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ANNUAL REPORT

2019-2020

ALL INDIA COORDINATED RESEARCH PROJECT (ICAR)
ON
POST HARVEST ENGINEERING AND TECHNOLOGY
JUNAGADH CENTRE

For presentation at the
36th Annual Workshop
to be held at
Online Mode

February 3 - 5, 2021

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

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FOREWORD

Storage and processing of agricultural products is the need to increase the farmers' income. Post-harvest engineering and technology is the important tool for this purpose. The concept of processing agricultural products and foods after harvesting, like processing of grains, fruits, vegetables, animal products, milk and other foods for preservation, value addition, making different products by using operations like cooling, peeling, grading, storage, pasteurization, sterilization, refrigeration, heat and mass transfer operations. The center renders services to society for preventing post-harvest losses, improve nutrition and add value to the products. Storage and processing of agricultural products at rural level generate employment in rural area, diminish poverty and motivate development of other related financial segments.

The Junagadh center contributed industriously by establishing agro processing centers, utilization of solar energy for drying of groundnut pod, storage of groundnut pods, reducing time of curing of onion to facilitate the land for new crops, development of machines for fruits cleaning and grading, spice processing, value addition to groundnut etc. 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. The center has brought fruitful findings on the storage of oil seeds, and cereals spice crops. These findings of research work became useful to farmers, industries and entrepreneurs.

As per the need of this region, the Junagadh center is working constantly on advance 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 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 thankfully acknowledged. I am sure the Junagadh centre will give considerably towards need of the agro industries and the life flourishing of the farmers of the region.

25 January, 2021
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 has been functioning at Junagadh Agricultural University, Ludhiana since 1980. This report is the outcome of sincere efforts and hard work of all research scientists. Post-harvest Technology has now been recognized as sun rising sector answerable for employment generation in rural area especially in the post green revolution era.

The All India Coordinated Research Project on Post-Harvest Engineering and Technology staff wish to converse their earnest recognitions to Dr. V. P. Chovatiya, I/c Vice Chancellor and Director of Research, Junagadh Agricultural University, Junagadh; for their appreciated direction, assumed inspiring remarks and profound consideration shown in the activities of the scheme. We hereby definite our sincere thanks to and Dr. N. K. Gontia, Principal & Dean, College of Agricultural Engineering & Technology, Junagadh for able nursing of the scheme work.

The staff members of the scheme pleasantly distinguish the financial assistance received by ICAR to run the scheme definitely. The positive approach and valued comment of Dr. K. Alagusundaram, Deputy Director General (Engineering) and Dr. S. