.65	11.31	2.830	7.99	1.098	4.80	0.3789	1.06	3.25	36.00
13	50.00	105	4.77	11.17	3.020	7.48	1.151	4.69	0.3878	1.01	3.41	36.05
14	50.00	105	4.71	11.29	2.690	6.54	1.102	4.78	0.3524	1.02	3.42	35.00

Table 2.17. Microbiological parameters of peanut sauce prepared through fermentation process.

Treatment no.	Defatted peanut cake flour, %	Brine fermentation time, days	Total plate count, log(CFU/g)	Lactic acid bacteria, log(CFU/g)	Yeast and mould count, log(CFU/g)
1	21.72	52	0.000	6.531	1.477
2	78.28	52	3.954	3.000	0.000
3	21.72	158	0.000	6.633	1.602
4	78.28	158	3.699	4.301	2.477
5	10	105	1.778	5.079	1.301
6	90	105	3.954	5.623	2.000
7	50	30	3.903	5.857	0.000
8	50	180	1.602	4.301	1.699
9	50	105	0.000	5.949	1.602
10	50	105	0.000	6.924	1.000
11	50	105	0.000	6.079	1.301
12	50	105	0.000	5.519	1.265
13	50	105	0.000	6.556	1.342
14	50	105	0.000	6.591	1.477

Table 2.18. Sensory characteristics of peanut sauce prepared through fermentation process.

Treatment no.	Defatted peanut cake flour (%)	Brine fermentation time (days)	Colour	Taste	Flavour	Overall acceptability
1	21.72	52	6.52	7.13	6.52	6.42
2	78.28	52	6.68	7.13	6.74	6.54
3	21.72	158	6.82	7.13	7.19	6.85
4	78.28	158	6.94	6.31	6.19	6.81
5	10	105	7.02	6.81	6.81	6.82
6	90	105	*6.76*	*6.63*	*6.52*	6.79
7	50	30	5.82	6.13	5.88	6.08
8	50	180	6.88	6.19	7.06	6.66
9	50	105	7.06	7.31	7.19	6.82
10	50	105	7.18	6.06	6.38	6.75
11	50	105	6.71	6.19	6.13	6.69
12	50	105	6.12	6.50	6.63	6.80
13	50	105	6.00	5.75	5.94	6.67
14	50	105	6.47	6.06	6.25	6.71

Table 2.19. Analysis of variance (ANOVA) and regression coefficients for response surface quadratic model of physical properties of peanut sauce prepared through fermentation process.

Source	Viscosity (cP)	Specific gravity
Intercept	2.09	1.13
Linear terms		
A (X_1)	+0.3267***	+0.0025*
B (X_2)	+0.0471	-0.0007*
Interaction terms		
AB (X_1X_2)	-0.0913	-0.0097
Quadratic terms		
A^2 (X_1^2)	+0.1481**	-0.0087*
B^2 (X_2^2)	+0.1622**	+0.0046
Indicators for model fitting		
R^2	0.9249	0.9197
Adj-R^2	0.8779	0.8696
Pred-R^2	0.6853	0.5777
Adeq Precision	12.6004	13.1773
F-value	19.70	18.33
Lack of fit	NS	NS
C.V. %	4.95	0.3183

A or X_1= Defatted peanut cake flour, B or X_2= brine fermentation time, ***Significant at p<0.001, **Significant at p<0.01, *Significant at p<0.05, S = Significant, NS = Non-significant

Table 2.20. Analysis of variance (ANOVA) and regression coefficients for response surface quadratic model of biochemical properties of peanut sauce prepared through fermentation process.

Source	True protein (%)	Total nitrogen (%)	Free amino acid (%)	Total sugar (%)	Reducing sugar (%)	pH	Total phenol (%)	Salt content (%)	Titratable acidity (%)	TSS (°Brix)
Intercept	4.67	11.25	2.87	7.25	1.14	4.76	0.3709	1.04	3.37	36.18
Linear terms										
A (X_1)	2.93***	5.19***	0.2346	-5.99***	-0.2166***	0.2087***	-0.0182	0.0721*	0.1244	-0.3643
B (X_2)	3.14***	2.50***	0.9924***	-1.05**	-0.1295***	-0.0563	-0.1013***	-0.0739*	0.2909*	0.4009
Interaction term										
AB (X_1X_2)	2.38***	-1.37***	0.6907*	0.6343	-0.1065**	0.0450	0.0150	0.0650	0.0546	0.1250
Quadratic terms										
A^2 (X_1^2)	2.19***	-0.7173***	-0.1918	1.17**	-0.2471***	0.0631	-0.0274	0.3454***	-0.2703*	-0.7750*
B^2 (X_2^2)	1.63***	-1.28***	0.4218	-0.0419	-0.0598*	0.0206	-0.0853***	0.0984**	0.1576	0.6000*
Indicators for model fitting										
R^2	0.9991	0.9995	0.8328	0.9824	0.9807	0.8771	0.9396	0.9534	0.6728	0.7507
Adj-R^2	0.9986	0.9992	0.7283	0.9715	0.9687	0.8003	0.9018	0.9243	0.4683	0.5949
Pred-R^2	0.9952	0.9972	0.5124	0.9054	0.8904	0.4550	0.6951	0.6836	-1.2784	0.4181
Adeq Precision	132.295	193.4684	9.6801	31.2140	26.4080	11.6284	15.1398	15.3350	7.0933	9.0506
F-value	1836.51	3210.38	7.97	89.54	81.51	11.42	24.87	32.77	3.29	4.82
Lack of fit	NS	NS	NS	NS	NS	NS	NS	S	S	NS
C.V. %	2.27	1.32	18.20	10.49	5.19	1.77	11.05	6.12	9.40	1.79

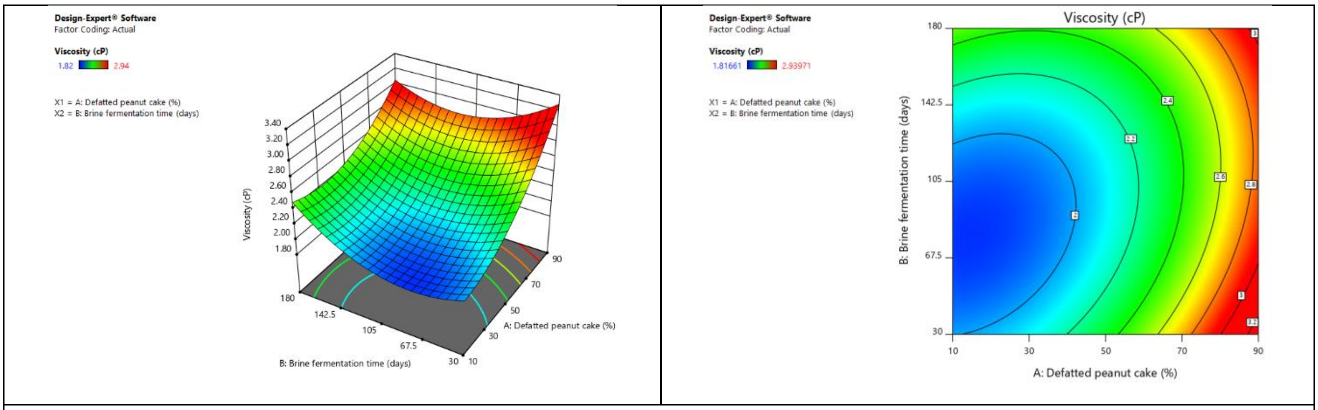
A or X_1= Defatted peanut cake flour, B or X_2= brine fermentation time, ***Significant at $p<0.001$, **Significant at $p<0.01$, *Significant at $p<0.05$, S = Significant, NS = Non-significant

Table 2.21. Analysis of variance (ANOVA) and regression coefficients for response surface quadratic model of sensory characteristics of peanut sauce prepared through fermentation process.

Source	Colour	Taste	Flavour	Overall acceptability
Intercept	6.59	6.31	6.42	6.74
Linear terms				
A (X_1)	-0.0104	-0.1347	-0.1492	0.0047
B (X_2)	0.2578	-0.0905	0.2239	0.1900***
Interaction term				
AB (X_1X_2)	-0.0106	-0.2031	-0.3050	-0.0400
Quadratic terms				
A^2 (X_1^2)	0.1817	0.3242	0.1478	0.0494
B^2 (X_2^2)	-0.0880	0.0430	0.0484	-0.1681***
Indicators for model fitting				
R^2	0.3874	0.3547	0.4596	0.9447
Adj-R^2	0.0045	-0.0486	0.1218	0.9102
Pred-R^2	-0.3654	-0.9889	-0.5634	0.7981
Adeq Precision	3.4155	2.6834	4.1141	17.4070
F-value	1.01	0.8794	1.36	27.34
Lack of fit	NS	NS	NS	NS
C.V. %	6.19	7.86	6.22	0.94

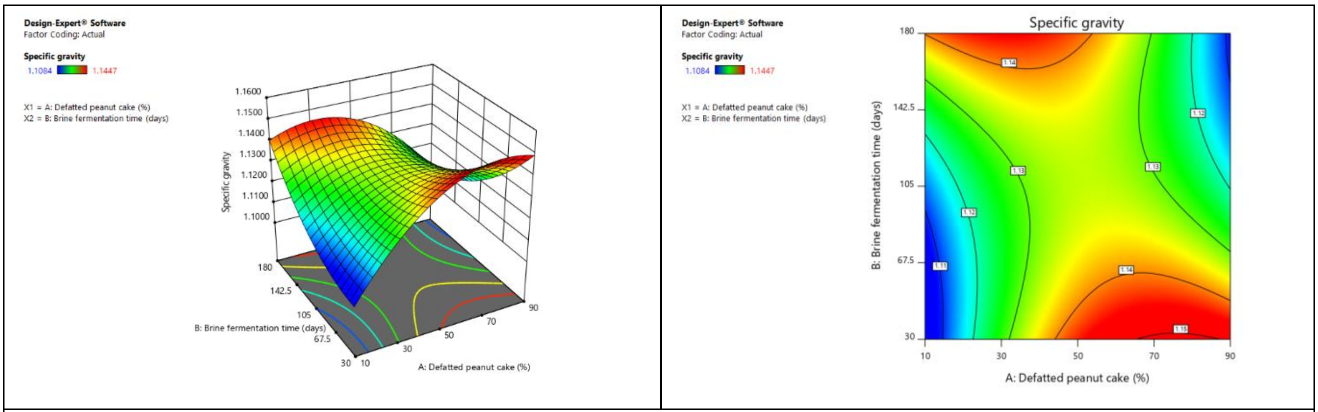
A or X_1= Defatted peanut cake flour, B or X_2= brine fermentation time, ***Significant at $p<0.001$, **Significant at $p<0.01$, *Significant at $p<0.05$, S = Significant, NS = Non-significant

❖ Response Surface Analysis (Fermentation process)



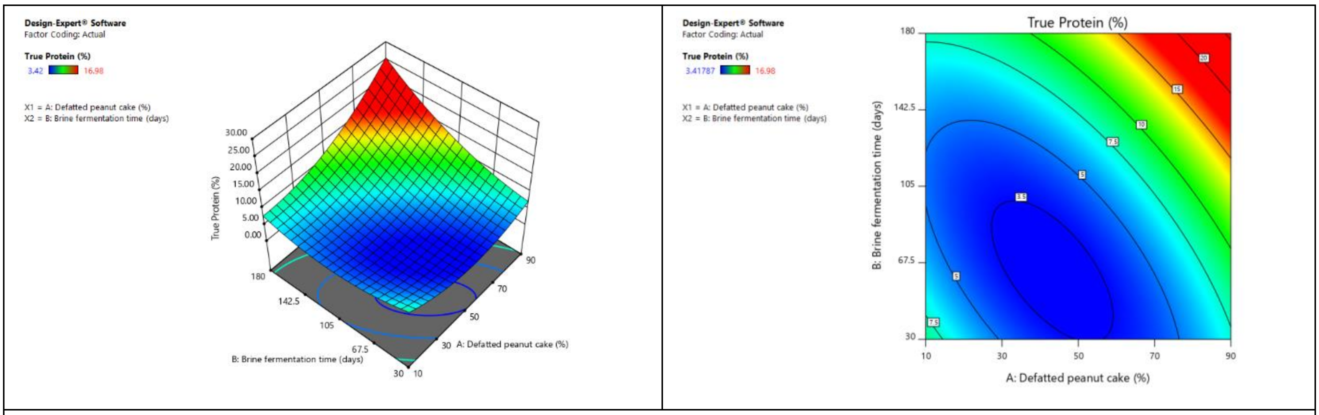
The viscosity was increased as the percentage of defatted peanut cake flour was increased. The viscosity was expected to be decreased up to 75 days of brine fermentation time. Further increase in brine fermentation time, it was observed to be increased. The predicted minimum viscosity (1.87 cP) was obtained at the combination of 14.18% defatted peanut cake flour and 78 days of brine fermentation time.

Fig. 2.18. Effect of different process parameters on viscosity of peanut sauce (Fermentation process)



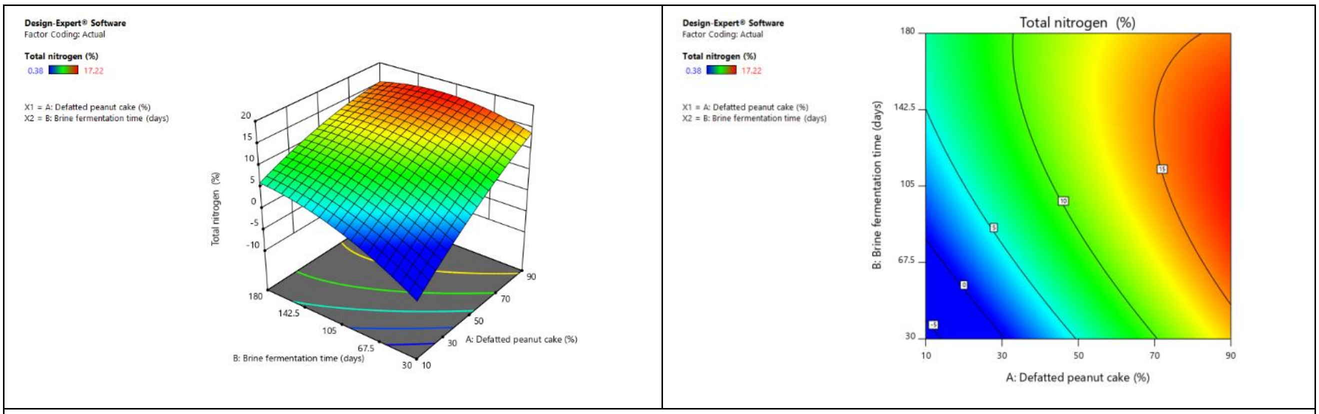
The specific gravity was increased as the percentage of defatted peanut cake flour percentage was increased up to 74% and further decreasing trend was found with increase in defatted peanut cake flour percentage. It's also indicated that the specific gravity increased as brine fermentation time was increased up to 180 days. The predicted maximum specific gravity (1.1510) was obtained at the combination of 78.74% defatted peanut cake flour and 30 days of brine fermentation time.

Fig. 2.19. Effect of different process parameters on specific gravity of peanut sauce (Fermentation process)



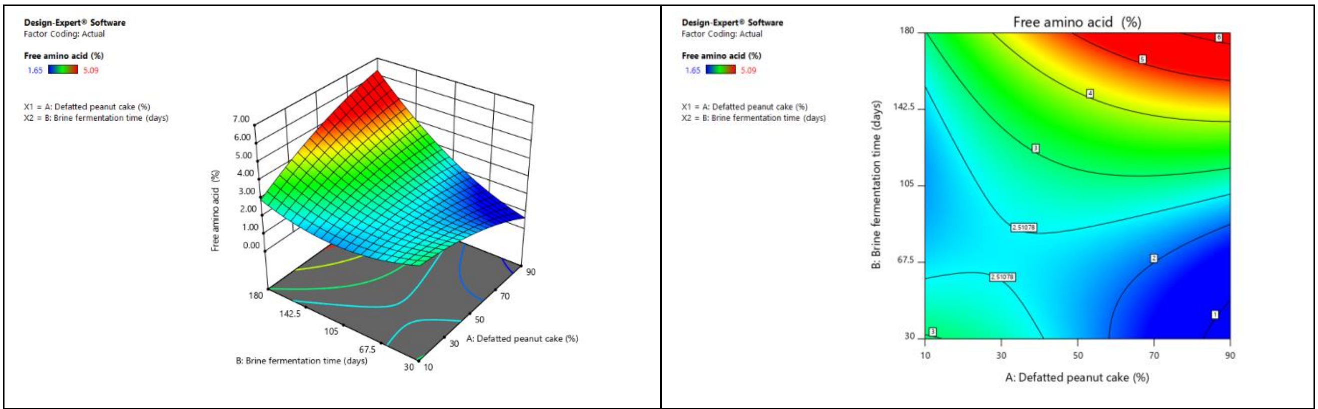
The true protein of peanut sauce decreased with increase in defatted peanut cake flour and brine fermentation time up to 53% and 110 days, respectively. Then true protein increased with further increase in defatted peanut cake flour and brine fermentation time. The maximum predicted true protein of peanut sauce was observed (25.60%) at the combination of 90% defatted peanut cake flour and 180 days brine fermentation time.

Fig. 2.20. Effect of different process parameters on true protein of peanut sauce (Fermentation process)



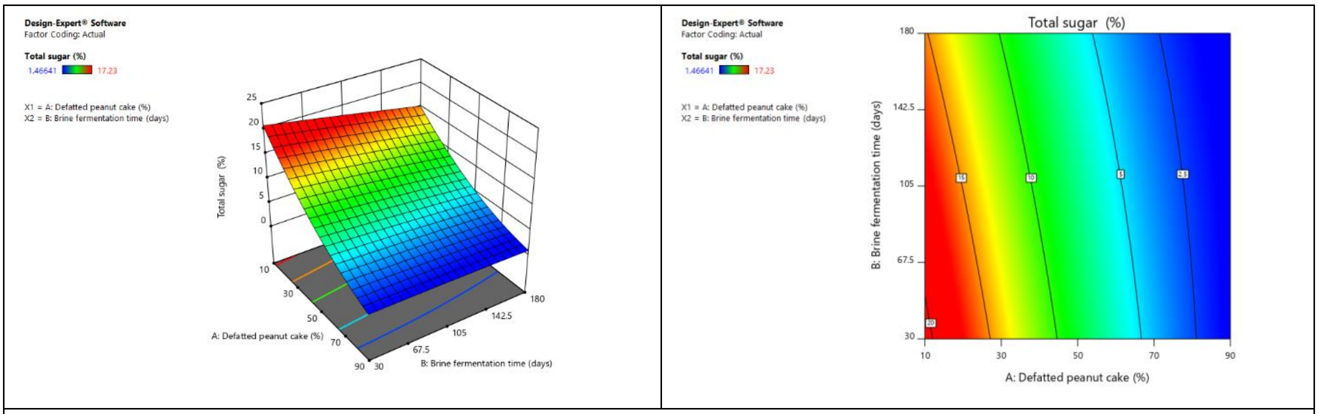
The total nitrogen of peanut sauce increased with an increase in defatted peanut cake flour and brine fermentation time. The predicted maximum total nitrogen (17.22%) would be obtained at the combination of 90% defatted peanut cake flour and 117 days of brine fermentation time.

Fig. 2.21. Effect of different process parameters on total nitrogen of peanut sauce (Fermentation process)



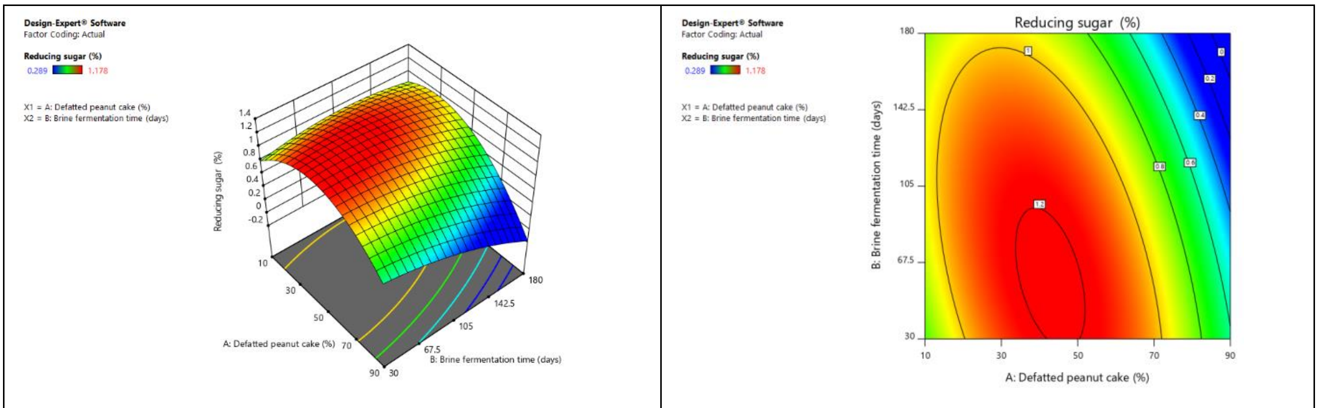
The decremented effect of free amino acid was observed up to 105 days of brine fermentation days. Beyond this, the free amino acid was observed to be increased up to the maximum level, i.e. 180 days. It can be observed that the free amino acid of peanut sauce decreased with an increase in defatted peanut cake The predicted maximum free amino acid (6.30%) was found at 90% defatted peanut cake and 180 days of brine fermentation time.

Fig. 2.22. Effect of different process parameters on free amino acid content of peanut sauce (Fermentation process)



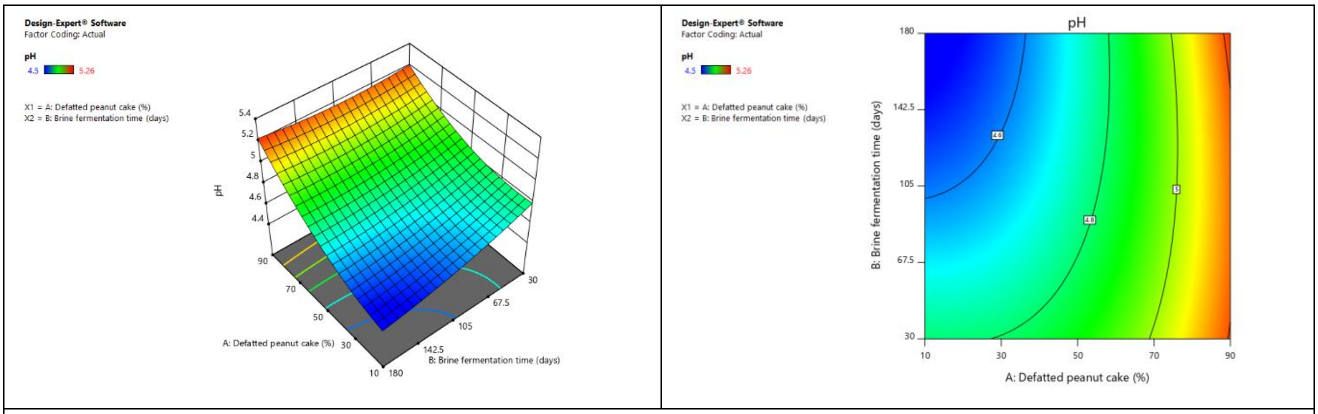
The total sugar was decreased as the percentage of defatted peanut cake flour and brine fermentation time was increased. The predicted maximum total sugar (20.68%) was obtained at the combination of 10% defatted peanut cake flour and 30 days of brine fermentation time.

Fig. 2.23. Effect of different process parameters on total sugar of peanut sauce (Fermentation process)



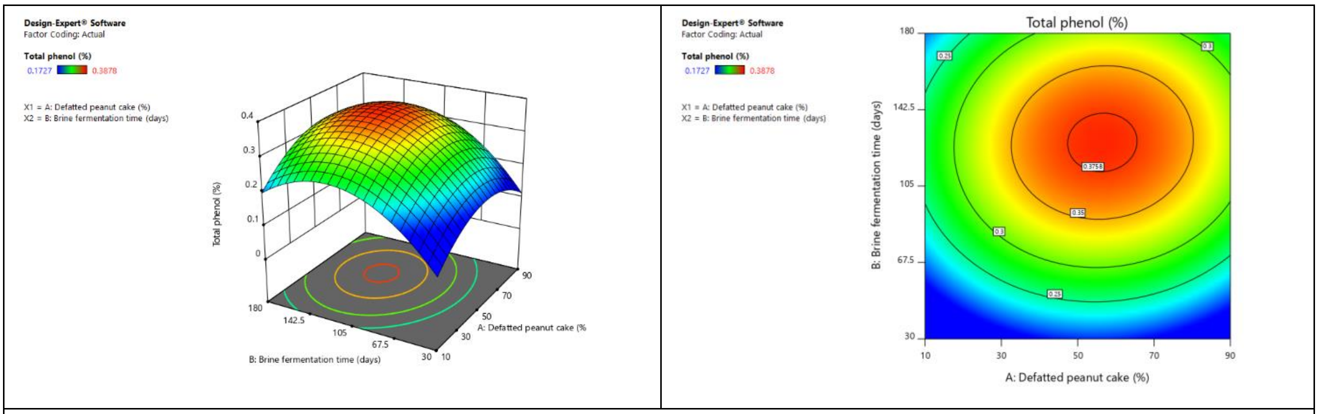
The value of reducing sugar of peanut sauce increased as the defatted peanut cake flour percentage was increased up to 45% but further decreased with increase in defatted peanut cake flour up to maximum level, i.e. 90%. Similarly reducing sugar of peanut sauce increased with increase in brine fermentation time up to its 105 days then decreased with increase in brine fermentation time up to maximum level, i.e. 180 days. The predicted maximum reducing sugar (1.22%) was obtained at the combination of 43% defatted peanut cake flour and 60 days of brine fermentation time.

Fig. 2.24. Effect of different process parameters on reducing sugar of peanut sauce (Fermentation process)



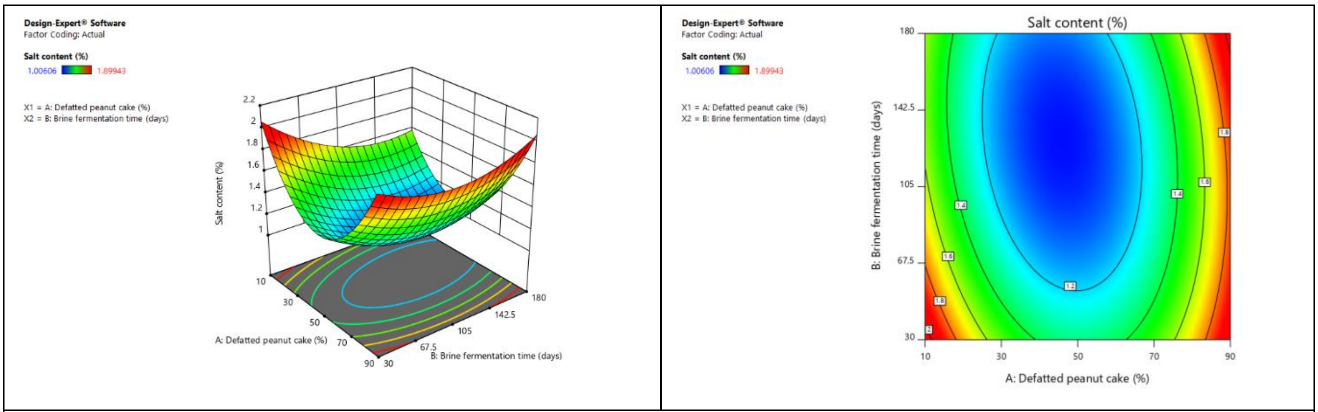
The value of pH of peanut sauce increased as percentage of defatted peanut cake flour was increased. In opposite way, pH of peanut sauce decreased with increase in brine fermentation time. The predicted minimum pH (4.46) was obtained at the combination of 10% defatted peanut cake flour and 180 days of brine fermentation time.

Fig. 2.25. Effect of different process parameters on pH of peanut sauce (Fermentation process)



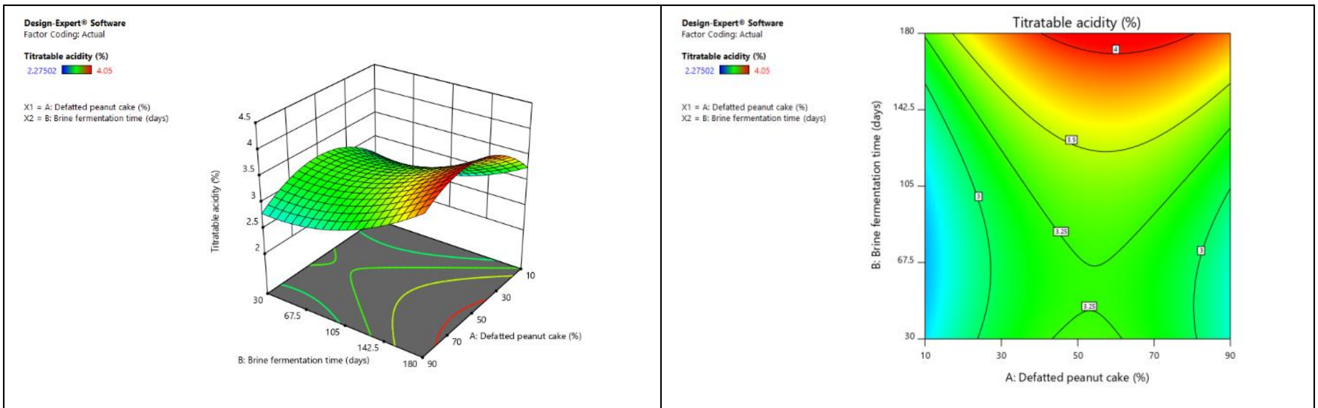
The total phenol content was found to be increased as the percentage of defatted peanut cake and brine fermentation time was increased up to 54% and 125 days, respectively. After that, total phenol content was found to be decreased as percentage of defatted peanut cake and brine fermentation time were increased up to the maximum level 90% and 180 days, respectively. The predicted maximum total phenol (0.3802) was obtained at the combination of 57% defatted peanut cake and 126 days of brine fermentation time.

Fig. 2.26. Effect of different process parameters on total phenol of peanut sauce (Fermentation process)



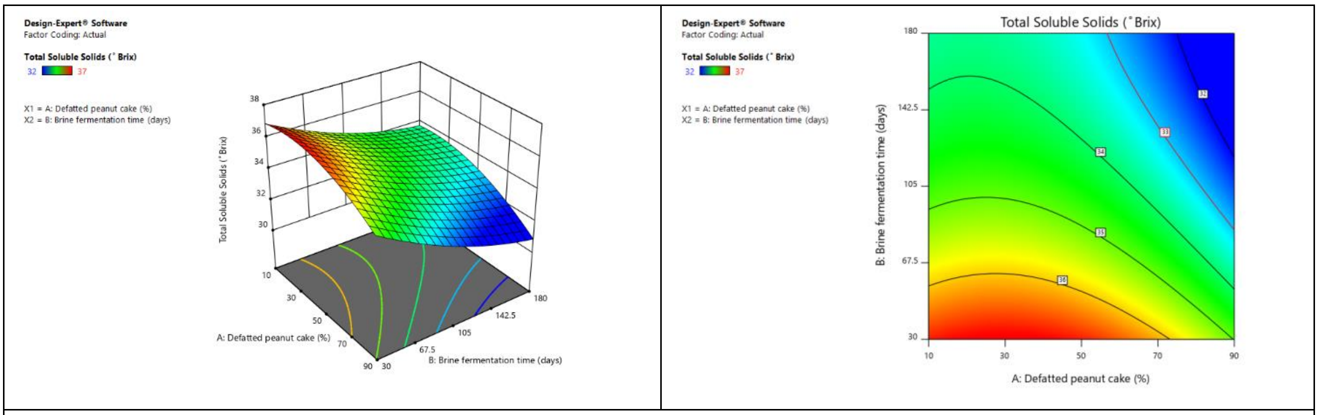
The value of salt content of peanut sauce decreased with an increase in defatted peanut cake flour and brine fermentation time relatively up to the level of 153% and 50 days, respectively. Further increase in defatted peanut cake flour and brine fermentation time, salt content increased. The predicted minimum salt content (1.02%) was obtained at the combination of 50% defatted peanut cake flour and 136 days of brine fermentation time and predicted maximum salt content (2.05%) was obtained at 90% defatted peanut cake flour and 180 days of brine fermentation time.

Fig. 2.27. Effect of different process parameters on salt content of peanut sauce (Fermentation process)



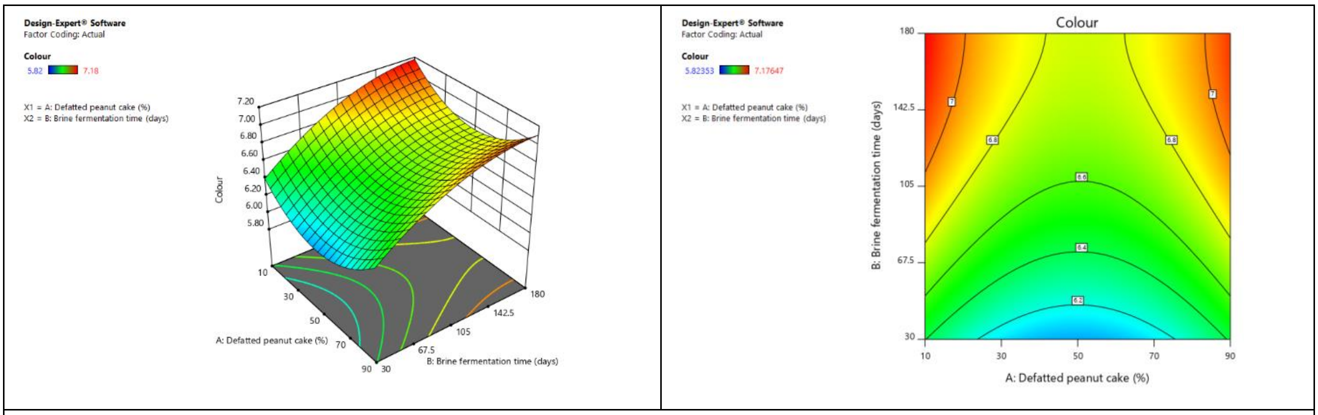
The value of titratable acidity of peanut sauce increased with an increase in defatted peanut cake flour up to 50% then decreased up to its maximum level, i.e. 90%. As increasing in brine fermentation time, titratable acidity of peanut sauce decreased up to 69 days and then further increased up to its maximum level, i.e. 180 days. The predicted minimum titratable acidity (2.67%) was obtained at the combination of 10% defatted peanut cake flour and 30 days of brine fermentation time and predicted maximum titratable acidity (4.13%) observed at 60% defatted peanut cake flour and 180 days of brine fermentation time.

Fig. 2.28. Effect of different process parameters on titratable acidity of peanut sauce (Fermentation process)



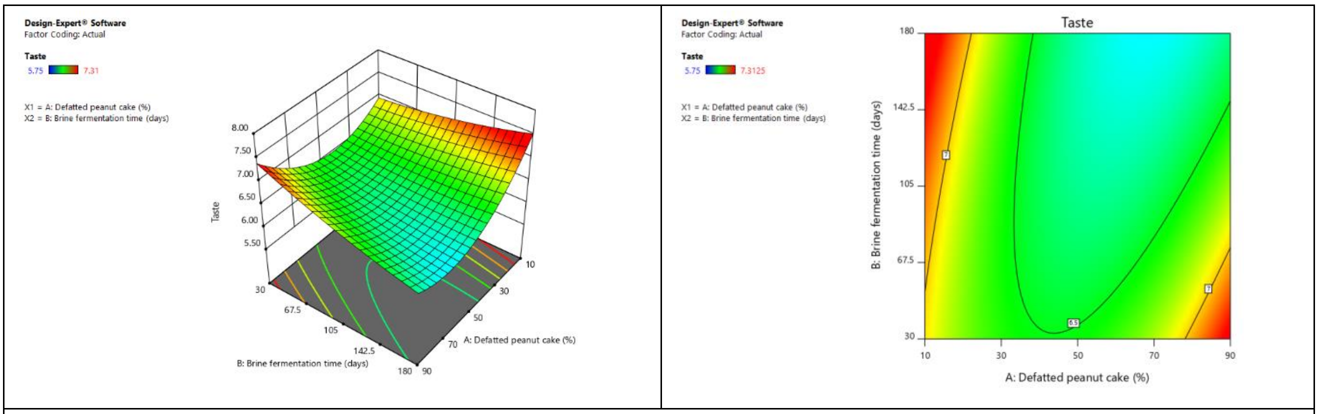
The value of TSS of peanut sauce increased with an increase in defatted peanut cake up to certain level, i.e. 30% and decreased further with increase in defatted peanut cake up to its maximum level, i.e. 90%. The value of TSS of peanut sauce decreased with an increase in brine fermentation time up to its maximum level, i.e. 180 days. The predicted maximum TSS of peanut sauce (37.09˚Brix) was obtained at the combination of 32% defatted peanut cake and 30 days of brine fermentation time.

Fig. 2.29. Effect of different process parameters on total soluble solid content of peanut sauce (Fermentation process)



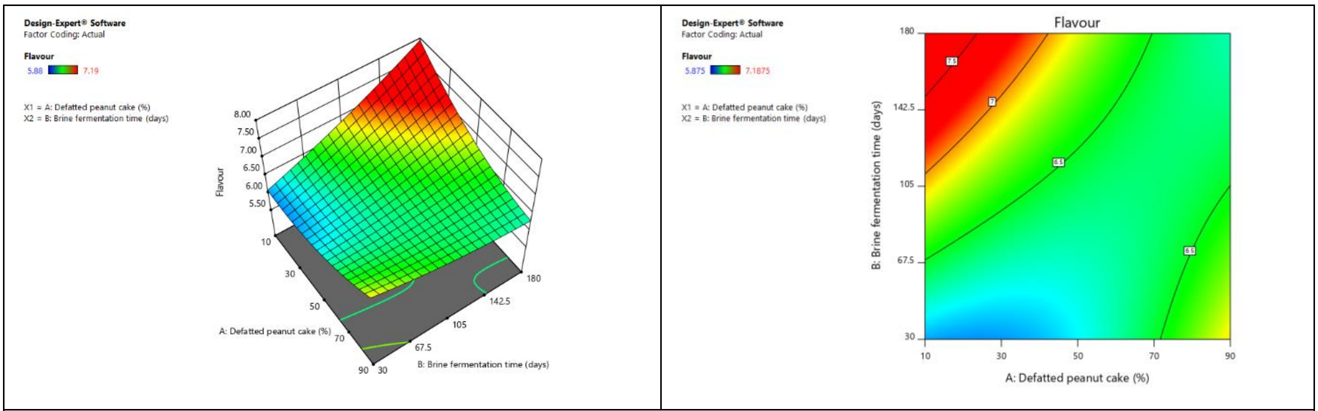
The sensory score of colour was decreased as the percentage of defatted peanut cake flour was increased up to its maximum level, i.e. 90%. The sensory score of colour of peanut sauce increased with increase in brine fermentation time up to 139 days and further decreased with increase in brine fermentation time up to its maximum level, i.e. 180 days. The predicted maximum sensory score of colour of peanut sauce (7.17) was found at 10% defatted peanut cake flour and 180 days of brine fermentation time.

Fig. 2.30. Effect of different process parameters on colour of peanut sauce (Fermentation process)



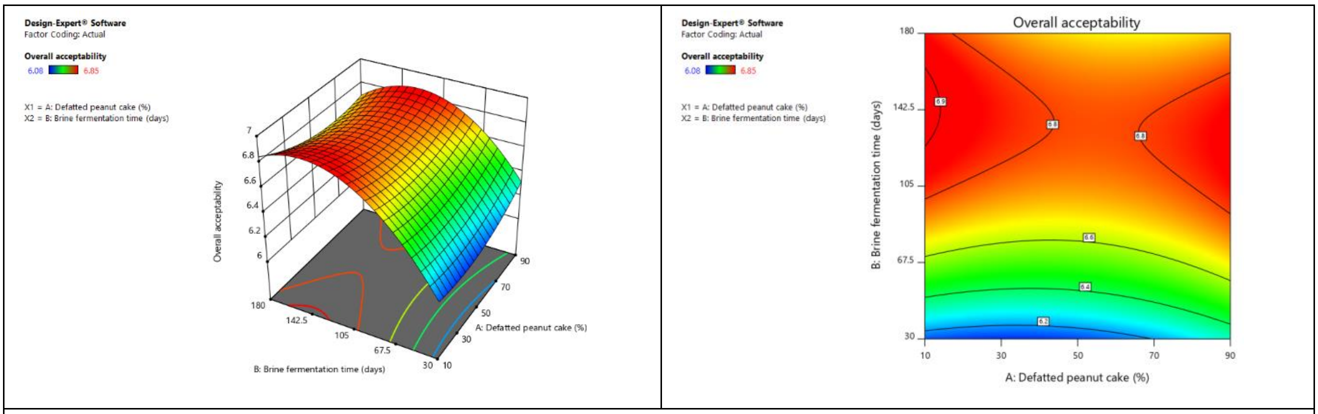
The decremental effect of sensory score of taste up to maximum level of defatted peanut cake flour, i.e. 90% and maximum level of brine fermentation time, i.e. 25% observed. The predicted maximum tasteful peanut sauce in terms of sensory score (7.50) was found at 10% defatted peanut cake flour and 180 days of brine fermentation time.

Fig. 2.31. Effect of different process parameters on taste of peanut sauce (Fermentation process)



The sensory score of flavour of peanut sauce decreased with an increase in defatted peanut cake flour up to its maximum level, i.e. 90%. Sensory score of flavour of peanut sauce decreased with increase in brine fermentation time up to 118 days and increased with further increase in brine fermentation time up to its maximum level, i.e. 180 days. The predicted maximum sensory score of flavour (7.93) was obtained at the combination of 10% defatted peanut cake flour and 180 days of brine fermentation time.

Fig. 2.32. Effect of different process parameters on flavour of peanut sauce (Fermentation process)



The sensory score of overall acceptability was decreased as the percentage of defatted peanut cake was increased up to 30% and with further increase in percentage of defatted peanut cake up to its maximum level, i.e. 90%, the overall acceptability was observed to be increased. Overall acceptability was found to be increased with an increase in brine fermentation time up to 143 days and thereafter, it was decreased with further increase in brine fermentation time up to its maximum level, i.e. 180 days. The predicted maximum overall acceptability (6.92) was found at 143% defatted peanut cake and 10 days of brine fermentation time.

Fig. 2.33. Effect of different process parameters on overall acceptability of peanut sauce (Fermentation process)

❖ Optimization of process variables

Table 2.22. Constraints, criteria and output for numerical optimization of peanut sauce.

Variables			
Constraint	**Goal**	**Importance**	**Optimum value**
Defatted peanut cake (%)	In the range	3	66
Brine fermentation time (Day)	In the range	3	158
Responses			
Constraint	**Goal**	**Importance**	**Predicted value**
Viscosity (cP)	None	-	2.48
Specific gravity	None	-	1.131
True protein (%)	Maximum	3	13.14
Total nitrogen (%)	Maximum	3	14.40
Free amino acid (%)	Maximum	3	4.68
Total sugar (%)	None	-	3.51
Reducing sugar (%)	None	-	0.687
pH	None	-	4.88
Total phenol (%)	Maximum	3	0.355
Salt content (%)	None	-	1.25
Titratable acidity (%)	None	-	3.84
Total soluble solids (˚Brix)	Maximum	3	32.81
Oxalate (mg/g)	None	-	6.79
Colour	None	-	6.81
Taste	None	-	6.18
Flavour	None	-	6.48
Overall acceptability	Maximum	3	6.76

❖ **Quality comparison of peanut sauce prepared through fermentation process with different commercial standards**

Table 2.23. Comparison of quality parameters of developed peanut sauce with different commercial standards of soy sauce.

Standard	Standard of soy sauce	Value for developed peanut sauce
TSS (FSSAI)	Not less than 25˚Brix	32.81˚Brix
Titratable acidity (FSSAI)	Not less than 0.6%	3.84%
Total nitrogen (FSSAI)	Not less than 1%	14.40%
Specific gravity (FAO & UAE standard)	Minimum 1.22	1.131
Salt (FAO & UAE)	Minimum 10% & Maximum 50%	1.25%

10.2 Preparation of peanut wadi

❖ **Proximate composition of defatted peanut flour**

Table 2.24. Proximate composition of defatted peanut flour used in the preparation of peanut wadi.

Sr. No.	Characteristic	Average values
1.	Moisture content % (w.b.)	5.64
2.	Carbohydrate (%)	23.59
3.	Protein (%)	61.98
4.	Fat (%)	3.96
5.	Ash (%)	4.76

- The work on preparation of peanut wadi could not be completed due to the following reason.
- ✓ Preliminary trials were conducted to prepare the peanut Wadi in laboratory using twin screw extruder (Model : Basic Technology Private Ltd., Kolkata).
- ✓ Results obtained in the preliminary trials are not satisfactory. Therefore, further trials were carried out using new defatted peanut flour.
- ✓ As the moisture content of defatted peanut flour samples are required to be elevated up to 60%, the free-flowing flour was converted into dough/sticky lumps. Due to this, there was an issue in the feeding of the material due to stickiness of the dough. Hence, the Twin Screw extruder available in the department is found not suitable to handle the high moisturized sample of defatted peanut flour. In view of this, the peanut wadi could not be prepared using the Twin Screw Extruder available in the department.

Plate 2.12. Sample of defatted peanut flour at 60% (wb) moisture content.

11. Financial Implications (` in Lakhs)

11.1 Expenditure on

(a) Manpower : ` 32.00

(b) Research/Recurring Contingencies : ` 0.32

(c) Non-Recurring Cost (Including cost of equipment) : ` 0.00

(d) Any Other Expenditure Incurred

11.2 Total Expenditure : ` 32.32

12. Cumulative Output

a. Special attainments/innovations -

b. List of Publications (one copy each to be submitted if not already submitted)

i. Research papers : Preparation is under progress
ii. Reports/Manuals : Prepared
iii. Working and Concept Papers : Nil
iv. Popular articles : Nil
v. Books/Book Chapters : Nil
vi. Extension Bulletins : Preparation is under progress

c. Intellectual Property Generation
(Patents - filed/obtained; Copyrights- filed/obtained; Designs- filed/obtained; Registration details of variety/germplasm/accession if any) : Nil

d. Presentation in Workshop/Seminars/Symposia/Conferences : Nil
(relevant to the project in which scientists have participated)

e. Details of technology developed : (Crop-based; Animal-based, including vaccines; Biological – biofertilizer, biopesticide, etc; IT based – database, software; Any other – please specify)
- Crop based technology

f. Trainings/demonstrations organized : Yes

g. Training received : Nil

i. Any other relevant information : The developed machine will be useful to the pulse processing industries for giving the enzymatic pre-treatment to pigeon pea grains. The developed machine can give enzymatic pre-treatment to pigeon pea grains very efficiently which increases the hulling efficiency and thereby reduces the processing cost and improves the benefit cost ratio as compared to traditional dhal processing method.

13. (a) Extent of achievement of objectives and outputs earmarked as per RPP-I

Objective wise	Activity	Envisaged output of monitorable target(s)	Output achieved	Extent of Achievement (%)
1. To develop a process technology for preparation of peanut sauce and peanut wadi.	1. Review collection/literature survey	1. The literature surveyed to get the in-depth knowledge of the past work done on this aspect and the present practices followed by the commercial players.	All the activities were completed and envisaged output was achieved	100%
	2. Designing of the experiment	2. Experiment was designed as per the RSM		
	3. Procurement of raw materials	3. The required quantity of raw materials was estimated and purchased from the market and stored safely till it utilized.		
	4. Procurement of microbial cultures and chemicals required to conduct the research trials	4. The standard microbial cultures were purchased from the reputed institutes. The standard chemical were utilized in the experiment and quality analysis.		
	5. Quality analysis of the raw materials	5. Important quality parameters of the raw materials are determined following the standard methods and protocols.		
	6. Preliminary trials for production of peanut sauce and peanut wadi	6. Preliminary trials for the production of peanut sauce and peanut wadi was carried out in the laboratory. Final trials were decided based on the results obtained in the preliminary trials.		
	7. Final trials for development of peanut sauce and peanut wadi using defatted peanut flour/kernels as per the different treatments	7. Final experimental trials for the preparation of peanut sauce and peanut wadi were carried out as per the treatments. The products obtained in the final trials were stored safely for further analysis.		

2. To study the effect of process parameters on different quality and sensory parameters of peanut sauce and peanut wadi	1. Physico-chemical and sensory analysis of the developed products	1. The samples obtained for the different treatments are analysed for their physico-chemical and sensory properties. The standard procedure and protocols were followed for the quality analysis of the samples.	All the activities were completed and envisaged output was achieved	100%
	2. Microbiological analysis of the peanut sauce	2. The microbiological analysis were done to check the microbial infections in the samples, if any.		
3. To standardize the process parameters for preparation of peanut sauce and peanut wadi	1. Data collection and its analysis	1. The data of physico-chemical and sensory parameters as obtained for the different samples were subjected to statistical analysis through Response Surface Methodology (RSM). The response surface graph and contour graphs were developed to study the interaction effect of process parameters on the selected response parameters. Regression analysis or analysis of variance was done to check the adequacy and validity of models obtained for the different response parameters.	All the activities were completed and envisaged output was achieved	100%
	2. Optimization of process parameters based on the experimental data	2. The process parameters were optimized based on the experiments results obtained for the different response parameters. The optimization was done using Design Expert-11 software by applying the appropriate criteria to each response parameter. The optimized process parameters are reported in the research report.		

(b) Reasons of shortfall, if any : The work on preparation of peanut wadi could not be completed due to the following reason.

- Preliminary trials are conducted to prepare the peanut Wadi in laboratory using twin screw extruder (Model : Basic Technology Private Ltd., Kolkata).
- Results obtained in the preliminary trials are not satisfactory. Further trials were carried out using new defatted peanut flour.
- As the moisture content of defatted peanut flour samples are required to be elevated up to 60%, the free flowing flour was converted into lumps. Due to this, there was an issue in the feeding of the material due to stickiness of the dough. Hence, the Twin Screw extruder available in the department is fond not suitable to handle the high moisturized sample of defatted peanut flour. In view of this, the peanut wadi could not be prepared using the Twin Screw Extruder available in the department.

14. Efforts made for commercialization/technology transfer : The samples of the developed peanut sauce was presented to the visiting entrepreneurs as well as students of the college. Further, the effort will be made to provide the training and literature of the developed process technology to the entrepreneurs and farmers for transfer of the developed technology.

15. (a) How the output is proposed to be utilized?

The process technology as developed from this project are to be utilized by the peanut processors or soy sauce manufacturers for the production of peanut sauce. Peanut sauce is not available anywhere in the market. Hence, the developed process technology will be very feasible and having a good scope for its adoption in the market.

(b) How it will help in knowledge creation?

Peanut sauce is not available anywhere in the market. No information is available for the process technology for the production of peanut sauce. This project created the valuable knowledge for how to produce peanut based sauce. Hence, the developed process technology will be very feasible and having a good scope for its adoption in the market for the commercial production of peanut sauce.

16. Expected benefits and economic impact(if any)

1. The process technology for the production of peanut sauce will be standardized.
2. The new chemical process and fermentation process based peanut product will be developed using defatted peanut flour.
3. The process technology for production of nutrient rich peanut sauce can be made available to the commercial players and food processors.
4. The proposed process technology will suggest the proper byproduct utilization of peanut for the preparation of value added product.
5. The process parameters for the preparation of peanut sauce will be optimized

17. Specify whether the project requires submission of RPP-IV for up scaling of research output. - No

18. Future line of research work/other identifiable problems

- Training programmes will be arranged for the students and entrepreneurs.
- The demonstration will be provided to all peanut processors and sauce manufacturers to aware them about the developed developed process technology and to provide hands on training.

19. Details on the research data (registers and records) generated out of the project deposited with the institute for future use

20. Signature of PI, CC-PI(s), all Co-PIs

P. R. Davara	**Prof. A. M. Joshi**	**M. N. Dabhi**	**Dr. P. J. Rathod**
Principal Investigator	Co-PI	Co-PI	Co-PI

21. Signature of Head of Division

22. Observations of PME Cell based on Evaluation of Research Project after Completion

23. Signature (with comments if any along with rating of the project in the scale of 1 to 10 on the overall quality of the work) of JD (R)/ Director

ONGOING INVESTIGATION – II

RPP - II

ANNEXURE - V

INDIAN COUNCIL OF AGRICULTURAL RESEARCH

RESEARCH PROJECT PROFORMA FOR MONITORING ANNUAL PROGRESS (RPP- II)

(Refer for Guidelines ANNEXURE-XI (E))

1. Institute Project Code : PH/JU/2022/1

2. Project Title: Processing of green tender sorghum.

3. Reporting Period: April 22 to December 2022

4. Project Duration: Date of Start –April 2022 Likely Date of Completion –March 2025

5. Project Team (Name(s) and designation of PI, CC-PI and all project Co-PIs, (with time spent for the project) if any additions/deletions

Sr. No	Name, designation and institute	Status in the project (PI/CC-PI/ Co-PI)	Time spent (%)	Work components assigned to individual scientist
1.	Dr. M. N. Dabhi, Research Engineer, AICRP on PHET, Dept. of Processing and Food Engg., College of Agril. Engg. & Tech., Junagadh Agril. University, Junagadh	PI	60%	1. Development of roaster, thresher and cleaner 2. Roasting of green sorghum 3. Threshing of roasted green sorghum 4. Cleaning of threshed roasted green sorghum 5. Data collection and its analysis 6. Report writing
2.	Dr. P. R. Davara, Assistant Research Engineer, AICRP on PHET, Dept. of Processing and Food Engg., College of Agril. Engg. & Tech., Junagadh Agril. University, Junagadh	Co-PI	10%	To assist the PI in all above aspects
3.	Dr. P. S. Pandit Assistant Professor, Centre of PHT, Navsari Agricutltural University, Navsari.	Co-PI	20%	To assist in the development of roaster, thresher and cleaner

4	Dr. P. J. Rathod Assistant Professor Department of Biochemistry College of Agriculture, Junagadh Agril. University, Junagadh	Co-PI	10%	1. Assessment of biochemical content of pauk 2. Data collection and report writing of biochemical pauk through laboratory analysis.

6. (a) Activities and outputs earmarked for the year (as per activities schedule given in RPP-I)

Objective wise	Activity	Scientist responsible	% of activity envisaged to be completed as per RPP-I	% achieved as targeted
1.	Development of roaster, thresher and cleaner.	Dr. M. N. Dabhi and Dr. P. S. Pandit	Hurda extractor is purchased, roaster purchased procedure through newspaper advertised is completed. But according to new rules to purchase through GeM is under progress.	50%

(b) If shortfall/addition, reasons for the same and how to catch up with the intended activities

7. Annual Progress Report (research results and achievements in bullets)

As per the proceeding of the last year, we have to purchase the hurda extractor from the Akola centre. We have purchased Hurda extractor from the Akola centre. That was received by July 2022. For purchase of roaster. It was circulated to the all centers whether they have developed the roaster or not. No one has developed the roaster. We have contacted to different roaster manufacturers. The capacity they developed is very high about 150-300 kg per batch capacity. We convinced them to fabricate for 50 kg per batch. Accordingly, we have advertised in Newspaper and received hard copy of tenders. But due to new purchase policy we have to purchase it under GeM process. Accordingly, the process is carried out. But no one has quoted. Again the GeM process is under progress.

Even roasting of sorghum was tested in the peanut roaster at peanut roasting industry. That roaster was gas operated hence, the burning of sorghum was observed. Hurda extractor was also tested. The output of the hurda extractor was very poor.

Plate 3.1. Roasting of green tender sorghum in peanut roaster

Plate 3.2. Hurda extractor for green tender sorghum

8. Output during Period under Report

a. Special attainments/innovations

b. List of Publications (one copy each to be submitted with RPP-II)

i. Research papers
ii. Reports/Manuals
iii. Working and Concept Papers
iv. Popular articles
v. Books/Book Chapters
vi. Extension Bulletins

c. Intellectual Property Generation

(Patents - filed/obtained; Copyrights- filed/obtained; Designs- filed/obtained; Registration details of variety/germplasm/accession if any)

d. Presentation in Workshop/Seminars/Symposia/Conferences

(Relevant to the project in which scientists have participated)

e. Details of technology developed

(Crop-based; Animal-based, including vaccines; Biological – biofertilizer, biopesticide, etc; IT based – database, software; Any other – please specify)

f. Trainings/demonstrations organized

g. Training received

h. Any other relevant information

9. Constraints experienced, if any: Conducting the experiment was late due to unavailability of roaster at our AICRP centres and purchase policy of Government.

10. Lessons Learnt

11. Evaluation

(a) Self-evaluation of the project for the period under report by the PI with rating in the scale of 1 to 10 — 7

(b) Evaluation by PI on the contribution of the team in the project including self

Sr. No.	Name	Status in the project (PI/CC-PI/Co-PI)	Rating in the scale of 1 to 10
1	Dr. M. N. Dabhi	PI	7
2	Dr. P. R. Davara	Co PI	7
3	Dr. P. S. Pandity	Co PI	
4	Dr. P. J. Rathod	Co PI	

12. Signature of PI, CC-PI(s), all Co-PIs

13. Signature (with specific comments on progress/achievements, shortfall and constraints along with rating of the project in the scale of 1 to 10) of Head of Division/Regional Center / Section ☐

14. Comments of IRC

15. Signature (with specific comments on progress/achievements, shortfall and constraints along with rating of the project in the scale of 1 to 10) of JD (R)/ Director ☐

NEW INVESTIGATION – I

RPP- I

ANNEXURE - I

INDIAN COUNCIL OF AGRICULTURAL RESEARCH

PROFORMA FOR PREPARATION OF STATUS REPORT FOR PROPOSAL OF A NEW RESEARCH PROJECT

(Refer for Guidelines ANNEXURE-XI(A))

1. Institute Name: College of Agril. Engg. & Tech., Junagadh Agril. University, Junagadh
2. Title of the project: Optimization of process parameters for protein extraction from peanut through fermentation.
3. Type of research project: Basic/~~Applied/Extension/Farmer Participatory/Other~~ (specify)
4. Genesis and rationale of the project :

Peanut (*Arachis hypogea* L.) being most valuable oilseed crop in world, known as "King of oilseeds", is a low priced commodity which is rich in nutrition. India has good performance in peanut area, production and yield i.e. 6.09 MH, 10.21 MT and 1676 kg./hectare respectively in 2020-21. In India, gujarat is leading state in peanut area, production and yield i.e. 2.16 MH, 4.13 MT and 1908 kg/hectare respectively (Agricultural Statistics at a Glance - 2021).

Proteins are one of the major essential nitrogen containing nutrients required by human beings for normal growth and maintenance (Jay *et al*., 2004). Proteins are mainly obtained from animal and plant sources. Animal protein sources include meat, fish, poultry, egg, milk and milk products while vegetable sources include pulses, oilseeds, legumes, fruits and vegetables (www.wikipedia.org/proteinnutrient). On comparison of animal and vegetable sources of protein, researchers concluded that animal sources are high in cholesterol which are related to occurrence of heart diseases and increased blood pressures. Animal sources are deficient in fiber which increases faecal weight and its absence in diet causes constipation problems. Plant sources are thus free from harmful cholesterols and also provides important minerals *viz.*, iron, magnesium and calcium whereas animal proteins are deficient in many mineral components. Also plant proteins serve as abundant sources of antioxidants and are easy to digest, free from certain allergens thus giving additional reasons for its mass use over costlier animal proteins to feed population to solve problems of protein deficiencies in developing countries (Zhang *et al.*, 2014).

Peanut is the oilseed which is high in fat content, good in protein content, high in energy content, average in carbohydrate content and good in fiber content. It also contains many other functional compounds like fibers, polyphenols, antioxidants, vitamins and minerals. (Kathleen, 2015). Peanuts contain all the 20 amino acids in variable proportions and is the biggest source of the protein called "arginine" (USDA, 2014). After the peanut oil is extracted, the protein content in the cake can reach 50% (Zhao *et al*. 2011).

Commercially it is used mainly for oil production. Apart from oil, peanuts are widely used for production of peanut butter, confections, roasted peanuts, snack products, extenders in meat product formulation, peanut sauce, peanut flour, peanut milk, peanut beverage, peanut snacks (salted and sweet bars) and peanut cheese analogs (Arya *et al*., 2016).

The partially defatted peanut flour produced after peanut milk preparation has not found any specific use in the food processing. This flour contains about 30% protein. Peanut protein has been isolated using various methods i.e. extraction-isoelectric precipitation (AEIEP), salt extraction-dialysis, micellar precipitation and aqueous extraction (pH > 7) (Lam, A.C.Y.*et al* 2018). Nutritional, sensory and technological properties of pea proteins can be influenced by the extraction process (Gao, Z. *et al*., 2020).That is why food researchers and the industry are constantly trying to develop new cost-effective and safe extraction methods with optimal extractability leading to adequate techno-functional and sensory properties (Stone, A.K. *et al*, 2015).

Apart from conventional methods, physical modification or pretreatments like high power sonication (HPS) can be used as a potential alternative method for the extraction of proteins as well as modification. The combination of physical treatment and fermentation with lactic acid producing bacteria will change the molecular structure and functions, reduce or eliminate anti-nutritional factors and hence improve the quality of protein ingredient (Kiers et al., 2000; Ojokoh et al., 2011). HPS disrupts plant metrices and facilitates the extraction of protein, carbohydrates and other bioactive compounds (Vilkhu et al., 2008). HPS can release carbohydrates and sugars which can be utilized in fermentation to produce hydrolytic enzymes and thus, modify substrates. Fermentation with lactic acid bacteria is a traditional technique that serves as a practical method for food preservation (Matejcekova, Z. *et al*., 2019). It has been used to enhance the bio accessibility and bioavailability of nutrients to improve the organoleptic properties and shelf life of various legume proteins (Schlegel, K.*et al.*, 2019). Fermentation consists of modifying food by microorganisms (bacteria, molds and yeasts) that grow and consume part of the substrates and enrich it with the products of their metabolism However, selection of the right microorganism is necessary, since some microorganisms including yeasts and molds might concern food safety. Lactic acid bacteria (LAB) with the generally recognized as safe (GRAS) status are of great interest in food fermentation (Klupsaite, D. *et al*., 2017). They are known for contributing to the improvement of desired sensory properties and improvement of food's aroma (Coda, R. *et al*., 2015).

LAB have been increasingly used for legume fermentation in the last decade. However, its effect is highly related to the legume type, LAB strain and fermentation conditions (Rui, X. *et al.*, 2017). Lactic acid fermentation can affect the structure and content of legume protein. This can be attributed to the proteolytic activity of bacteria mechanism during fermentation, by which the polypeptide chain is broken down, and new polypeptides with a lower molecular weight are formed (Lampart-Szczapa*et al*., 2006). The changes in protein conformation and structure alter the functionality and nutritional properties of the final products (Sozer, N. *et al*., 2019)

The LAB species such as *Streptococcus thermophilus*, *Lactobacillus delbrueckii subsp. bulgaricus*, *Lactobacillus acidophilus*, *Lactobacillus helveticus* and *Lactobacillus* *plantarum* have been frequently reported for their positive effects on the organoleptic properties of legume protein (Yousseef, M. *et al*., 2016).The development of LAB during pea protein fermentation helps the improvement of aroma and flavor by either reducing the occurrence of compounds responsible for off-flavor or masking undesirable green notes (Ben-Harb, S. *et al*., 2019). LAB fermentation is also an effective way for partial or complete degradation of anti-nutritional factors and improvement of protein bioavailability and digestibility (Czarnecka, M. *et al*., 1998).

Taking into account the positive effects of LAB fermentation on the legume properties and the drop in pH due to lactic acid formation, the aim of the present study was to explore an alternative extraction method of peanut proteins based on high power sonication and fermentation, where the decrease in pH was achieved by lactic fermentation instead of mineral acid addition. Two different commercial LAB strain or starters were selected for their aptitude for acidification and / or their recognized positive effect on legume protein properties: *Lactobacillus plantarum* and *Pediococcus acidilactici*. The fermentation-assisted extraction was expected to modify the protein profile isolated with this process. To evaluate this effect, extraction yield of protein isolates were evaluated by response surface methodology. Other biochemical, functional and physical properties of the samples were further analyzed to evaluate proteins which are extracted from defatted peanut flour.

5. Knowledge/Technology gaps and justification for taking up the present project including the questions to be answered :

Peanut is the oilseed which is high in fat content, good in protein content, high in energy content, average in carbohydrate content and good in fiber content. It also contains many other functional compounds like fibers, polyphenols, antioxidants, vitamins and minerals. (Kathleen, 2015). Peanuts contain all the 20 amino acids in variable proportions and is the biggest source of the protein called “arginine” (USDA, 2014). After the peanut oil is extracted, the protein content in the cake can reach 50% (Zhao et al., 2011).

Extraction of peanut protein from defatted peanut flour carried out by different conventional methods. But nutritional, sensory and technological properties of peanut proteins can be influenced due to these processes. A treatment combination i.e. High power sonication and Fermentation methods might be improve the above said properties of peanut protein. Water to defatted peanut flour might be affect the different strains of lactic acid producing bacteria and sonication process. So, the effect of different factors will be checked in this experiment.

The method and data for extraction of protein from different legumes through sonication and fermentation is available. But, very negligible information is available for extraction of peanut protein from defatted peanut flour. Hence, the experiment on for extraction of peanut protein from defatted peanut flour is adopted in this study to develop the process technology and to generate the information about the interaction between process parameters to optimize the levels which will be helpful to the society and food processors.

6. Critical review of present status of the technology at national and international levels along with complete references :
   - Emkani M. et al (2021) studied pea protein extraction through lactic fermentation. In this study, pH was reduced by lactic fermentation instead of mineral acid addition. Different bacterial strains viz. *Streptococcus thermophilus*, *Lactobacillus acidophilus* and *Bifidobacterium lactis* are used for the protein extraction. Total nitrogen content and protein nitrogen content of globulin fraction was observed ~ 14.5 % and ~ 9.5 % respectively. While total nitrogen content and protein nitrogen content of albumin fraction was observed ~ 11 % and ~ 7 % respectively. Nitrogen extraction yield of globulin and albumin fractions was found ~ 48 % and ~ 35 % respectively. In this study, SDS-PAGE was also performed for polypeptide profiling. Globulin-rich sample profiles revealed the presence of bands ranging from 10 to 99 kDa, characteristic of pea proteins. Various subunits of vicilin including the monomer (Vαβγ, ~50 kDa, Vαβ, ~30–36 kDa, Vβγ, ~25–30 kDa, Vα, ~20kDa, Vβ, ~13kDa, Vγ, ~12–16 kDa), legumin monomer (Lαβ, ~60kDa) and the higher-molecular-weight bands corresponded to lipoxygenase (LOX ~94 kDa) and convicilin (CV, ~71 kDa) was observed while in albumin rich sample profiles also showed clear bands of LOX, lectine (Lect, ~17 kDa) and some contaminations by globulin polypeptides, mainly Vαβ.
   - Gayol *et al*. (2013) reported the optimization of protein concentration process from residual peanut oil cake (POC). Different protein extraction and precipitation conditions were used: water/flour ratio (10:1, 20:1 and 30:1), pH (8.0, 9.0 and 10.0), NaCl concentration (0 and 0.5 M), extraction time (30, 60 and 120 mins.), temperature (25, 40 and 60^{o}C), extraction stages (1, 2 and 3), and precipitation pH (4.0, 4.5 and 5.0). The extraction and precipitation conditions which showed the highest protein yield were 10:1 water / flour ratio, extraction at pH 9.0, without NaCl, 2 staeges of 30 mins. At 40^{o}C and precipitation at pH 4.5. Under these conditions, the peanut protein concentrate (PC) obtained 86.22 % protein, while the initial POC had 38.04 %.
   - Gao Z. et al. (2020) studied the impact of alkaline extraction pH (8.5, 9.0, and 9.5) on chemical composition, molecular structure, solubility and aromatic profile of pea protein isolate (PPI). They observed that protein recovery yield increased from 49.20% to 57.56% as the alkaline extraction pH increased from 8.5 to 9.5.pH 9.0 was found to be the optimal condition for preparing premium PPI in terms of yield, functionality, and aromatic profile using alkaline extraction-isoelectric precipitation process. PPI extracted at pH 9.0 possessed the lowest beany flavor The lowest lipoxygenase activity at pH 9.0 may contribute to the least beany flavor in PPI.
   - Gore et al (2022) analysed proteins from different varieties of groundnut seeds through SDS-PAGE profiling. Protein fraction viz. albumin, globulin, glutelin and prolamin were extracted during the study, in which albumin % and globulin % content found to be in range of 16.2 to 20.43 % and 72.05-78.5 % respectively while glutelin % and prolamin % was found to be very lower in all varieties with the mean of 2.17 % and 2.57 % respectively. In SDS-PAGE profiling, it was observed albumin and globulin had the highest MW-Rf values in bands collectively (20–23), whereas glutelin and prolamin had the lowest MW-Rf values bands with ranged between 6-10 and correlation matrix between protein fractionation indicated that globulin was negatively correlated with prolamin and glutelin fraction.

References:

- Ali A. W.; Devinder K.; Idrees A. and Sogi D.S. 2007. Extraction optimization of watermelon seed protein using response surface methodology. *LWT Food Science and Technology,* 41:1514-1520.
- Bartkiene, E.; Krungleviciute, V.; Juodeikiene, G.; Vidmantiene, D.; Maknickiene, Z. 2015. Solid state fermentation with lactic acid bacteria to improve the nutritional quality of lupin and soya bean. *J. Sci. Food Agric. 95*, 1336–1342, doi:10.1002/jsfa.6827.
- Ben-Harb, S.; Saint-Eve, A.; Panouille, M.; Souchon, I.; Bonnarme, P.; Dugat-Bony, E.; Irlinger, F. 2019. Design of microbial consortia for the fermentation of pea-protein-enriched emulsions. *Int. J. Food Microbiol. 293*, 124–136, doi:10.1016/j.ijfoodmicro.2019.01.012.
- Cabuk, B.; Nosworthy, M.G.; Stone, A.K.; Korber, D.R.; Tanaka, T.; House, J.D.; Nickerson, M.T. 2018. Effect of Fermentation on the Protein Digestibility and Levels of Non-Nutritive Compounds of Pea Protein Concentrate. *Food Technol. Biotechnol. 56*, 257–264, doi:10.17113/ftb.56.02.18.5450.
- Emkani M.; Oliete B. and Saurel R. 2021. Pea Protein Extraction Assisted by Lactic Fermentation: Impact on Protein Profile and Thermal Properties. Food. 10, 549. https://doi.org/10.3390/foods10030549.
- Gayol, M.F.; Pramparo, M.C.; Nepote, V.; Fernandez, H. and Grosso, N.R. 2013. Optimization of protein concentration process from residual peanut oil cake. Grasas Y Aceies, 64(5): 489-496.
- Gore V.B.; Rathod P.J.; Vala A.G. and D.Kumar. 2022. Analysis of protein profiling through SDS-PAGE of spreading types varieties of groundnut grown in India. The Pharma Innovation Journal; SP-11(9): 2811-2817.
- Gao, Z.; Shen, P.; Lan, Y.; Cui, L.; Ohm, J.-B.; Chen, B.; Rao, J. 2020. Effect of alkaline extraction pH on structure properties, solubility,and beany flavor of yellow pea protein isolate. *Food Res. Int. 131*, 109045, doi:10.1016/j.foodres.2020.109045.
- Irakoze, P.C. and Sindayigaya, E. 2012. Response surface methodology for optimized extraction of protein from malted sorghum flour. *serie sciences exactes*, 26:97-113.
- Jay, R. H. and Michael, J. F. 2004. Macronutrient utilization during exercise : implications for performance and supplementation. Journal of sports science and medicine, 3:118-130.
- Klupsaite, D.; Juodeikiene, G.; Zadeike, D.; Bartkiene, E.; Maknickiene, Z.; Liutkute, G. 2017. The influence of lactic acid fermentation on functional properties of narrow-leaved lupine protein as functional additive for higher value wheat bread. *LWT. 75*, 180–186, doi:10.1016/j.lwt.2016.08.058.
- Rui, X.; Wang, M.; Zhang, Y.; Chen, X.; Li, L.; Liu, Y.; Dong, M. 2017. Optimization of soy solid-state fermentation with selected lacticacid bacteria and the effect on the anti-nutritional components. *J. Food Process. Preserv. 41*, e13290, doi:10.1111/jfpp.13290.
- Sozer, N.; Melama, L.; Silbir, S.; Rizzello, C.G.; Flander, L.; Poutanen, K. 2019. Lactic acid fermentation as a pre-treatment process for faba bean flour and its effect on textural, structural and nutritional properties of protein-enriched gluten-free faba bean breads. *Foods. 8*, 431, doi:10.3390/foods8100431.
- Xing, Q.; Dekker, S.; Kyriakopoulou, K.; Boom, R.M.; Smid, E.J.; Schutyser, M.A.I. 2020. Enhanced nutritional value of chickpea protein concentrate by dry separation and solid state fermentation. *Innov. Food Sci. Emerg. Technol. 59*, 102269, doi:10.1016/j.ifset.2019.102269.

7. Expertise available with the investigating group/Institute

   The PI & Co-PIs of project having enough experience of working in the field of Processing and Food Engineering. Experts in the field of Processing and Food Engineering. Assistant Biochemist is available from Dept. of Biochemistry & Biotechnology, JAU, Junagadh.

8. Brief note on Proprietary/Patent Perspective (for projects related to technology development)/Ethics/Animal Welfare/Bio Safety Issues

   - No issues are there on these aspects.

9. (a) Expected output

   - The process technology for the extraction of peanut protein using physical and biological methods will be standardized.
   - The process technology can be made available to the commercial players and food processors.
   - A green technology of protein extraction will be availed to the society.

   (b) Clientele/Stake holders (including economic and socio aspects)

   i. Peanut growers
   ii. Peanut processors
   iii. Consumers

10. Signatures

[Project Leader] [Co-PIs] ……

11. Comments and signature

[Head of Division]

ANNEXURE- II

INDIAN COUNCIL OF AGRICULTURAL RESEARCH

RESEARCH PROJECT PROFORMA FOR INITIATION OF A RESEARCH PROJECT (RPP - I)

(Refer for Guidelines ANNEXURE-XI (B))

1. Institute Project Code (to be provided by PME Cell)
2. Project Title: Optimization of process parameters for protein extraction from peanut through fermentation.
3. Key Words : Defatted peanut flour, fermentation, peanut protein, Bacterial strains : *Lactobacillus plantarum* and *Pediococcus acidilactici*, High power sonication.
4. (a) Name of the Lead Institute : College of Agril. Engg. & Tech., Junagadh Agril. University, Junagadh

   (b) Name of Division/ Regional Center/ Section : AICRP on PHET, Junagadh centre

5. (a) Name of the Collaborating Institute(s) : --

   (b) Name of Division/ Regional Center/ Section of Collaborating Institute(s) : ---

6. Project Team (Name(s) and designation of PI, CC-PI and all project Co-PIs, with time proposed to be spent)

Sr. No.	Name, designation and institute	Status in the project (PI/CC-PI/ Co-PI)	Time to be spent (%)	Work components to be assigned to individual scientist
1.	Prof. A. M. Joshi Assistant Microbiologist, AICRP on PHET, Dept. of Processing and Food Engg., College of Agril. Engg. & Tech., Junagadh Agril. University, Junagadh	PI	60%	1. Review collection/literature survey 2. Collect the bacterial cultures from MTCC, Chandigarh and take a Preliminary trial. 3. Process development for peanut protein isolate using defatted peanut flour. 4. Laboratory trials as per the different treatments. 5. Physico-chemical and sensory analysis of the products. 6. Data collection and its analysis. 7. Report writing.

2.	Dr. P. J. Rathod Assistant Biochemist, Dept. of Bio-Technology, JAU, Junagadh	Co-PI-I	15%	To assist the PI to carry out biochemical analysis of the product
3.	Dr. P. R. Davara, Assistant Research Engineer, AICRP on PHET, Dept. of Processing and Food Engg., College of Agril. Engg. & Tech., Junagadh Agril. University, Junagadh	Co-PI-II	15%	1. To assist the PI to carry out the engineering parameters of the product. 2. To assist the PI in statistical analysis.
4.	Dr. M. N. Dabhi, Research Engineer, AICRP on PHET, Dept. of Processing and Food Engg., College of Agril. Engg. & Tech., Junagadh Agril. University, Junagadh.	Co-PI-III	10%	To assist the PI in taking administrative approvals as and when needed to carry out the different project related activities

8. Priority Area to which the project belongs : Post Harvest Technology
(If not already in the priority area, give justification)

9. Project Duration : Date of Start: 01-03-2023 Likely Date of Completion **:**31-12-2024

10. (a) Objectives :

- To study the effect of process parameters on recovery of peanut protein isolate from defatted peanut flour.
- To determine biochemical and physical properties of peanut protein isolate.
- To determine the functional properties of the peanut protein isolate.

(b) Practical utility:

- The process technology for the extraction of peanut protein using physical and biological methods will be standardized.
- The process technology can be made available to the commercial players and food processors.
- A green technology of protein extraction will be availed to the society.

11. Activities and outputs details :.

Objective wise	Activity	Month & Year of		Output monitorable target(s)	% to be carried out in different years			Scientist(s) responsible
		Start	Comple-tion		1	2	..	
1.	Review collection	March -23	May-23	1. To collect the data on extraction of protein from defatted peanut flour. 2. To study the work done in the past.	100 %	--	-	Prof. A. M. Joshi
2.	Procurement and Quality analysis of proposed product raw material	June-23	Aug-23	Procurement of defatted peanut flour and bacterial cultures. Quality will be analysed.	100 %	--	- -	Prof. A. M. Joshi Dr. M. N. Dabhi
3.	Preliminary laboratory trials	Sept-23	Jan-24	Preliminary trial run for peanut protein extraction will be carried out.	100 %	--	- - -	Prof. A. M. Joshi, Dr. P. R. Davara Dr. P. J. Rathod
4.	Extraction of peanut protein as per the final treatments.	Feb-24	May-24	Final treatment trials and quality analysis will be carried out.	--	100 %	- - -	Prof. A. M. Joshi, Dr. P. R. Davara Dr. P. J. Rathod
5.	Quality analysis of peanut protein isolates.	June-24	Sept-24	Peanut protein will be analysed for its physical, biochemical and functional quality.	--	100 %	- - -	Dr. P. J. Rathod Prof. A. M. Joshi, Dr. P. R. Davara,

6.	Data analysis and report writing	Oct-24	Jan-25	Compilation of collected data and preparation of report	--	100 %	- - -	Prof. A. M. Joshi, Dr. P. R. Davara, Dr. M. N. Dabhi

	2023									2024												2025
Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan
Review collection																						
			Procurement and Quality analysis of proposed product raw material																			
						Preliminary laboratory trials																
											Extraction of peanut protein as per the final treatments.											
															Quality analysis of peanut protein isolates.							
																			Data analysis and report writing			

12. Technical Programme (brief)

<u>Justification</u> :

Peanut is the oilseed which is high in fat content, good in protein content, high in energy content, average in carbohydrate content and good in fiber content. It also contains many other functional compounds like fibers, polyphenols, antioxidants, vitamins and minerals. (Kathleen, 2015). Peanuts contain all the 20 amino acids in variable proportions and is the biggest source of the protein called "arginine" (USDA, 2014). After the peanut oil is extracted, the protein content in the cake can reach 50% (Zhao et al., 2011).

Extraction of peanut protein from defatted peanut flour carried out by different conventional methods. But nutritional, sensory and technological properties of peanut proteins can be influenced due to these processes. A treatment combination i.e. High power sonication and Fermentation methods might be improve the above said properties of peanut protein. Water to defatted peanut flour might be affect the different strains of lactic acid producing bacteria and sonication process. So, the effect of different factors will be checked in this experiment.

The method and data for extraction of protein from different legumes through sonication and fermentation is available. But, very negligible information is available for extraction of peanut protein from defatted peanut flour. Hence, the experiment on for extraction of peanut protein from defatted peanut flour is adopted in this study to develop the process technology and to generate the information about the interaction between process parameters to optimize the levels which will be helpful to the society and food processors.

Status (review) :

- Emkani M. et al (2021) studied pea protein extraction through lactic fermentation. In this study, pH was reduced by lactic fermentation instead of mineral acid addition. Different bacterial strains viz. *Streptococcus thermophilus*, *Lactobacillus acidophilus* and *Bifidobacterium lactis* are used for the protein extraction. Total nitrogen content and protein nitrogen content of globulin fraction was observed ~ 14.5 % and ~ 9.5 % respectively. While total nitrogen content and protein nitrogen content of albumin fraction was observed ~ 11 % and ~ 7 % respectively. Nitrogen extraction yield of globulin and albumin fractions was found ~ 48 % and ~ 35 % respectively. In this study, SDS-PAGE was also performed for polypeptide profiling. Globulin-rich sample profiles revealed the presence of bands ranging from 10 to 99 kDa, characteristic of pea proteins. Various subunits of vicilin including the monomer (Vαβγ, ~50 kDa, Vαβ, ~30–36 kDa, Vβγ, ~25–30 kDa, Vα, ~20kDa, Vβ, ~13kDa, Vγ, ~12–16 kDa), legumin monomer (Lαβ, ~60kDa) and the higher-molecular-weight bands corresponded to lipoxygenase (LOX ~94 kDa) and convicilin (CV, ~71 kDa) was observed while in albumin rich sample profiles also showed clear bands of LOX, lectine (Lect, ~17 kDa) and some contaminations by globulin polypeptides, mainly Vαβ.
- Gayol *et al*. (2013) reported the optimization of protein concentration process from residual peanut oil cake (POC). Different protein extraction and precipitation conditions were used: water/flour ratio (10:1, 20:1 and 30:1), pH (8.0, 9.0 and 10.0), NaCl concentration (0 and 0.5 M), extraction time (30, 60 and 120 mins.), temperature (25, 40 and 60^{o}C), extraction stages (1, 2 and 3), and precipitation pH (4.0, 4.5 and 5.0). The extraction and precipitation conditions which showed the highest protein yield were 10:1 water / flour ratio, extraction at pH 9.0, without NaCl, 2 staeges of 30 mins. At 40^{o}C and precipitation at pH 4.5. Under these conditions, the peanut protein concentrate (PC) obtained 86.22 % protein, while the initial POC had 38.04 %.
- Gao Z. et al. (2020) studied the impact of alkaline extraction pH (8.5, 9.0, and 9.5) on chemical composition, molecular structure, solubility and aromatic profile of pea protein isolate (PPI). They observed that protein recovery yield increased from 49.20% to 57.56% as the alkaline extraction pH increased from 8.5 to 9.5.pH 9.0 was found to be the optimal condition for preparing premium PPI in terms of yield, functionality, and aromatic profile using alkaline extraction-isoelectric precipitation process. PPI extracted at pH 9.0 possessed the lowest beany flavor The lowest lipoxygenase activity at pH 9.0 may contribute to the least beany flavor in PPI.
- Gore et al (2022) analysed proteins from different varieties of groundnut seeds through SDS-PAGE profiling. Protein fraction viz. albumin, globulin, glutelin and prolamin

were extracted during the study, in which albumin % and globulin % content found to be in range of 16.2 to 20.43 % and 72.05-78.5 % respectively while glutelin % and prolamin % was found to be very lower in all varieties with the mean of 2.17 % and 2.57 % respectively. In SDS-PAGE profiling, it was observed albumin and globulin had the highest MW-Rf values in bands collectively (20–23), whereas glutelin and prolamin had the lowest MW-Rf values bands with ranged between 6-10 and correlation matrix between protein fractionation indicated that globulin was negatively correlated with prolamin and glutelin fraction.

Objectives :

1. To study the effect of process parameters on recovery of peanut protein isolate from defatted peanut flour.
2. To determine biochemical and physical properties of peanut protein isolate.
3. To determine the functional properties of the peanut protein isolate.

<u>Technical programme</u>

- **Experimental Detail :**

(a) Experimental Design : Response Surface Methodology : CCRD (3 = 2 numerical factors + 1 categoric factor)

(b) Base material : Defatted peanut flour

(c) Bacterial cultures : *Lactobacillus plantarum* (L) & *Pediococcus acidilactici* (P)

(Two different experiments are to be conducted for two bacterial cultures as per the below given treatments)

- **Treatments Detail :**

Independent parameters

Sr. No.	Factor	Code	Coded levels				
			-2	**-1**	**0**	**+1**	**+2**
1	Water to flour ratio	X_1	6	7.5	9	10.5	12
2	Sonication time	X_2	2	4.5	7	9.5	12

- **Treatment combinations :**

Run	Water to Flour Ratio	Sonication time (mins.)
1	9:1	2
2	10.5:1	9.5
3	7.5:1	9.5
4	12:1	7
5	9:1	12
6	6:1	7
7	9:1	7
8	9:1	7
9	9:1	7
10	7.5:1	4.5
11	9:1	7
12	9:1	7
13	9:1	7
14	10.5:1	4.5

- **Dependent parameters :**

  1. Acidification kinetics at 0,6,12,24,48 and 72 hours
  2. Biochemical parameters
     a) Moisture content
     b) Oil content
     c) Ash content
     d) SDS-PAGE
  3. Physical parameters
     a) Bulk density
     b) True density
     c) Porosity
  4. Functional parameters
     a) Water absorption index
     b) Water solubility index
     c) Protein isolate recovery
     d) Protein yield

- **Methodology :**

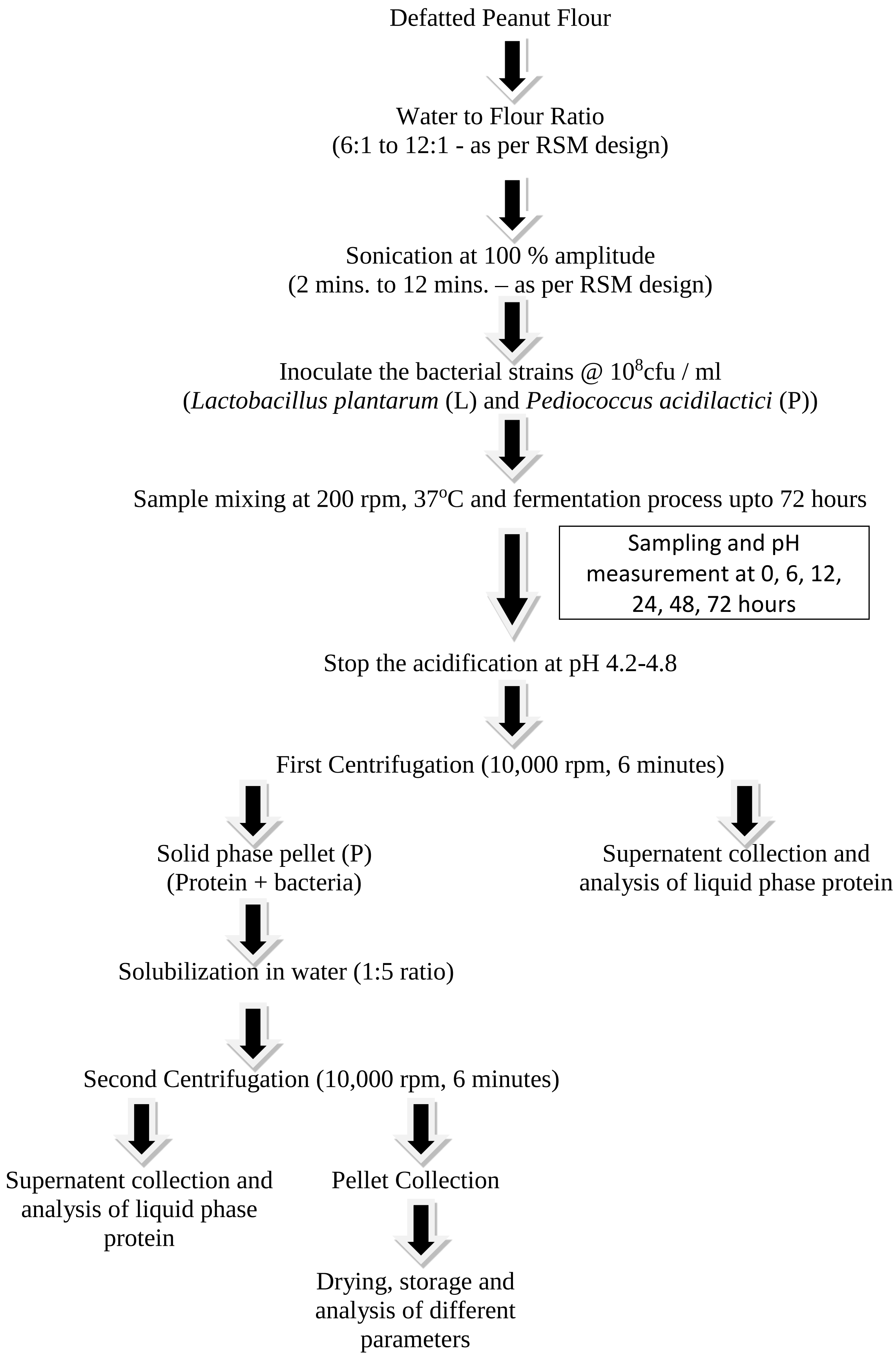


Fig. 4.1. Process flow chart for extraction of peanut protein.

Possible outputs :

- The process technology for the extraction of peanut protein using physical and biological methods will be standardized.
- The process technology can be made available to the commercial players and food processors.
- A green technology of protein extraction will be availed to the society.

References :

- Ali A. W.; Devinder K.; Idrees A. and Sogi D.S. 2007. Extraction optimization of watermelon seed protein using response surface methodology. *LWT Food Science and Technology*, 41:1514-1520.
- Bartkiene, E.; Krungleviciute, V.; Juodeikiene, G.; Vidmantiene, D.; Maknickiene, Z. 2015. Solid state fermentation with lactic acid bacteria to improve the nutritional quality of lupin and soya bean. *J. Sci. Food Agric. 95*, 1336–1342, doi:10.1002/jsfa.6827.
- Ben-Harb, S.; Saint-Eve, A.; Panouille, M.; Souchon, I.; Bonnarme, P.; Dugat-Bony, E.; Irlinger, F. 2019. Design of microbial consortia for the fermentation of pea-protein-enriched emulsions. *Int. J. Food Microbiol. 293*, 124–136, doi:10.1016/j.ijfoodmicro.2019.01.012.
- Cabuk, B.; Nosworthy, M.G.; Stone, A.K.; Korber, D.R.; Tanaka, T.; House, J.D.; Nickerson, M.T. 2018. Effect of Fermentation on the Protein Digestibility and Levels of Non-Nutritive Compounds of Pea Protein Concentrate. *Food Technol. Biotechnol. 56*, 257–264, doi:10.17113/ftb.56.02.18.5450.
- Emkani M.; Oliete B. and Saurel R. 2021. Pea Protein Extraction Assisted by Lactic Fermentation: Impact on Protein Profile and Thermal Properties. Food. 10, 549. https://doi.org/10.3390/foods10030549.
- Gayol, M.F.; Pramparo, M.C.; Nepote, V.; Fernandez, H. and Grosso, N.R. 2013. Optimization of protein concentration process from residual peanut oil cake. Grasas Y Aceies, 64(5): 489-496.
- Gore V.B.; Rathod P.J.; Vala A.G. and D.Kumar. 2022. Analysis of protein profiling through SDS-PAGE of spreading types varieties of groundnut grown in India. The Pharma Innovation Journal; SP-11(9): 2811-2817.
- Gao, Z.; Shen, P.; Lan, Y.; Cui, L.; Ohm, J.-B.; Chen, B.; Rao, J. 2020. Effect of alkaline extraction pH on structure properties, solubility,and beany flavor of yellow pea protein isolate. *Food Res. Int. 131*, 109045, doi:10.1016/j.foodres.2020.109045.
- Irakoze, P.C. and Sindayigaya, E. 2012. Response surface methodology for optimized extraction of protein from malted sorghum flour. *serie sciences exactes*, 26:97-113.
- Jay, R. H. and Michael, J. F. 2004. Macronutrient utilization during exercise : implications for performance and supplementation. Journal of sports science and medicine, 3:118-130.
- Klupsaite, D.; Juodeikiene, G.; Zadeike, D.; Bartkiene, E.; Maknickiene, Z.; Liutkute, G. 2017. The influence of lactic acid fermentation on functional properties of narrow-leaved lupine protein as functional additive for higher value wheat bread. *LWT. 75*, 180–186, doi:10.1016/j.lwt.2016.08.058.
- Rui, X.; Wang, M.; Zhang, Y.; Chen, X.; Li, L.; Liu, Y.; Dong, M. 2017. Optimization of soy solid-state fermentation with selected lacticacid bacteria and the effect on the anti-nutritional components. *J. Food Process. Preserv. 41*, e13290, doi:10.1111/jfpp.13290.
- Sozer, N.; Melama, L.; Silbir, S.; Rizzello, C.G.; Flander, L.; Poutanen, K. 2019. Lactic acid fermentation as a pre-treatment process for faba bean flour and its effect on textural,

structural and nutritional properties of protein-enriched gluten-free faba bean breads. *Foods. 8*, 431, doi:10.3390/foods8100431.

- Xing, Q.; Dekker, S.; Kyriakopoulou, K.; Boom, R.M.; Smid, E.J.; Schutyser, M.A.I. 2020. Enhanced nutritional value of chickpea protein concentrate by dry separation and solid state fermentation. *Innov. Food Sci. Emerg. Technol. 59*, 102269, doi:10.1016/j.ifset.2019.102269.

13. Financial Implications (in Lakhs) : Rs. 39.32 lakhs

(A) Financed by the institute

12.1 Manpower (Salaries / Wages)

S. No.	Staff Category	Man months	Cost
1.	Scientific	23	35,00,000
2.	Technical	5	4,00,000
3.	Supporting	--	--
4.	SRFs/RAs	--	--
5.	Contractual	--	--
	Total	28	39,00,000

12.2 Research/Recurring Contingency

S. No.	Item	Year(1)	Year (2)	Year (3)…	Total
1.	Consumables	10000	10000	--	20000
14.	Travel	5000	--	--	5000
15.	Field Preparation/ Planting/ Harvesting (Man-days/costs)	--	--	--	--
16.	Inter-cultivation & Dressing (Man-days/costs)	--	--	--	--
17.	Animal/Green house/Computer Systems/Machinery Maintenance	2000	--	--	2000
18.	Miscellaneous(Other costs)	5000	--	--	5000
	Total(Recurring)	22000	10000	--	32000

Justification : ---

12.3 Non-recurring (Equipment)

S. No.	Item	Year (1)	Year (2)	Year (3)…	Total
1.		--	--	--	--
2.		--	--	--	--
	Total (Non-recurring)	--	--	--	--

Justification : ---

12.4 Any Other Special Facility required (including cost)

12.5 Grand Total (12.1 to 12.4)

Item	Year (1)	Year (2)	Year (3)	Total
Grand Total	20,00,000	19,32,000	--	39,32,000

(B) Financed by an organization other than the Institute (if applicable) : No

(i) Name of Financing Organization : NA

(ii) Total Budget of the Project :

(iii) Budget details

S. No.	Item	Year(1)	Year(2)	Year (3)…	Total
1	Recurring Contingency				
	Travelling Allowance	--	--	--	--
	Workshops	--	--	--	--
	Contractual Services/ Salaries	--	--	--	--
	Operational Cost	--	--	--	--
	Consumables	--	--	--	--
2	Non - Recurring Contingency				
	Equipment	--	--	--	--
	Furniture	--	--	--	--
	Vehicle	--	--	--	--
	Others (Miscellaneous)	--	--	--	--
3	HRD Component				
	Training	--	--	--	--
	Consultancy	--	--	--	--
4	Works (i) New (ii) Renovation	--	--	--	--
5	Institutional Charges				

ANNEXURE - III
INDIAN COUNCIL OF AGRICULTURAL RESEARCH
CHECKLIST FOR SUBMISSION OF RPP-I
(Refer for Guidelines ANNEXURE-XI(C)

1. Project Title: Optimization of process parameters for protein extraction from peanut through fermentation.

2. Date of Start & Duration : March – 2023 to December - 2024

3. Institute Project [√] or Externally Funded [ ]

4. Estimated Cost of the Project : 39,32,000/- INR

5. Project Presented in the Divisional/Institutional Seminar? Yes / ~~No~~ [√]

6. Have suggested modifications incorporated? ~~Yes~~ / No [ ]

7. Status Report enclosed ~~Yes~~ / No

8. Details of work load of investigators in approved ongoing projects:

Project Leader				Co-PI – I				Co-PI – II…			
Proj. Code.	% Time spent	Date of start	Date of completion	Proj. Code.	% Time spent	Date of start	Date of completion	Proj. Code.	% Time spent	Date of start	Date of completion

9. Work Plan/Activity Chart enclosed Yes / ~~No~~ [√]

10. Included in Institute Plan Activity Yes / ~~No~~ [√]

11. Any previous Institute/Adhoc/Foreign aided projects on similar lines? ~~Yes~~ / No [√]

12. New equipment required for the project ~~Yes~~ / No [√]

13. Funds available for new equipment ~~Yes~~ / No [√]

14. Signatures

Project Leader Co-PI-I Co-PI-II Co-PI–III

HOD/PD/I/c

ANNEXURE - IV
INDIAN COUNCIL OF AGRICULTURAL RESEARCH
APPRAISAL BY THE PME CELL OF RPP-I
(Refer for Guidelines ANNEXURE-XI (D)

1. Institute Name : AICRP on PHET, JAU, Junagadh
2. Project Title: Optimization of process parameters for protein extraction from peanut through fermentation.
3. On scale 1-10 give score to (a) to (j)

(a)	Relevance of research questions	☐
(b)	Addressing priority of the institute and/or National priority	☐
(c)	New innovativeness expected in the study	☐
(d)	Appropriateness of design/techniques for the questions to be answered	☐
(e)	Elements of bias addressed in the study	☐
(f)	Adequacy of scientist(s) time allocation	☐
(g)	Extent of system review and meta analysis	☐
(h)	Effective control to experiments	☐
(i)	Economic evaluation and cost efficiency analysis	☐
(j)	How appropriately the expected output answers the questions being addressed in the specific subject matter/area (Basic/Applied/Translational/Others)?	☐
	***Total Score out of 100**	

* The score obtained is suggestive of the overall quality ranking of the project

4. Was there any other project carried in the past in the same area/topic?

Yes ☐ No ☐

If yes, list the project numbers.

5. Signature of PME Cell Incharge

NEW INVESTIGATION – II

RPP- I

ANNEXURE - I

INDIAN COUNCIL OF AGRICULTURAL RESEARCH

PROFORMA FOR PREPARATION OF STATUS REPORT FOR PROPOSAL OF A NEW RESEARCH PROJECT
(Refer for Guidelines ANNEXURE-XI(A))

1. Institute Name: College of Agril. Engg. & Tech., Junagadh Agril. University, Junagadh
2. Title of the project: Management of insect pest of storage wheat in bin by ozone.
3. Type of research project: ~~Basic~~/Applied/~~Extension/Farmer Participatory/Other~~ (specify)
4. Genesis and rationale of the project :

An academic research on this title is carried out at Junagadh Centre for one year storage period and best results were found. At the end of one year storage period there was only 5 insects/kg sample were found. Germination percentage of wheat grains were more than 80%. Maximum wheat damage percentage were only 12%. Based on the results for better output with modification in the treatment and entomological point of view this investigation is proposed.

Wheat is an important cereal crop in India. In India, wheat occupies 30.00 million hectares with total production of 93.51 million tones. (Anonymous 2012-13a). In Gujarat, wheat occupies 1.05 million hectares with total production of 3.14 million tones and productivity of 2990 kg/ha (Anonymous 2012-13b). Wheat when stored is often attacked by number of pests, viz. Lesser grain borer, Khapra beetle, Rust red flour beetle, etc. Fumigation is the best technique to completely remove the pests from the grains. Many fumigants have been found effective against storage pests, but are hazardous, due to their residual effect in the grains. This adverse effect of chemical fumigants need diversified efforts for evolving more convenient, safer and alternative methods to minimize the losses on wheat.

Ozone in its gaseous form has been shown to have potential to kill insect pests in commodities (Mason et al., 1999; Kells *et al*., 2001). High mortality was achieved for adults of the maize weevil, *Sitophilus zeamais* Motschulsky, and the larvae of the Indian meal moth, *Plodia interpunctella* Hubner when exposed to low ozone concentrations ranging from 5 to 45 ppm (Kells *et al*., 2001).Ozone toxicity during ontogeny of two species of flour beetles, *T. confusum and T. casteneum* was tested by Erdman,H E.(1980). Lemic et al (2019) investigated that ozone has the potential to become a realistic choice for suppressing harmful insects in storage systems for humans and livestock, either alone or as a complement to other control methods. Bonjour et al (2011) state ozonation has potential for the control of some stored grain insect pests on wheat.

Ozone is a highly reactive form of oxygen where three molecules are bonded together. Interest in ozone applications for agriculture and food processing has increased in recent years. In 2001, ozone was declared a GRAS (generally recognized as safe) substance by the FDA, USA. Ozone is a safe, powerful disinfectant as well as the strongest commercially available oxidant; it can be used to control biological growth of unwanted organisms in products and equipment used in the food processing industries. Ozone is particularly suited to the food industry because of its ability to disinfect microorganisms & pests without adding chemical.

5. Knowledge/Technology gaps and justification for taking up the present project including the questions to be answered :

   Generally wheat grains are stored in bag. Due to automation in grain handling and storage systems, now a days silo storage are increasing and private stackholders prefers to store wheat in silo. Chemicals are used to control the insect-pest during storage. An alternative chemical free technology is a dire need to compete the storage systems in silo. An academic research for ozone treatment in wheat stored in bin is carried out with different cycles and different ozone exposure period in bin at Junagadh Centre for one year storage period and best results were found. At the end of one year storage period germination percentage of wheat grains were more than 80%. Maximum wheat damage percentage were only 5%. There was only 2-3 insects/kg sample were found. Based on the results for better output with modification in the treatment and entomological point of view this investigation is proposed.

6. Critical review of present status of the technology at national and international levels along with complete references :

   - Tadesse *et al.,* (2008) investigated that dominant primary storage insect pests associated with stored wheat include the granary weevil, rice weevil, maize weevil. Major secondary storage pests in wheat include the red flour beetle, confused flour beetle and almond Moth.
   - Kalsa *et al.,* (2019) worked on insect population during storage. In this experiment, wheat samples were collected over a period of eight months. They concluded that the densities of live *Sitophilus spp*. in samples with chemical treatment at storage (227.0 insects per kg) were statistically similar to untreated wheat grain (259.4 insects per kg). The density of *S. granarius* was 209.4 insects per kg, *R. dominica* was mainly detected at densities of 4 insects per kg. Moreover, *Liposceliss spp.* were detected with 31 insects per kg to 200 insects per kg. The mean percentage of insect damaged kernels ranged from 3.6 to 13.6. Non-significant differences were detected in percentage weight loss and insects. The weight loss ranged from 0.0% to 16.7%. There were non-significant differences among samples in the percentage of seed germination. Generally, insect-infested samples exhibited significantly lower mean germination (70.3%) than insect-free samples (80.5%).

   - Soares *et al.* (2020) developed storage silo with ozone gas fungal decontamination using IoT based real-time monitoring. In fig. 2.4 and 2.5 shown that O_3 generator and grain storage unit structures with specific design of gas insertion. The conduction of O_3 gas was accomplished through openings pipes that release O_3. In each silo there were three tubes with up to 36 openings. Humidity and temperature sensors were inserted into the silos using cables. As a result, significant reduction of toxigenic fungi. The system was able to monitor and identify fungal species according to temperature and humidity of the silo.

- Nickhil e*t al.* (2021) developed pilot-scale silo structure for storage of chickpea in 3 stainless steel (304 Grade) bins (250 kg capacity) with specific function of ozone supply (fig.2.6). They were treated chickpea with gaseous ozone until the concentration reached the desirable level, which was detected by the ozone sensors mounted on the bins. The samples were then stored for 6 months without any more treatments.

- Maier *et al.* (2006) studied on ozonation as a non-chemical stored product protection technology. Ozone analyzer has monitoring ozone concentration range from 0 to 2000 ppm. They reported 100 % insect mortality gain after three days of exposure at 50 ppm of ozone to grains.
- Mason *et al.* (2006) worked on the controlling stored grain insects with ozone fumigation. Once grain has been exposed to ozone, subsequent movement through the grain is much quicker. At the high concentration, 100% mortality of adult red flour beetles, confused flour beetles and maize weevils, as well as greatly reduced emergence.
- Nickhil *et al.* (2021) investigated that Ozone concentration, moisture content of the grain, grain bed thickness, and storage temperature had significant effects on the disinfestation of *C. maculatus* insects. 100% insect mortality (adult and egg) were achieved with treated at 1000 ppm ozone for 5 consecutive days.
- Savi and Scussel (2014) exposed for 40, 60, 90, and 120 min to O_3 gas in wheat storage. They recorded that up to 120 min exposure did not affect the quality and seed germination.
- According to Avdeeva *et al.* (2018), applying ozone to improve the germination of winter wheat seeds found that in addition to promoting germination, the seeds' germination energy is also increased.

References:

Anonymous (2012-13a), Area, production and yield of wheat IASRI WWW.iasri.res.in./agridata

Anonymous (2012-13b), Area, production and yield of wheat during 2011-12 and 2012-13.WWW.krishijagran.com

Avdeeva, V.; Zorina, E.; Bezgina, J. and Kolosova, O. (2018). Influence of ozone on germination and germinating energy of winter wheat seeds. Engineering for Rural Development, 23-25. Avdeeva, V.; Zorina, E.; Bezgina, J. and Kolosova, O. (2018). Influence of ozone on germination and germinating energy of winter wheat seeds. Engineering for Rural Development, 23-25.

Bonjour, E. L.; Opit, G. P.; Hardin, J.; Jones, C. L.; Payton, M. E. and Beeb, R. L. (2011). Efficacy of ozone fumigation against the major grain pests in stored wheat. *Journal of Economic Entomology,* **104(1):** 308-316.

Erdman,H E.(1980).Ozone toxicity during ontogeny of two species of flour beetles, *T.confusum and T.casteneum.* Environmental Entomology**, 9**:16-17

FDA (2001). United state of food and drug administration. Rules and Regulations. Part 173-Secondary Direct Food additives permitted in food for human consumption. Federal Register, 66:123

Kalsa, K. K.; Subramanyam, B.; Demissie, G.; Mahroof, R.; Worku, A. and Gabbiye, N. (2019). Evaluation of postharvest preservation strategies for stored wheat seed in Ethiopia. Journal of Stored Products Research, 81:53-61.

Kells SA, Mason LJ, Maier DE, Woloshuk CP., 2001. Efficacy and fumigation characteristics of ozone in stored maize. J. Stored Prod. Res. **37**, 371-382.

Lemic, D.; Jembrek, D.; Bazok, R. and Zivkovi, I. P. (2019). Ozone effectiveness on wheat weevil suppression: preliminary research. Insects, 10: 1-12.the rate of ozone consumption. *Journal of Stored Products Research*, **46:**149-154.

Maier, D. E.; Hulasare, R.; Campabadal, C. A.; Woloshuk, C. P. and Mason, L. (2006). Ozonation as a non-chemical stored product protection technology. In: Proceeding of 9 th International Working Conference on Stored Product Protection. Campinas, Sao Paulo, Brazil. pp. 773-777.

Mason LJ, Strait CA, Woloshuk CP, Maier DE (1999). Controlling of stored grain insects with ozone fumigation. Proceeding of the seventh international working conference on stored product protection, Beijing, China.

Nickhil, C.; Mohapatra, D.; Kar, A.; Giri, S. K.; Verma, U. S.; Sharma, Y. and Singh, K. K. (2021). Delineating the effect of gaseous ozone on disinfestation efficacy, protein quality, dehulling efficiency, cooking time and surface morphology of chickpea grains during storage. Journal of Stored Products Research, 93.

Savi, G. D. and Scussel, V. M. (2014). Effects of ozone gas exposure on toxigenic fungi species from fusarium, aspergillus, and penicilliumgenera. Ozone: Science & Engineering, 36(2): 144–152.

Soares, C.; Gomes, E.; Dahlke, F.; De Rolt, C.; Plentz, P.; Dantas, M. and Scussel, V. (2020). Use of IoT to Real-Time Monitoring of Storage Silo and Ozone Gas Fungal Decontamination Strategy. International Journal of Computers and Applications, 175:1-7.

Tadesse, A.; Ayalew, A.; Getu, E. and Tefera, T. (2008). Review of Research on PostHarvest Pests. In: A Tadesse (ed), Increasing Crop Production through Improved. Plant Protection-Volume I (pp.475–561).

7. Expertise available with the investigating group/Institute

The PI & Co-PIs of project having enough experience of working in the field of Processing and Food Engineering. Experts in the field of Processing and Food Engineering.

8. Brief note on Proprietary/Patent Perspective (for projects related to technology development)/Ethics/Animal Welfare/Bio Safety Issues

- No issues are there on these aspects.

9. (a) Expected output

    1. The technology can be made available to the commercial storager and food processors.
    2. A green technology of post-harvest wheat will be availed to the society.

   (b) Clientele/Stake holders (including economic and socio aspects)

   i. Wheat growers ii. Wheat processors iii. Consumers

10. Signatures

[Project Leader] [Co-PIs] ……

11. Comments and signature

[Head of Division]

ANNEXURE- II

INDIAN COUNCIL OF AGRICULTURAL RESEARCH

RESEARCH PROJECT PROFORMA FOR INITIATION OF A RESEARCH PROJECT (RPP - I)

(Refer for Guidelines ANNEXURE-XI (B))

1. Institute Project Code (to be provided by PME Cell)
2. Project Title: Management of insect pest of storage wheat in bin by ozone.
3. Key Words : Ozone, wheat, bulk storage, ozone exposure time, ozone cycle, physicochemical characteristics, storage bin
4. (a) Name of the Lead Institute : College of Agril. Engg. & Tech., Junagadh Agril. University, Junagadh

   (b) Name of Division/ Regional Center/ Section : AICRP on PHET, Junagadh centre

5. (a) Name of the Collaborating Institute(s) : --

   (b) Name of Division/ Regional Center/ Section of Collaborating Institute(s) : ---

6. Project Team (Name(s) and designation of PI, CC-PI and all project Co-PIs, with time proposed to be spent)

Sr. No.	Name, designation and institute	Status in the project (PI/CC-PI/ Co-PI)	Time to be spent (%)	Work components to be assigned to individual scientist
1.	Prof. D. V. Khanpara Assistant Entomology , AICRP on PHET, Dept. of Processing and Food Engg., College of Agril. Engg. & Tech., Junagadh Agril. University, Junagadh	PI	75%	Planning, data collection, statistical analysis and final report Writing
2.	Prof. A. M. Joshi Assistant Microbiologist, AICRP on PHET, Dept. of Processing and Food Engg., College of Agril. Engg. & Tech., Junagadh Agril. University, Junagadh	Co-PI-I	15%	Helping in analysis and data collection
3.	Dr. M. N. Dabhi, Research Engineer, AICRP on PHET, Dept. of Processing and Food Engg., College of Agril. Engg. & Tech., Junagadh Agril. University, Junagadh.	Co-PI-III	10%	Supervision and Co-ordination

7. Priority Area to which the project belongs : Post Harvest Technology
(If not already in the priority area, give justification)

8. Project Duration : Date of Start: 01-12-2022 Likely Date of Completion **:**31-10-2024

9. (a) Objectives :

1. To evaluate the effectiveness of ozonization treatments on storage insect pest of wheat in bin storage.

2. To evaluate the effect of ozone treatments on germination of wheat in bin storage.

(b) Practical utility :

- To control insect of storage wheat by non-hazardous method to human is very important in large scale storage in silos.

10. Activities and outputs details:.

Objective wise	Activity	Month & Year of		Output monitorable target(s)	% to be carried out in different years		Scientist(s) responsible
		Start	Comple-tion		1	2	
1.	Review collection	Dec-22	Jan-23	- To collect the review on insect pest stored wheat. -To study the work done in the past.	100%	-	Prof. D. V. Khanpara
2.	Collection information of storage Bin material, design, manufacture insturies	Feb 23	Sep 23	-To fix size of bin -To select the material quality of bin -To decide manufacture dealer of bin	100%		Prof. D. V. Khanpara Prof. A. M. Joshi Dr. M. N. Dabhi
3.	Preparation and purchase bin. Ozone machine, wheat seed	Oct 23	April 24	-To procurement of good quality ozone machine -To procurement of good quality wheat seed -To procurement of good quality wheat storage nin	100%		Prof. D. V. Khanpara Prof. A. M. Joshi Dr. M. N. Dabhi

4.	Installation trial, collection data, monitoring trial, observation recorded	May 24	Oct 2024	-To record initial observation -To give base treatment -To give ozone treatment as per schedule -To record observation at end of trial		100%	Prof. D. V. Khanpara Prof. A. M. Joshi Dr. M. N. Dabhi
5.	Data analysis and result preparation	Nov 24	Jan 25	Compilation of collected data and preparation of report		100%	Prof. D. V. Khanpara Prof. A. M. Joshi Dr. M. N. Dabhi

2022	2023												2024												2025
Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan
Review collection																									
		Collection information of storage Bin material, design, manufacture insturies																							
										Preparation and purchase bin. Ozone machine, wheat seed															
																	Installation trial, collection data, monitoring trial, observation recorded								
																							Data analysis and result preparation		

11. Technical Programme (brief)

Justification :

Wheat is an important cereal crop in India. In India, wheat occupies 30.00 million hectares with total production of 93.51 million tones. (Anonymous 2012-13a). In Gujarat, wheat occupies 1.05 million hectares with total production of 3.14 million tones and productivity of 2990 kg/ha (Anonymous 2012-13b).Wheat when stored is often attacked by number of pests, viz. Lesser grain borer, Khapra beetle, Rust red flour beetle, etc. Fumigation is the best technique to completely remove the pests from the grains. Many fumigants have been found effective against storage pests, but are hazardous, due to their residual effect in the grains. This adverse effect of chemical fumigants need diversified efforts for evolving more convenient, safer and alternative methods to minimize the losses on wheat.

Ozone in its gaseous form has been shown to have potential to kill insect pests in commodities (Mason et al., 1999; Kells et al., 2001). High mortality was achieved for adults of the maize weevil, *Sitophilus zeamais* Motschulsky, and the larvae of the Indian meal moth, *Plodia interpunctella* Hubner when exposed to low ozone concentrations ranging from 5 to 45 ppm (Kells et al., 2001).Ozone toxicity during ontogeny of two species of flour beetles,*T.confusum and T.casteneum* was tested by Erdman,H E.(1980).

Ozone is a highly reactive form of oxygen where three molecules are bonded together. Interest in ozone applications for agriculture and food processing has increased in recent years. In 2001, ozone was declared a GRAS (generally recognized as safe) substance by the FDA, USA.Ozone is a safe, powerful disinfectant as well as the strongest commercially available oxidant; it can be used to control biological growth of unwanted organisms in products and equipment used in the food processing industries. Ozone is particularly suited to the food industry because of its ability to disinfect microorganisms & pests without adding chemical.

Objectives :

1. To evaluate the effectiveness of ozonazation treatments on storage insect pest of wheat in bin storage.
2. To evaluate the effect of ozone treatments on germination of wheat in bin storage.

Technical programme

- **Experimental Detail :**
  - (a) Experimental Design : CRD
  - (b) Replication : 2
  - **(c) Treatments Detail :** One common treatment of ozone @1000mg/120 minute will be given to all treatment except control at time of installation of trial. Next treatment will be given as per dose mention in treatment at 5 days interval.

Sr. No	Treatents
1.	One dose of ozone @1000mg/120 minute after installation
2.	Two dose of ozone @1000mg/120 minute after installation
3.	Three dose of ozone @1000mg/120 minute after installation
4	Four dose of ozone @1000mg/120 minute after installation
5	Five dose of ozone @1000mg/120 minute after installation
6	Six dose of ozone @1000mg/120 minute after installation
7	Seventh dose of ozone @1000mg/120 minute after installation
8	Eight dose of ozone @1000mg/120 minute after installation
9	Ten dose of ozone @1000mg/120 minute after installation
10	Control(Untreated)

- **Dependent parameters :**

(d) Observation to be recorded:

(A) Entomological Parameters:

i. Pest population

ii. Percent grain damage

(B) Physical parameters: Germination percentage

Methodology:

Wheat will be procured from University research station, Krishigadh JAU, Junagadh. 25 kg grains of wheat will be stored in fabricated 20 GI metal cylindrical storage bins (25 kg capacity). All GI metal cylindrical storage bins will be kept at room temperature in laboratory for six month. Observation of all entomological and physical parameters during storage will be recorded at initial and end of experiment.

Plate 5.1. Fabrication of storage bin specifically designed with ozone gas circulating system

Possible outputs:

- The technology can be made available to the commercial storager and food processors.
- A green technology of post-harvest wheat will be availed to the society.

References :

Anonymous (2012-13a), Area, production and yield of wheat IASRI WWW.iasri.res.in./agridata

Anonymous (2012-13b), Area, production and yield of wheat during 2011-12 and 2012-13.WWW.krishijagran.com

Avdeeva, V.; Zorina, E.; Bezgina, J. and Kolosova, O. (2018). Influence of ozone on germination and germinating energy of winter wheat seeds. Engineering for Rural Development, 23-25. Avdeeva, V.; Zorina, E.; Bezgina, J. and Kolosova, O. (2018). Influence of ozone on germination and germinating energy of winter wheat seeds. Engineering for Rural Development, 23-25.

Bonjour, E. L.; Opit, G. P.; Hardin, J.; Jones, C. L.; Payton, M. E. and Beeb, R. L. (2011). Efficacy of ozone fumigation against the major grain pests in stored wheat. *Journal of Economic Entomology,* **104(1):** 308-316.

Erdman,H E.(1980).Ozone toxicity during ontogeny of two species of flour beetles, *T.confusum and T.casteneum.* Environmental Entomology**, 9**:16-17

FDA (2001). United state of food and drug administration. Rules and Regulations. Part 173-Secondary Direct Food additives permitted in food for human consumption. Federal Register, 66:123

Kalsa, K. K.; Subramanyam, B.; Demissie, G.; Mahroof, R.; Worku, A. and Gabbiye, N. (2019). Evaluation of postharvest preservation strategies for stored wheat seed in Ethiopia. Journal of Stored Products Research, 81:53-61.

Kells SA, Mason LJ, Maier DE, Woloshuk CP., 2001. Efficacy and fumigation characteristics of ozone in stored maize. J. Stored Prod. Res. **37**, 371-382.

Lemic, D.; Jembrek, D.; Bazok, R. and Zivkovi, I. P. (2019). Ozone effectiveness on wheat weevil suppression: preliminary research. Insects, 10: 1-12.the rate of ozone consumption. *Journal of Stored Products Research***, 46***:*149-154.

Maier, D. E.; Hulasare, R.; Campabadal, C. A.; Woloshuk, C. P. and Mason, L. (2006). Ozonation as a non-chemical stored product protection technology. In: Proceeding of 9 th International Working Conference on Stored Product Protection. Campinas, Sao Paulo, Brazil. pp. 773-777.

Mason LJ, Strait CA, Woloshuk CP, Maier DE (1999). Controlling of stored grain insects with ozone fumigation. Proceeding of the seventh international working conference on stored product protection, Beijing, China.

Nickhil, C.; Mohapatra, D.; Kar, A.; Giri, S. K.; Verma, U. S.; Sharma, Y. and Singh, K. K. (2021). Delineating the effect of gaseous ozone on disinfestation efficacy, protein quality, dehulling efficiency, cooking time and surface morphology of chickpea grains during storage. Journal of Stored Products Research, 93.

Savi, G. D. and Scussel, V. M. (2014). Effects of ozone gas exposure on toxigenic fungi species from fusarium, aspergillus, and penicilliumgenera. Ozone: Science & Engineering, 36(2): 144–152.

Soares, C.; Gomes, E.; Dahlke, F.; De Rolt, C.; Plentz, P.; Dantas, M. and Scussel, V. (2020). Use of IoT to Real-Time Monitoring of Storage Silo and Ozone Gas Fungal Decontamination Strategy. International Journal of Computers and Applications, 175:1-7.

Tadesse, A.; Ayalew, A.; Getu, E. and Tefera, T. (2008). Review of Research on PostHarvest Pests. In: A Tadesse (ed), Increasing Crop Production through Improved. Plant Protection-Volume I (pp.475–561).

12. Financial Implications (in Lakhs) : Rs. 42.17 lakhs

(A) Financed by the institute

12.1 Manpower (Salaries / Wages)

S. No.	Staff Category	Man months	Cost
1.	Scientific	25	37,00,000
2.	Technical	4	3,50,000
3.	Supporting	--	--
4.	SRFs/RAs	--	--
5.	Contractual	--	--
	Total	29	40,50,000

12.2 Research/Recurring Contingency

S. No.	Item	Year(1)	Year (2)	Year (3)…	Total
1.	Consumables	125000	30000	--	155000
2.	Travel	5000	--	--	5000
3.	Field Preparation/ Planting/ Harvesting (Man-days/costs)	--	--	--	--
4.	Inter-cultivation & Dressing (Man-days/costs)	--	--	--	--
5.	Animal/Green house/Computer Systems/Machinery Maintenance	2000	--	--	2000
6.	Miscellaneous(Other costs)	5000	--	--	5000
	Total(Recurring)	137000	30000	--	167000

Justification : --

12.3 Non-recurring (Equipment)

S. No.	Item	Year (1)	Year (2)	Year (3)…	Total
1.		--	--	--	--
2.		--	--	--	--
	Total (Non-recurring)	--	--	--	--

Justification : ---

12.4 Any Other Special Facility required (including cost)

12.5 Grand Total (12.1 to 12.4)

Item	Year (1)	Year (2)	Year (3)	Total
Grand Total	22,00,000	20,17,000	--	42,17,000

(B) Financed by an organization other than the Institute (if applicable) : No

(i) Name of Financing Organization : NA

(ii) Total Budget of the Project :

(iii) Budget details

S. No.	Item	Year(1)	Year(2)	Year (3)…	Total
1	Recurring Contingency				
	Travelling Allowance	--	--	--	--
	Workshops	--	--	--	--
	Contractual Services/ Salaries	--	--	--	--
	Operational Cost	--	--	--	--
	Consumables	--	--	--	--
2	Non - Recurring Contingency				
	Equipment	--	--	--	--
	Furniture	--	--	--	--
	Vehicle	--	--	--	--
	Others (Miscellaneous)	--	--	--	--
3	HRD Component				
	Training	--	--	--	--
	Consultancy	--	--	--	--
4	Works (i) New (ii) Renovation	--	--	--	--
5	Institutional Charges				

ANNEXURE - III

INDIAN COUNCIL OF AGRICULTURAL RESEARCH
CHECKLIST FOR SUBMISSION OF RPP-I
(Refer for Guidelines ANNEXURE-XI(C)

1. Project Title : Management of insect pest of storage wheat in bin by ozone
2. Date of Start & Duration : Dec – 2022 to October - 2024
3. Institute Project [√] or Externally Funded [ ]
4. Estimated Cost of the Project : 42, 17,000/- INR
5. Project Presented in the Divisional/Institutional Seminar? ~~Yes~~ / No [ ]
6. Have suggested modifications incorporated? ~~Yes~~ / No [ ]
7. Status Report enclosed ~~Yes~~ / No
8. Details of work load of investigators in approved ongoing projects:

Project Leader				Co-PI – I				Co-PI – II…			
Proj. Code.	% Time spent	Date of start	Date of completion	Proj. Code.	% Time spent	Date of start	Date of completion	Proj. Code.	% Time spent	Date of start	Date of completion
-	-	-	-	-	-	-	-	PH/JU/ 2022/01	50	01/05/2022	Continue
								-	-	-	-
								-	-	-	-
				-	-	-	-	-	-	-	-

9. Work Plan/Activity Chart enclosed Yes / ~~No~~ [√]
10. Included in Institute Plan Activity Yes / ~~No~~ [√]
11. Any previous Institute/Adhoc/Foreign aided projects on similar lines? ~~Yes~~ / No [√]
12. New equipment required for the project ~~Yes~~ / No [√]
13. Funds available for new equipment ~~Yes~~ / No [√]
14. Signatures

Project Leader Co-PI-I Co-PI-II Co-PI–III

HOD/PD/I/c

ANNEXURE - IV
INDIAN COUNCIL OF AGRICULTURAL RESEARCH
APPRAISAL BY THE PME CELL OF RPP-I
(Refer for Guidelines ANNEXURE-XI (D)

1. Institute Name : AICRP on PHET, JAU, Junagadh
2. Project Title: Management of insect pest of storage wheat in bin by ozone.
3. On scale 1-10 give score to (a) to (j)

(a)	Relevance of research questions	☐
(b)	Addressing priority of the institute and/or National priority	☐
(c)	New innovativeness expected in the study	☐
(d)	Appropriateness of design/techniques for the questions to be answered	☐
(e)	Elements of bias addressed in the study	☐
(f)	Adequacy of scientist(s) time allocation	☐
(g)	Extent of system review and meta-analysis	☐
(h)	Effective control to experiments	☐
(i)	Economic evaluation and cost efficiency analysis	☐
(j)	How appropriately the expected output answers the questions being addressed in the specific subject matter/area (Basic/Applied/Translational/Others)?	☐
	***Total Score out of 100**	

* The score obtained is suggestive of the overall quality ranking of the project

4. Was there any other project carried in the past in the same area/topic?

Yes ☐ No ☐

If yes, list the project numbers.

5. Signature of PME Cell Incharge

NEW INVESTIGATION – III

RPP- I

ANNEXURE - I

INDIAN COUNCIL OF AGRICULTURAL RESEARCH

PROFORMA FOR PREPARATION OF STATUS REPORT

FOR PROPOSAL OF A NEW RESEARCH PROJECT

(Refer for Guidelines ANNEXURE-XI(A))

1. Institute Name : College of Agril. Engg. & Tech., Junagadh Agril. University, Junagadh
2. Title of the project : Development of peanut based extruded product suitable for fasting.
3. Type of research project: Basic/~~Applied/Extension/Farmer Participatory/Other~~ (specify)
4. Genesis and rationale of the project :

Fasting is a ritual from many thousands of years which is a healing and a religious or spiritual process. Fasting is an integral part of the Indian culture and tradition and thought to be important as it nourishes both the physical and spiritual needs of the person. Also many religions including Christianity, Judaism and the Eastern religions have encouraged fasting for penitence, mourning, sacrifice and union with the God. During fasting people would like to eat traditional product prepared from sago, sweet potato, potato and fruits. Indian people are preferred khichadi, sabudana (sago) vada, sweet potato kheer, potato vada and fruit juices made traditionally at home. But there are fewer choices available for commercial product in market such as potato chips and banana chips snacks. In recent years, the demand for snacks with improved nutritional and functional properties has been increased. Among these, expanded product has gained preference of both consumers and producers (Rathod and Annapure, 2016).

Peanut, amaranth, barnyard millet and tapioca pearl are the few food materials which are used in the preparation of dishes during fasting. Peanut is a rich and promising source of protein and somewhere similar to that of soybean. On account of growing demand from food industries and health-conscious consumers, study and developments in peanut based products, technologies and machineries are necessary of peanut growing and processing regions. Amaranth has one of the highest levels of protein that is also easier for the human body to absorb. It also contains an amino acid called Lysine which is missing from other cereals, making it a complete protein source. Phytosterols present in Amaranth help lower cholesterol. One of the main reason of its popularity in India as it has become an important part in Hindu fasting rituals. Barnyard millet is an appropriate food for patients intolerant to gluten which causes celiac disease. Seeds of this crop are nutritious. Tapioca pearls or sabudana primarily contain starch, a simple carbohydrate that is easily digested and is also a direct source of energy. It is low in sodium content, practically has no cholesterol and comprises significant quantities of calcium, for strengthening bones. It is used in the preparation of various traditional dishes, snacks such as wafers, fried chips and also used as animal feed at household level.

5. Knowledge/Technology gaps and justification for taking up the present project including the questions to be answered :

The snack industry is the fastest growing food sector and is the king in producing convenience foods. Extrusion plays a major role in producing such kind of popular foods like puffs, pasta, cereals, gums etc. Extruded snacks are processed food products made from a combination of ingredients that are either pushed through a mold or precision cut. Consumer acceptance of extruded foods is mainly due to the convenience, value, attractive appearance, and texture found to be particular for these foods, especially when it concerns to snack products. Novel ingredients, cutting-edge extrusion technology, and innovative processing methods are combined to yield new snack products with ever widening appeal to health-conscious consumers that are seeking different textures and mouth feeling with convenience.

During the various festivals celebrated in India, fasting is an integral part of Hindu rituals. Amaranth, barnyard millet, tapioca pearls and peanuts are very popular food materials which are utilized in the preparation of various fast foods on the occasion of various Hindu festivals. Extruded snacks with multiple cereals and tubers are very famous food products consumed by peoples of all ages. No any extruded products are available in the market which can be used for the fasting purpose. Peanut, amaranth, barnyard and tapioca pearls are easily available and economical raw material source for production of extruded product. Defatted peanut flour is very rich in the protein content and can play a good role in improving the protein level in the extruded products. Amaranth, barnyard and tapioca pearls also contains a very important nutritional components required by our body. Further, all these food materials are found suitable for preparation of fasting food as per the Hindu rituals. A very negligible information is available on the utilization of all these food materials in the preparation of extruded products. In view of this, the present investigation is undertaken to develop extruded snacks suitable for fasting by utilizing peanut, amaranth, barnyard and tapioca pearl flours as a raw material.

6. Critical review of present status of the technology at national and international levels along with complete references :

Pathak and Kochhar (2017) reported that a majority of world population suffers from qualitative and quantitative insufficiency of dietary protein and calories intake. In all such cases, physiological maintenance and growth are impaired and malnutrition results. In this context extrusion is a beneficial process. Extrusion is one of the commonly adopted processing technique by food industries which employs mixing, forming, texturing and cooking to develop a novel food product. It is one of the contemporary food processing technologies applied for development of variety of snacks, specialty and supplementary foods. The versatility of extrusion technology makes it convenient for development of nutritionally rich extruded products with wide range of raw material and useful as a source of vehicle for value addition. Extruded products have less moisture, longer shelf life, microbiologically safe and there are plenty of ways to make value added and fortified extruded products with combination of different raw materials. This review comprehensively covers the potential of extrusion technology in development of various types of value added extruded products that can be popularized for combating malnutrition globally.

Davara *et al.* (2022) developed the extruded snack products by blending of corn flour and defatted peanut flour using twin screw extruder. The combined effects of feed moisture content, defatted peanut flour content, die head temperature and screw speed on the important physical (expansion ratio) and functional (water absorption index, water holding capacity and water solubility index) properties of extrudates were studied. The Response Surface Methodology (RSM) was used in designing the experiment. Since, the defatted peanut flour is poor in starch content, the flour content restricted the gelatinization and limited the expansion of the product. Defatted peanut flour was found to be suitable for the preparation of extruded snacks with the appropriate blending corn flour as a base material. The optimum treatment condition was found as 13% feed moisture content, 26% defatted peanut flour, 135 °C die head temperature and 250 rpm screw speed for the production of extruded product by blending of defatted peanut flour with corn flour.

Dokić *et al*. (2009) studied that extruded amaranth grain products have specific aroma and can be used as snack food, supplement in breakfast cereals, or as raw material for further processing. Extruded products of corn-amaranth grits blends, containing 20% or 50% amaranth grain grits, were produced by extrusion-cooking using a laboratory Brabender single screw extruder 20 DN. Extrudates with various texture were obtained. During extrusion process starch granules are partially degraded, hence rheological properties were examined. All samples exhibited thixotropic flow behavior. Those samples in which part of the corn grits was replaced with amaranth one had lower viscosity and exhibited lower level of structuration during storage. Increasing amount of amaranth grits in the extrusion blend causes increase of density and hardness of the extrudated products and decrease in expansion index. When part of the corn grits is replaced with amaranth grits viscosity of gels decreases compared to pure corn grits.

Rajashekar *et al.* (2019) developed the extruded product using barnyard millet (20-30%), finger millet (10-30%), corn grits (40-60%), and green gram dhal (10%) blends. The extruded products were compared with control Corn grits (100%). Physical and sensory qualities of extruded products were investigated. Bulk density was reduced with increasing corn grits content and expansion ratio increased with increasing corn grits composition. The proximate analysis was carried out for all samples. Compare to all samples with control the T1 sample (barnyard millet, finger millet, corn grits, green gram dhal were 30,20,40,10 percent respectively) showed good attributes and which was combination of cereal and pulse so it may be balance our protein requirement. The selected extruded product T1 studied shelf life studied at room temperature till 45 days the product was good.

Patel *et al.* (2016) developed a protein-rich puffed snack using a twin screw extruder and the effects of varying levels of tapioca starch (11 to 40 parts), rennet casein (6 to 20 parts) and sorghum flour (25 to 75 parts) on physico-chemical properties and sensory attributes of the product studied. An increasing level of sorghum flour resulted in a decreasing whiteness (Hunter L* value) of the snack. Although the starch also generally tended to make the product increasingly darker, both starch and casein showed redness parameter (a* value) was not significantly influenced by the ingredients levels, the yellow hue (b* value) generally declined with the increasing sorghum level. Tapioca starch significantly increased the expansion ratio and decreased the bulk density and hardness value of the snack, whereas the opposite effects seen in case of sorghum flour. While the water solubility index (WSI) was enhanced by starch, water absorption index was appreciably improved by sorghum. Incorporation of casein (up to 25 %) improved the sensory colour and texture scores, and so also the overall acceptability rating of the product. Sorghum flour had an adverse impact on all the sensory attributes whereas starch only on the colour score. The casein or starch level had no perceivable effect on the product's flavour score. The response surface data enabled optimization of the snack-base formulation for the desired protein level or desired sensory characteristics

7. Expertise available with the investigating group/Institute

The PI & Co-PI of project is having enough experience of working in the field of Processing and Food Engineering. Both the project members are the experts in the field of Processing and Food Engineering. The PI is quite capable and qualified to handle this project. The facility and man power is available in the institute to conduct the experimental activities in the laboratory.

8. Brief note on Proprietary/Patent Perspective (for projects related to technology development)/Ethics/Animal Welfare/Bio Safety Issues

- No issues are there on these aspects.

9. (a) Expected output

1. No any fasting snack product is available in the market. The new peanut based extruded product along with other food materials which is suitable for fasting will be developed.
2. Protein content in the extruded product will be improved due to blending of peanut flour. Other food materials like amaranth, barnyard millet and tapioca pearl are also very nutritious and suitable for preparation of extruded product. The new process will develop the fasting snack product with more nutritional value in comparison to commercially available extruded products.
3. The flour proportion of different food materials will be optimized to prepare the fasting snack product with good sensory characteristics.
4. The process parameters for the preparation of peanut flour based fasting extruded product will be optimized.
5. The proposed process technology will suggest the proper byproduct utilization of peanut for the preparation of value added product.

a. Clientele/Stake holders (including economic and socio aspects)

iv. Peanut growers
v. Peanut processors
vi. Sauce manufacturers
vii. Consumers

10. Signatures

[Project Leader] [Co-PIs] ……

11. Comments and signature

[Head of Division]

ANNEXURE- II

INDIAN COUNCIL OF AGRICULTURAL RESEARCH

RESEARCH PROJECT PROFORMA FOR INITIATION OF A RESEARCH PROJECT

(RPP - I)

(Refer for Guidelines ANNEXURE-XI (B))

1. Institute Project Code (to be provided by PME Cell)
2. Project Title : Development of peanut based extruded product suitable for fasting.
3. Key Words : Defatted peanut flour, amaranth, barnyard millet, tapioca pearl, extrusion cooking, fasting
4. (a) Name of the Lead Institute : College of Agril. Engg. & Tech., Junagadh Agril. University, Junagadh

   (b) Name of Division/ Regional Center/ Section : AICRP on PHET, Junagadh centre
5. (a) Name of the Collaborating Institute(s) : --

   (b) Name of Division/ Regional Center/ Section of Collaborating Institute(s) : ---
6. Project Team(Name(s) and designation of PI, CC-PI and all project Co-PIs, with time proposed to be spent)

S. No.	Name, designation and institute	Status in the project (PI/CC-PI/ Co-PI)	Time to be spent (%)	Work components to be assigned to individual scientist
1.	Dr. P. R. Davara, Assistant Research Engineer, AICRP on PHET, Dept. of Processing and Food Engg., College of Agril. Engg. & Tech., Junagadh Agril. University, Junagadh	PI	75%	1. Review collection/literature survey 2. Designing of the experiment 3. Procurement of raw materials 4. Quality analysis of the raw materials 5. Experimental trials for the optimization of flour proportion of different ingredient food materials 6. Sensory analysis of extruded products prepared during preliminary trials for the optimization of flour proportion 7. Optimization of the flour proportion based on the data of sensory parameters obtained for the different extruded product 8. Laboratory trials for the preparation of peanut based extruded product at the

				optimized flour proportion as per the experimental treatments 9. Physico-chemical and sensory analysis of the developed extruded products 10. Data collection and its analysis 11. Optimization of the processing parameters based on the experimental data 12. Report writing
2.	Dr. M. N. Dabhi, Research Engineer, AICRP on PHET, Dept. of Processing and Food Engg., College of Agril. Engg. & Tech., Junagadh Agril. University, Junagadh	Co-PI	25%	To assist the PI in carrying out the different activities of the project as and when needed

7. Priority Area to which the project belongs : Post Harvest Technology

(If not already in the priority area, give justification)

8. Project Duration: Date of Start: 01-03-2023 Likely Date of Completion **:** 31-03-2025

9. (a) Objectives

1. To utilize the different fasting food materials *viz.* peanut, amaranth, barnyard and tapioca pearls in the production of extruded snack product.
2. To optimize the proportion of peanut flour and flours of other fasting food materials for the preparation of extruded products based on sensory parameters.
3. To develop extruded product from peanut flour and other fasting food materials under different processing conditions.
4. To evaluate the physico-chemical, functional and sensory properties of developed extruded products.
5. To optimize the processing condition for the development of extruded products suitable for fasting.

(b) Practical utility

1. No any fasting snack product is available in the market. The new peanut based extruded product along with other food materials which is suitable for fasting will be developed.
2. Protein content in the extruded product will be improved due to blending of peanut flour. Other food materials like amaranth, barnyard millet and tapioca pearl are also very nutritious and suitable for preparation of extruded product. The new process will develop the fasting snack product with more nutritional value in comparison to commercially available extruded products.
3. The flour proportion of different food materials will be optimized to prepare the fasting snack product with good sensory characteristics.

4. The process parameters for the preparation of peanut flour based fasting extruded product will be optimized.
5. The proposed process technology will suggest the proper byproduct utilization of peanut for the preparation of value added product.

10. Activities and outputs details

Objective wise	Activity	Month & Year of		Output monitorable target(s)	% to be carried out in different years			Scientist(s) responsible
		Start	Completion		1	2	..	
1.	Review collection/literature survey	March-23	May-23	1. To collect the data on utilization of peanut, amaranth, barnyard millet and tapioca pearl flours in the production of extruded products. 2. To study the work done in the past	100%	--	--	Dr. P. R. Davara
2.	Designing of the experiment	June-23	June-23	Designing of the experiments as per the Response surface methodology for the following two aspects 1. Optimization of flour proportion of different food materials 2. Optimization of processing parameters	100%	--	-	Dr. P. R. Davara
3.	Procurement of raw materials	July-23	Aug-23	Raw materials like defatted peanut flour, amaranth flour, barnyard millet flour and tapioca pearl flour will be procured	100%	--	--	Dr. P. R. Davara

4.	Quality analysis of the raw materials	Sept-23	Oct-23	Physico-chemical characteristics of raw materials will be determined	100%	--	-	Dr. P. R. Davara
5.	Experimental trials for the optimization of flour proportion of different ingredient food materials	Nov-23	Dec-23	Preliminary trials will be carried out for the preparation of extruded product using flour of different raw materials selected for the project	100%	100 %	-	Dr. P. R. Davara
6.	Sensory analysis of extruded products prepared during preliminary trials for the optimization of flour proportion	Jan-24	May-24	The extruded product obtained after preliminary trials will be analysed for their sensory charactristics	--	100 %	--	Dr. P. R. Davara
7	Optimization of the flour proportion based on the data of sensory parameters obtained for the different extruded products	June-24	July-24	The data of sensory parameters will be analysed through Design Expert software to get the optimized flour proportion.		100 %		Dr. P. R. Davara
8	Laboratory trials for the preparation of peanut based extruded product at the optimized flour proportion as per the experimental treatments	Aug-24	Sept-24	Experimental trials will be carried out by taking the flour proportion at the optimized levels by varying the different processing parameters		100 %		Dr. P. R. Davara

9.	Physico-chemical and sensory analysis of the developed extruded products	Sept-24	Oct-24	Developed extruded products will be analysed for their physico-chemical and sensory quality	--	100 %	--	Dr. P. R. Davara
10.	Data collection and its analysis	Nov-24	Dec-24	The data of various physico-chemical and sensory parameters will be collected and statistically analysed	--	100 %	--	Dr. P. R. Davara, Dr. M. N. Dabhi
11.	Optimization of the processing parameters based on the experimental data	Dec-24	Jan-25	The data of physico-chemical and sensory parameters will be analysed through Design Expert software to get the optimized processing condition.		100 %		Dr. P. R. Davara, Dr. M. N. Dabhi
12.	Report writing	Feb-25	March-25	Compilation of collected data and preparation of report			100 %	Dr. P. R. Davara, Dr. M. N. Dabhi

11. Technical Programme (brief)

Justification :

Fasting is a ritual from many thousands of years which is a healing and a religious or spiritual process. Fasting is an integral part of the Indian culture and tradition and thought to be important as it nourishes both the physical and spiritual needs of the person. Also many religions including Christianity, Judaism and the Eastern religions have encouraged fasting for penitence, mourning, sacrifice and union with the God. During fasting people would like to eat traditional product prepared from sago, sweet potato, potato and fruits. Indian people are preferred khichadi, sabudana (sago) vada, sweet potato kheer, potato vada and fruit juices made traditionally at home. But there are fewer choices available for commercial product in market such as potato chips and banana chips snacks. In recent years, the demand for snacks with improved nutritional and functional properties has been increased. Among these, expanded product has gained preference of both consumers and producers (Rathod and Annapure, 2016).

Peanut, amaranth, barnyard millet and tapioca pearl are the few food materials which are used in the preparation of dishes during fasting. Peanut is a rich and promising source of protein and somewhere similar to that of soybean. On account of growing demand from food industries and health-conscious consumers, study and developments in peanut based products, technologies and machineries are necessary of peanut growing and processing regions. Amaranth has one of the highest levels of protein that is also easier for the human body to absorb. It also contains an amino acid called Lysine which is missing from other cereals, making it a complete protein source. Phytosterols present in Amaranth help lower cholesterol. One of the main reason of its popularity in India as it has become an important part in Hindu fasting rituals. Barnyard millet is an appropriate food for patients intolerant to gluten which causes celiac disease. Seeds of this crop are nutritious. Tapioca pearls or sabudana primarily contain starch, a simple carbohydrate that is easily digested and is also a direct source of energy. It is low in sodium content, practically has no cholesterol and comprises significant quantities of calcium, for strengthening bones. It is used in the preparation of various traditional dishes, snacks such as wafers, fried chips and also used as animal feed at household level.

The snack industry is the fastest growing food sector and is the king in producing convenience foods. Extrusion plays a major role in producing such kind of popular foods like puffs, pasta, cereals, gums etc. Extruded snacks are processed food products made from a combination of ingredients that are either pushed through a mold or precision cut. Consumer acceptance of extruded foods is mainly due to the convenience, value, attractive appearance, and texture found to be particular for these foods, especially when it concerns to snack products. Novel ingredients, cutting-edge extrusion technology, and innovative processing methods are combined to yield new snack products with ever widening appeal to health-conscious consumers that are seeking different textures and mouth feeling with convenience.

During the various festivals celebrated in India, fasting is an integral part of Hindu rituals. Amaranth, barnyard millet, tapioca pearls and peanuts are very popular food materials which are utilized in the preparation of various fast foods on the occasion of various Hindu festivals. Extruded snacks with multiple cereals and tubers are very famous food products consumed by peoples of all ages. No any extruded products are available in the market which can be used for the fasting purpose. Peanut, amaranth, barnyard and tapioca pearls are easily available and economical raw material source for production of extruded product. Defatted peanut flour is very rich in the protein content and can play a good role in improving the protein level in the extruded products. Amaranth, barnyard and tapioca pearls also contains a very important nutritional components required by our body. Further, all these food materials are found suitable for preparation of fasting food as per the Hindu rituals. A very negligible information is available on the utilization of all these food materials in the preparation of extruded products. In view of this, the present investigation is undertaken to develop extruded snacks suitable for fasting by utilizing peanut, amaranth, barnyard and tapioca pearl flours as a raw material.

Status (review) :

Pathak and Kochhar (2017) reported that a majority of world population suffers from qualitative and quantitative insufficiency of dietary protein and calories intake. In all such cases, physiological maintenance and growth are impaired and malnutrition results. In this context extrusion is a beneficial process. Extrusion is one of the commonly adopted processing technique by food industries which employs mixing, forming, texturing and cooking to develop a novel food product. It is one of the contemporary food processing technologies applied for development of variety of snacks, specialty and supplementary foods. The versatility of extrusion technology makes it convenient for development of nutritionally rich extruded products with wide range of raw material and useful as a source of vehicle for value addition. Extruded products have less moisture, longer shelf life, microbiologically safe and there are plenty of ways to make value added and fortified extruded products with combination of different raw materials. This review comprehensively covers the potential of extrusion technology in development of various types of value added extruded products that can be popularized for combating malnutrition globally.

Davara *et al.* (2022) developed the extruded snack products by blending of corn flour and defatted peanut flour using twin screw extruder. The combined effects of feed moisture content, defatted peanut flour content, die head temperature and screw speed on the important physical (expansion ratio) and functional (water absorption index, water holding capacity and water solubility index) properties of extrudates were studied. The Response Surface Methodology (RSM) was used in designing the experiment. Since, the defatted peanut flour is poor in starch content, the flour content restricted the gelatinization and limited the expansion of the product. Defatted peanut flour was found to be suitable for the preparation of extruded snacks with the appropriate blending corn flour as a base material. The optimum treatment condition was found as 13% feed moisture content, 26% defatted peanut flour, 135 °C die head temperature and 250 rpm screw speed for the production of extruded product by blending of defatted peanut flour with corn flour.

Dokić *et al.* (2009) studied that extruded amaranth grain products have specific aroma and can be used as snack food, supplement in breakfast cereals, or as raw material for further processing. Extruded products of corn-amaranth grits blends, containing 20% or 50% amaranth grain grits, were produced by extrusion-cooking using a laboratory Brabender single screw extruder 20 DN. Extrudates with various texture were obtained. During extrusion process starch granules are partially degraded, hence rheological properties were examined. All samples exhibited thixotropic flow behavior. Those samples in which part of the corn grits was replaced with amaranth one had lower viscosity and exhibited lower level of structuration during storage. Increasing amount of amaranth grits in the extrusion blend causes increase of density and hardness of the extrudated products and decrease in expansion index. When part of the corn grits is replaced with amaranth grits viscosity of gels decreases compared to pure corn grits.

Rajashekar *et al.* (2019) developed the extruded product using barnyard millet (20-30%), finger millet (10-30%), corn grits (40-60%), and green gram dhal (10%) blends. The extruded products were compared with control Corn grits (100%). Physical and sensory qualities of extruded products were investigated. Bulk density was reduced with increasing corn grits content and expansion ratio increased with increasing corn grits composition. The proximate analysis was carried out for all samples. Compare to all samples with control the T1 sample (barnyard millet, finger millet, corn grits, green gram dhal were 30,20,40,10 percent respectively) showed good attributes and which was combination of cereal and pulse so it may be balance our protein requirement. The selected extruded product T1 studied shelf life studied at room temperature till 45 days the product was good.

Patel *et al.* (2016) developed a protein-rich puffed snack using a twin screw extruder and the effects of varying levels of tapioca starch (11 to 40 parts), rennet casein (6 to 20 parts) and sorghum flour (25 to 75 parts) on physico-chemical properties and sensory attributes of the product studied. An increasing level of sorghum flour resulted in a decreasing whiteness (Hunter L* value) of the snack. Although the starch also generally tended to make the product increasingly darker, both starch and casein showed redness parameter (a* value) was not significantly influenced by the ingredients levels, the yellow hue (b* value) generally declined with the increasing sorghum level. Tapioca starch significantly increased the expansion ratio and decreased the bulk density and hardness value of the snack, whereas the opposite effects seen in case of sorghum flour. While the water solubility index (WSI) was enhanced by starch, water absorption index was appreciably improved by sorghum. Incorporation of casein (up to 25 %) improved the sensory colour and texture scores, and so also the overall acceptability rating of the product. Sorghum flour had an adverse impact on all the sensory attributes whereas starch only on the colour score. The casein or starch level had no perceivable effect on the product's flavour score. The response surface data enabled optimization of the snack-base formulation for the desired protein level or desired sensory characteristics.

Objectives

1. To utilize the different fasting food materials *viz.* peanut, amaranth, barnyard and tapioca pearls in the production of extruded snack product.
2. To optimize the proportion of peanut flour and flours of other fasting food materials for the preparation of extruded products based on sensory parameters.
3. To develop extruded product from peanut flour and other fasting food materials under different processing conditions.
4. To evaluate the physico-chemical, functional and sensory properties of developed extruded products.
5. To optimize the processing condition for the development of extruded products suitable for fasting.

Technical programme

❖ Extruded product preparation

The procedure to be followed for the preparation of extruded product using twin screw extruder is presented in the process flow chart as given in Fig. 1.

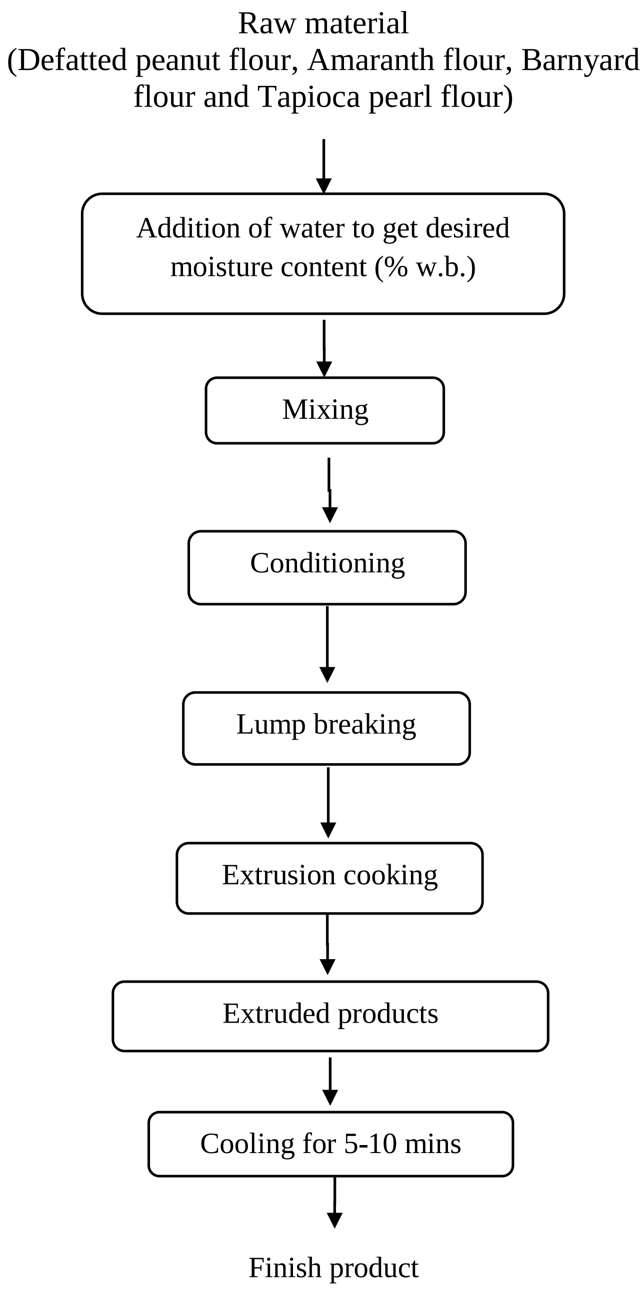


Fig. 6.1 Process flow chart for preparation of extruded product.

❖ **Optimization of flour proportion for development of extruded product suitable for fasting**

Experiment trials will be conducted to optimize the proportions of different flours, *viz.* defatted peanut flour, amaranth flour, barnyard flour and tapioca flours, in the preparation of extruded products. The different proportions of these flours are to be mixed with each other as suggested by the Mixture Design of Response Surface Methodology (RSM) as given in the Table 1. The extruded products will be prepared by keeping the feeder temperature (60°C), barrel temperature (100°C), die temperature (135°C) and screw rpm (250 rpm) at constant level. The extruded products as prepared by the different flour combinations will be evaluated for their sensory paraments (Appearance, Taste, Colour, Crispness and Overall Acceptability) using 9-point hedonic scale method. Then the optimization of the flour proportion will be carried out using RSM based on the sensory score of the different extruded products. The final and optimized formulation of composite flour will be selected for the preparation of extruded product.

Table 6.1. Treatment details for optimization of flour proportion.

Treatment No.	Defatted peanut flour (%)	Amaranth flour (%)	Barnyard flour (%)	Tapioca pearls flour (%)	Total
1	13.53	49.33	14.90	22.24	100.00
2	10.00	39.43	10.00	40.57	100.00
3	29.05	10.00	37.19	23.76	100.00
4	24.56	24.79	25.85	24.81	100.00
5	50.00	10.00	30.00	10.00	100.00
6	10.00	10.00	30.00	50.00	100.00
7	30.00	50.00	10.00	10.00	100.00
8	24.56	24.79	25.85	24.81	100.00
9	39.00	10.00	10.00	41.00	100.00
10	25.37	14.63	50.00	10.00	100.00
11	39.00	10.00	10.00	41.00	100.00
12	25.37	14.63	50.00	10.00	100.00
13	24.56	24.79	25.85	24.81	100.00
14	10.00	10.00	50.00	30.00	100.00
15	35.54	22.65	31.82	10.00	100.00
16	50.00	30.00	10.00	10.00	100.00
17	10.00	28.50	43.34	18.17	100.00
18	24.56	24.79	25.85	24.81	100.00
19	19.45	20.55	10.00	50.00	100.00
20	10.00	47.03	32.97	10.00	100.00

❖ **Optimization of processing conditions for development of extruded product suitable for fasting**

Response Surface Methodology (RSM) will be used for designing the experiments (Khuri and Cornell, 1987). A Central Composite Rotatable Design (CCRD) with 3 variables each at 5 levels will be employed to get the treatment details.

Table 6.2. Coded and uncoded values of independent parameters to be used in the optimization of processing condition for the preparation of extruded product

Parameters	Code	Coded and Uncoded value				
		-1.682	-1	0	+1	+1.682
Moisture content (%)	(X_1)	12	13.22	15	16.78	18
Screw speed (rpm)	(X_2)	200	220	250	280	300
Die head temperature (°C)	(X_3)	90	102	120	138	150

Table 6.3. Treatment combinations as per the central composite rotatable design for preparation of extruded product.

Treatment No.	Coded			Uncoded		
	X_1	X_2	X_3	Moisture (%)	Screw speed (rpm)	Die head temperature (°C)
1	-1	-1	-1	13.22	220	102
2	1	-1	-1	16.78	220	102
3	-1	1	-1	13.22	280	102
4	1	1	-1	16.78	280	102
5	-1	-1	1	13.22	220	138
6	1	-1	1	16.78	220	138
7	-1	1	1	13.22	280	138
8	1	1	1	16.78	280	138
9	-1.68	0	0	12.00	250	120
10	1.68	0	0	18.00	250	120
11	0	-1.68	0	15.00	200	120
12	0	1.68	0	15.00	300	120
13	0	0	-1.68	15.00	250	90
14	0	0	1.68	15.00	250	150
15	0	0	0	15.00	250	120
16	0	0	0	15.00	250	120
17	0	0	0	15.00	250	120
18	0	0	0	15.00	250	120
19	0	0	0	15.00	250	120
20	0	0	0	15.00	250	120

❖ **Observations to be recorded**

Sr. No.	Parameter	Method	Reference
1. Machine parameters (Twin screw extruder)			
1	Torque (Nm)	Digital torque meter	David *et al.* (2016)
2	Mass flow rate (g/min)	$\frac{\text{Weight of sample collected}}{\text{Time taken to collect sample (seconds)}}$	Deshpande and Poshadri (2011)

2. Physical Parameters of extruded product			
1	Bulk density (g/ml)	$\frac{\text{Weight of extrudates}}{\text{Volume extrudates}} X\ 100$	Anderson *et al.* (1969)
2	Expansion ratio (%)	$\frac{\text{Extrudate diameter}}{\text{Die diameter}} X\ 100$	Fan *et al.* (1996)
3. Biochemical parameters of extruded product			
1	Moisture content (%)	Hot air oven method	AOAC (2005)
2	Carbohydrate (%)	Phenol sulphuric acid method	AOAC (1965)
3	Protein (%)	Micro kjeldahl method	AOAC (1965)
4	Fat (%)	Soxhlet method	AOAC (2005)
5	Ash ((%)	muffle furnace	AOAC (2005)
6	Calorific value	(carbohydrates × 4 kcal) + (protein × 4 kcal) + (fat × 9 kcal)	Saini and Yadav (2018)
4. Functional Parameters			
1	Water solubility index (%)	$\frac{\text{Weight of dissolved solid in supernatant}}{\text{Weight of dry solids}} X\ 100$	Anderson *et al.* (1969)
2	Water absorption index (%)	$\frac{\text{Weight of sediment}}{\text{eight of dry solids}} X100$	Anderson *et al.* (1969)
3	Hardness(%)	Texture analyser	Ding *et al.* (2005)
4	Crispness (%)	Texture analyser	Ding *et al.* (2005).
5. Sensory parameters			
1	Appearance	9-point hedonic scale method (Amerine *et al.*, 1965)	
2	Colour		
3	Taste		
4	Overall acceptability		

❖ **Statistical Analysis**

The effect of three independent variables, X_1(Moisture Content), X_2(Screw speed) and X_3(Die head temperature), on different response variables will be evaluated by using the RSM. A Central Composite Rotatable Design (CCRD) of 3 variables each at five levels with 6 centre point combinations will be employed (1) to study the main effect of parameters, (2) to create models between the variables, and (3) to determine the effect of these variables to optimize the selected response variables. The statistical analysis of the experimental data will be carried out to observe the significance of the effect of selected process parameters on the various responses. Design Expert software 'DE-10' will be used for regression and graphical analysis of the data (Stat-Ease, 2000). The optimum values of the selected process parameters will be obtained by solving the regression equation and by analysing the response surface contour plots (Khuri and Cornell, 1987).

Possible outputs :

- No any fasting snack product is available in the market. The new peanut based extruded product along with other food materials which is suitable for fasting will be developed.
- Protein content in the extruded product will be improved due to blending of peanut flour. Other food materials like amaranth, barnyard millet and tapioca pearl are also very nutritious and suitable for preparation of extruded product. The new process will develop the fasting snack product with more nutritional value in comparison to commercially available extruded products.
- The flour proportion of different food materials will be optimized to prepare the fasting snack product with good sensory characteristics.
- The process parameters for the preparation of peanut flour based fasting extruded product will be optimized.

References :

Amerine, J. H., Pangborn, R. M. and Rosster, E. B. (1965). Principles of Sensory Evaluation of Food. *Academic Press Inc*., New York.

Anderson, R. A., Conway, H. F. and Griffin, E. L. (1969). Gelatinization of corn grits by roll and extrusion cooking. *J Cereal Sci*., 14:4-12.

AOAC (1965). Official Methods of Analysis of the Association of Agricultural Chemist. 10th Ed., Washington DC, pp. 744-745.

AOAC (2005). Official Methods of Analysis of the AOAC International, 18th ed., Gaithersburg, MD, USA.

Davara, P.R., Muliya, M. H., Dabhi, M. N. and Sangani, V.P. (2022). Physical and Functional Properties of Extruded Snack Products Prepared by Blending of Defatted Peanut Flour with Corn Flour, International Journal of Agriculture, Environment and Biotechnology, Vol. 15(Sp. Issue), 347-358.

David, I. G., Iro, N. and Mamudu, H. B. (2016). Optimization of Physical and Functional Properties of Sorghum-Bambara Groundnut Extrudates. Journal of Food Research, 5 (2) : 81-97.

Deshpande, H. W. and Poshadri, A. (2011). Physical and sensory characteristics of extruded snacks prepared from Foxtail millet based composite flours. *International Food Research*, 18: 751-756.

Dokic, L. P., Bodroža-Solarov, M. I., Hadnađev, M. S. and Ivana, R. N. (2009). Properties of extruded snacks supplemented with Amaranth grain grits. *Acta Periodica Technologica*, 40 : 17-24.

Fan, J., Mitchell, J. R. and Blanchard, J. M. V. (1996). The effect of sugars on the extrusion of maize grits: The role of the glass transition in determining product density and shape. *International Journal of Food Science and Technology*, 31: 55-65.

Khuri, A.L. and Cornell, J.A. (1987). Response Surfaces: Designs and Analyses. *Marcel Dekker Inc., New York*.

Patel, J. R., Patel, A. A. and Singh, A. K. (2016). Production of a protein-rich extruded snack base using tapioca starch, sorghum flour and casein. *Journal of food science and technology*, 53(1):71–87.

Pathak, N. and Kochhar, A. (2018). Solution to Develop Quality Snacks for Malnourished Generation. *International Journal of Current Microbiology and* Applied Sciences, 7(1) : 1293-1307.

Rajashekar, C. H., Jyothirmayi, T., Bhasker, V. and Maloo, S. (2019). Development and optimisation of millet based extruded snack using barnyard and finger millet. *International Journal of Food Science and Nutrition*, 4(4) : 58-60.

Rathod, R. P. and Annapure, U. S (2016). Development of extruded fasting snacks by using vari rice, sweet potato and banana powder with applying response surface methodology. *Journal of Food Measurement and Characterization*. 10 (3) :715-725.

Saini, R. and Yadav, K. (2018). Development and quality evaluation of little millet (Panicum sumatrense) based extruded product. *Journal of Pharmacognosy and Phytochemistry*,7(3): 3457-3463

12. Financial Implications (in Lakhs) : Rs. 32.32 lakhs

(A) Financed by the institute

12.1 Manpower (Salaries / Wages)

S. No.	Staff Category	Man months	Cost
1.	Scientific	23	30,00,000
2.	Technical	5	2,00,000
3.	Supporting	--	--
4.	SRFs/RAs	--	--
5.	Contractual	--	--
	Total	28	32,00,000

12.2 Research/Recurring Contingency

S. No.	Item	Year(1)	Year (2)	Year (3)…	Total
1.	Consumables	10000	10000	--	20000
2.	Travel	5000	--	--	5000
3.	Field Preparation/ Planting/ Harvesting (Man-days/costs)	--	--	--	--
4.	Inter-cultivation & Dressing (Man-days/costs)	--	--	--	--
5.	Animal/Green house/Computer Systems/Machinery Maintenance	2000	--	--	2000
6.	Miscellaneous(Other costs)	5000	--	--	5000
	Total(Recurring)	22000	10000	--	32000

Justification : --

12.3 Non-recurring (Equipment)

S. No.	Item	Year (1)	Year (2)	Year (3)…	Total
1.		--	--	--	--
2.		--	--	--	--
	Total (Non-recurring)	--	--	--	--

Justification: ---

12.4 Any Other Special Facility required (including cost)

12.5 Grand Total (12.1 to 12.4)

Item	Year (1)	Year (2)	Year (3)	Total
Grand Total	16,22,000	16,10,000	--	32,32,000

(B) Financed by an organization other than the Institute (if applicable) : No

(i) Name of Financing Organization : NA

(ii) Total Budget of the Project :

(iii) Budget details

S. No.	Item	Year(1)	Year(2)	Year (3)…	Total
1	Recurring Contingency				
	Travelling Allowance	--	--	--	--
	Workshops	--	--	--	--
	Contractual Services/ Salaries	--	--	--	--
	Operational Cost	--	--	--	--
	Consumables	--	--	--	--
2	Non - Recurring Contingency				
	Equipment	--	--	--	--
	Furniture	--	--	--	--
	Vehicle	--	--	--	--
	Others (Miscellaneous)	--	--	--	--
3	HRD Component				
	Training	--	--	--	--
	Consultancy	--	--	--	--
4	Works (i) New (ii) Renovation	--	--	--	--
5	Institutional Charges				

13. Expected Output : Process will be standardised for preparation of peanut sauce.

14. Expected Benefits and Economic Impact

- No any fasting snack product is available in the market. The new peanut based extruded product along with other food materials which is suitable for fasting will be developed.

- Protein content in the extruded product will be improved due to blending of peanut flour. Other food materials like amaranth, barnyard millet and tapioca pearl are also very nutritious and suitable for preparation of extruded product. The new process will develop the fasting snack product with more nutritional value in comparison to commercially available extruded products.
- The flour proportion of different food materials will be optimized to prepare the fasting snack product with good sensory characteristics.
- The process parameters for the preparation of peanut flour based fasting extruded product will be optimized.

13. Risk Analysis

14. Signature

Project Leader   Co-PI-I

Co-PI-II

15. Signature of HoD

16. Signature of JD (R)/ Director

ANNEXURE - III

INDIAN COUNCIL OF AGRICULTURAL RESEARCH

CHECKLIST FOR SUBMISSION OF RPP-I

(Refer for Guidelines ANNEXURE-XI(C))

1. Project Title: . Development of peanut based extruded product suitable for fasting
2. Date of Start & Duration : Date of Start: 01-03-2023

   Likely Date of Completion: 31-03-2025
3. Institute Project [√] or Externally Funded [ ]

4. Estimated Cost of the Project : 32.32 lakh

5. Project Presented in the Divisional/Institutional Seminar? ~~Yes~~ / No

6. Have suggested modifications incorporated? ~~Yes~~ / No

7. Status Report enclosed Yes / ~~No~~

8. Details of work load of investigators in approved ongoing projects:

Project Leader				Co-PI – I				Co-PI – II…
Proj. Code.	% Time spent	Date of start	Date of compl-etion	Proj. Code.	% Time spent	Date of start	Date of completion	………

9. Work Plan/Activity Chart enclosed Yes / ~~No~~

10. Included in Institute Plan Activity Yes / ~~No~~

11. Any previous Institute/Adhoc/Foreign aided projects on similar lines? Yes / ~~No~~

12. New equipment required for the project ~~Yes~~ / No

13. Funds available for new equipment ~~Yes~~ / No

14. Signatures

Project Leader Co-PI-I Co-PI-II Co-PI–n

HOD/PD/I/c

ANNEXURE - IV

INDIAN COUNCIL OF AGRICULTURAL RESEARCH

APPRAISAL BY THE PME CELL OF RPP-I

(Refer for Guidelines ANNEXURE-XI (D))

4. Institute Name
5. Project Title
6. On scale 1-10 give score to (a) to (j)

(a)	Relevance of research questions	☐
(b)	Addressing priority of the institute and/or National priority	☐
(c)	New innovativeness expected in the study	☐
(d)	Appropriateness of design/techniques for the questions to be answered	☐
(e)	Elements of bias addressed in the study	☐
(f)	Adequacy of scientist(s) time allocation	☐
(g)	Extent of system review and meta analysis	☐
(h)	Effective control to experiments	☐
(i)	Economic evaluation and cost efficiency analysis	☐
(j)	How appropriately the expected output answers the questions being addressed in the specific subject matter/area (Basic/Applied/Translational/Others)?	☐
	***Total Score out of 100**	

* The score obtained is suggestive of the overall quality ranking of the project

4. Was there any other project carried in the past in the same area/topic?

Yes ☐ No ☐

If yes, list the project numbers.

5. Signature of PME Cell Incharge

SUMMARY OF PROGRESS REPORT

1. PH/JU/85/1 : Operational research project on Agro- processing center.

At Tadka Pipliya agro processing center, oil milling, wheat cleaning, groundnut decortication, sesame processing, groundnut threshing, pulse milling and spice milling operations were carried out. They have earned about Rs. 248060/-.

At Agro Processing Centre, Virol, oil milling, spice milling and wheat cleaning were carried. They have earned Rs. 354050/-.

At Agro Processing Centre, Loej, oil milling and wheat cleaning were carried out. They have earned Rs. 291000/-.

At Agro Processing Centre, Chotila, oil milling was carried out. They have earned about Rs. 18250/-.

2. PH/JU/2020/02: Standardization of process technology for preparation of peanut sauce and peanut wadi (Chunks).

Peanut sauce is prepared in both the process that is chemical process and fermentation process. Optimized value were found that 90% kerne with 16.50 % acidic concentration and 25 hrs hydrolysis time produces the peanut sauce with quality and higher overall acceptability. The quality of the peanut sauce was also compared with the FSSAI and FAO standard of soy sauce. The quality of the peanut sauce match with the FSSAI and FAO standard of soy sauce.

The work on preparation of peanut wadi could not be completed due to the some reasons. Preliminary trials were conducted to prepare the peanut Wadi in laboratory using twin screw extruder (Model: Basic Technology Private Ltd., Kolkata). Results obtained in the preliminary trials are not satisfactory. Therefore, further trials were carried out using new defatted peanut flour. As the moisture content of defatted peanut flour samples are required to be elevated up to 60%, the free-flowing flour was converted into lumps. Due to this, there was an issue in the feeding of the material due to stickiness of the dough. Hence, the Twin Screw extruder available in the department is fond not suitable to handle the high moisturized sample of defatted peanut flour. In view of this, the peanut wadi could not be prepared using the Twin Screw Extruder available in the department.

3. PH/JU/2022/01: Processing of green tender sorghum.

Hurda extractor is purchased, roaster purchased procedure through newspaper advertised is completed. But according to new rules to purchase through GeM is under progress. Even roasting of sorghum was tested in the peanut roaster at peanut roasting industry. That roaster was gas operated hence, the burning of sorghum was observed. Hurda extractor was also tested. The output of the hurda extractor was very poor.

Tentative Technical Programme for the year 2023-2024

Sr. No.	Code No.	Title
1.	PH/JU/85/1	Operational research project on Agro-processing center.
2.	PH/JU/2022/01	Processing of green tender sorghum.
3.	New Investigation - I	Optimization of process parameters for protein extraction from peanut through fermentation.
4.	New Investigation - II	Development of peanut based extruded product suitable for fasting
5.	New Investigation - III	Management of insect pest of storage wheat in bin by ozone.

Action taken of proceeding of 37th Annual Workshop:

Sr. No.	Project	Comment	Action taken
1	**Processing of green tender Sorghum**	Approved for one year Work should be done in collaboration of Akola centre. For the period of April-2022 to October-2023	Hudra extractor is purchased from Akola centre. No one AICRP on PHET centre has developed the roaster. Hence, roaster purchase through GeM is under progress. Even the roasting in the peanut roaster at industry level is tested for green tender sorghum. Hurda extractor is also tested.

PUBLICATION, TRAINING AND DEMONSTRATION

Publications:

Books/Book chapter/Bulletin:

1. **Joshi A. M**., Khanpara Brijesh, Vagh Dhara. 2021. Effect of ozone and plastic material against the microbes of tomatoes. LAP Lambert Academic Publishing.
2. Gojiya D.K., Dobariya U.M., **Joshi A. M.** 2021. Studies on physical properties of peanuts popular in saurashtra region.LAP Lambert Academic Publishing.
3. **Davara, P. R.,** Gadhiya, P. P., Sudhir and Mitesh Kumar. 2021. Protein Enriched Ready To Eat Product.Scholar's Press, International Book Market Service Ltd., member of OmniScriptum Publishing Group, Mauritius.
4. Sangani, V. P., Chotaliya, V. C. and **Davara, P. R**. 2021. Pigeon Pea Milling.Scholar's Press, International Book Market Service Ltd., member of OmniScriptum Publishing Group, Mauritius.
5. Sojitra, J. B., Vyas, D. M., **Davara, P. R.** 2021. Papain Production Technology.
6. **Davara, P. R.,** Thumar, N. C., Agravat, H. V. and Limbasiya, J. J. 2021. Wheat Grinding Under Evaporative Water Cooled Condition.Scholar's Press, International Book Market Service Ltd., member of OmniScriptum Publishing Group, Mauritius.
7. **Dabhi M. N.** and Joshi N. U. 2022. "Bor, gunda, kotha tatha karmdama mulyavardhan". Chapter in book "Fal pakoma mulyavardhan". Published by Gujarat Bagayat Vikas volume 87. April-June 2022. pp. 48-51.
8. **M. N. Dabhi.** 2022. Enzymatic process for pigeon pea. Chapter in Book "Legumes Research - Volume 1" ISBN:978-1-83969-490-5. Dabhi, M. N. (2021). Enzymatic Process for Pigeon Pea. In J. C. Jimenez-Lopez, & A. Clemente (Eds.), Legumes Research - Volume 1. IntechOpen. https://doi.org/10.5772/ intechopen.100853.
9. **S. P. Cholera, M. N. Dabhi, A. M. Joshi, R. D. Dhudashiya,** P. N. Sarsavadiya, M. S. Dulawat, P. J. Rathod. 2022. Design and development of on farm solar assisted dryer for drying of groundnut pods for longer storage. Bulleting published by AICRP on PHET, PFE Department, CAET, JAU, Junagadh.

Research Articles

1. **Ashish M. Joshi, Mukesh N. Dabhi**, Devanand K Gojiya and M S Shitap. 2022. Effect of ozonisation against the microorganisms of lime fruits. The Pharma Innovation Journal. SP-11(8):819-822. NAAS 5.23 2022.
2. **M. N. Dabhi, P. R. Davara**, H. P. Gajera, Nirav Joshi and Parth Saparia. 2022. Bioactive compounds of turmeric powder affected by grinding method and feed temperature. International Journal of Agriculture, Environment and Biotechnology. 15(Special Issue): 337-346. NAAS 4.54. 2022.
3. **P. R. Davara**, Mohit H. Muliya, **M. N. Dabhi** and V.P. Sangani. 2022. Physical and functional properties of extruded products prepared by blending of defatted peanut flour with corn flour. International Journal of Agriculture, Environment and Biotechnology. 15(Special Issue): 347-358. NAAS 4.54. 2022.
4. V. P. sangani, A. N. Dalsaniya and **P. R. Davara**. 2022. Effect of blanching on the quality of green peas during freezing. International Journal of Agriculture, Environment and Biotechnology. 15(Special Issue): 359-368. NAAS 4.54. 2022.
5. Ravina Parmar and **Mukseh N. Dabhi**. 2022. Physical properties of fresh turmeric rhizomes (Var. Salem). International Journal of Agriculture, Environment and Biotechnology. 15(Special Issue): 369-378. NAAS 4.54. 2022.

6. Shingala Abhishaben M., **M. N. Dabhi**, P.J. Rathod and Rathod Ravikumar R. 2022. Influence of ozone treatment on carbohydrate content of wheat during bulk storage. International Journal of Agriculture, Environment and Biotechnology. 15(Special Issue): 401-406. NAAS 4.54. 2022.
7. Nirav U. Joshi and **Mukesh and Dabhi**. 2022. Moisture dependent physical properties of psyllim seeds for different varieties. International Journal of Agriculture, Environment and Biotechnology. 15(Special Issue): 427-436. NAAS 4.54. 2022.
8. Devanand Gojiya, **Paresh Davara**, Vanraj Gohil and **Mukesh Dabhi**. 2022. Process standardization for formulating protein-augmented corn-based extrudates using defatted sesame flour: Sesame oil industry waste valorization. J Food Process Preserv. 2022;00:e17203. wileyonlinelibrary.com/journal/jfpp |1of 13. https://doi.org/10.1111/jfpp.17203. NAAS 8.19. 2022.
9. Abhishaben M. Shingala, **M. N. Dabhi**, P. J. Rathod and Trushal L. Dharsenda. 2022. Effect of ozone gas exposure time and ozone cycle on starch content of wheat (Triticum aestivum) during bulk storage. The Pharma Innovation. 11(10):1621-1626. NAAS 5.23 2022.
10. Shingala Abhishaben M. and **M. N. Dabhi**. 2022. Influence of Ozone Treatment on Gluten Content of Wheat (Triticum aestivum) during Bulk Storage. Frontiers in Crop Improvement. 10:2215-2220. Special issue-V. NAAS 4.67. 2022.

Abstract Published

P. M. Sirwani, M. N. Dabhi and P. J. Rathod**.** Effect of low temperature grinding on proximate components of fenugreek seed powder. Abstract published in Souvenir & Abstract book of 1st International Conference on Contribution of Agriculture for Challenges and Opportunity of Food Security till 2030 held at Mangalayan University, Jabalpur during 15-16 October, 2022.

P. R. Davara, A. K. Varshney, H. P. Gajera, V. P. Sangani. Preservation of clarified prickly pear juice. Abstract published in sovenir of International symposium on India@2047: Agricultural Engineering Perspective. Jointly organized by ISAE, New Delhi and TNAU, Coimbtore at Coimbtore during 9-11 November, 2022.

A. M. Shingala, **M. N. Dabhi** and R. R. Rathod. Influence of ozone treatment on protein content of wheat during bulk storage. Abstract published in sovenir of International symposium on India@2047: Agricultural Engineering Perspective. Jointly organized by ISAE, New Delhi and TNAU, Coimbtore at Coimbtore during 9-11 November, 2022.

M. N. Dabhi, P. R. Davara, N. U. Joshi, P. S. Saparia. Effect of feed temperature and circulation of liquid through water jacket on grinding temperature of turmeric. Abstract published in sovenir of International symposium on India@2047: Agricultural Engineering Perspective. Jointly organized by ISAE, New Delhi and TNAU, Coimbtore at Coimbtore during 9-11 November, 2022.

P. R. Davara, P. P. Gadhiya, Mitesh Kumar, Sudhir, **M. N. Dabhi**, V. P. Sangani. Effect of process parameters on the quality of extruded products prepared by blending of defatted peanut flour with barnyard millet flour. Abstract published in sovenir of International symposium on India@2047: Agricultural Engineering Perspective. Jointly organized by ISAE, New Delhi and TNAU, Coimbtore at Coimbtore during 9-11 November, 2022.

R. G. Parmar, N. U. Joshi and **M. N. Dabhi**. Mathematical modelling of blanched turmeric rhizomes (Var. Salem) by tray drying. Abstract published in sovenir of International symposium on India@2047: Agricultural Engineering Perspective. Jointly organized by ISAE, New Delhi and TNAU, Coimbtore at Coimbtore during 9-11 November, 2022.

Extension Activities

1. One research bulletin and one pamphlet is printed on solar dryer.
2. Under SCSP project, farmers training is organized on 22/03/2022 at Village Bhankhokhari, Ta. Jam Khambhaliya, Dist. Devbhumi Dwarka. attended the training.
3. V. P. Sangani, P. R. Davara. Pulse electric field- A non-thermal processing, Agriculture and Food, E- Newsletter. E-ISSN-2581-8317. 2022.
4. V. P. Sangani and P. R. Davara. Pulse Electric Field - A Non-Thermal Processing Technology Agriculture & Food : e-Newsletter, Vol. 4, Issue 2. 2022.
5. P. R. Davara and V. P. Sangani. Application of High-Pressure Processing in Food Preservation Agriculture & Food : e-Newsletter, Vol. 4, Issue 2. 2022
6. V. P. Sangani and P. R. Davara. *Kathol Pakonu Processing ane Mulyavardhan Krushi Jivan, Issue 8.* 2022
7. V. P. Sangani and P. R. Davara. Food Additives - An Application in Food Industries
8. Agriculture & Food : e-Newsletter, Vol. 4, Issue 5. 2022
9. P. R. Davara and V. P. Sangani. Application of Enzyme Technology in the Pulse Milling. Agriculture & Food : e-Newsletter, Vol. 4, Issue 5. 2022
10. P. R. Davara and V. P. Sangani. કેરીમાં મૂલ્યવર્ધન. Gujarat Horticulture Board, Vol. 87. 2022
11. P. R. Davara and V. P. Sangani. Application of Radio Frequency Heating in the Food Processing. Agriculture & Food : e-Newsletter, Vol. 4, Issue 6. 2022.
12. *Krushi Pedashona Processing mate Upyogi Machinery.* P. R. Davara. Date: 19-11-2021 on Akashwani Rajkot. Gujarati.

Demonstration conducted :

1. Demonstration of developed processing machineries were arranged at Bhan khokhari, Ta. Jam-khambhaliya, Dist. Devbhumi Dwarka on 22nd February, 2022. About 150 farmers have participated in the demonstration.

Glimpses of Training

Registration of SC farmer in training and demonstration programme

Welcome address by Dr. V. K. Jogal Programme Co-ordinator, AKRSP, JamKhambhalia

Inauguration of Training Programme

Address by Dr. H. C. Chhodvadia, AEE, JAU.

Expert lecture delivered by Dr. M. N. Dabhi, Research Engineer, AICRP-PHET

Expert lectures by Prof. P. B. Vekariya, Assistant professor, AICRP-IWM

Expert talk delivered by Dr. P. R. Davara, Assistant professor, AICRP-PHET

Expert lectures by Dr. V. P. Sangani, Assistant professor, Department of PFE.

Expert lectures by Dr. G. V. Prajapati, Research Engineer, AICRP-PEASEM

Distribution of Input kits to famrers by dignitaries

Demonstration of agricultural processing model by Dr. P. R. Davara

Demonstration of foldable plastic box by Dr. G. V. Prajapati

Demonstration of mulch role by Prof. P. B. Vekariya

- **HUMAN RESOURCE DEVELOPMENT**
  1. Dr. P. R. Davara attended webinar on "Microencapsulation of Nutraceuticals" Online 03-02-2022 ICAR-CIPHET, Ludhiana.
  2. Dr. M. N. Dabhi has virtually attended the International Conference on "Water, Agriculture, Dairy and Food Processing for Sustainable Economy" (WADFPSE- 2022). The conference is being organized both in physical and virtual mode by "University Corporate Resource Centre (UCRC)" Eternal University, Baru Sahib in association with "Institute of Rural Management, Anand (IRMA)" on March, 25th- 26th, 2022. Dr. Dabhi has presented the research paper on "Phenolics and antioxidant activity of turmeric powder as affected by grinding temperature"
  3. Dr. P. R. Davara attended the training on Up-gradation of HRD skills for Extensiton Personnel. Anand. 16-05-2022 to 21-05-2022. EEI, AAU, Anand
  4. Dr. P. R. Davara attended webinar Quit India Movement to Food Secured India. Udaipur. 08-08-2022 MPUAT, Udaipur.
  5. Dr. M. N. Dabhi and Dr. P. R. Davara has virtually attended International Conference on Advances in Agriculture and Food System towards Sustainable Development Goals (AAFS2022). Organized by All India Agricultural Students Association, New Delhi, University of Agricultural Sciences, Bangalore, and ICAR, New Delhi during 22-24 August, 2022. Dr. M. N. Dabhi made presentation on Bioactive compounds of turmeric powder affected by grinding method and feed temperature. Dr. P. R. Davara made the presentation on Physical and functional properties of extruded snack products prepared by blending of defatted peanut flour and corn flour.
  6. Dr. P. R. Davara attended webinar on Statistical methods in food processing. AFSTI. 10-10-2022 to 11-10-2022. AFSTI
  7. Dr. M. N. Dabhi has virtually attended International Conference on Contribution of Agriculture for Challenges and Opportunity of Food Security till 2030 (Hybrid Mode). Organized by Mangalayatan University Jabalpur and Society for World Envrionment, Food and Technology (SWEFT), Meerut (UP), at Mangalayatan University, Jabalpur during 15-16 October, 2022. Dr. M. N. Dabhi made presentation on Effect of low temperature grinding on proximate components of fenugreek seed powder.


COLLEGE OF
AGRICULTURAL ENGINEERING AND TECHNOLOGY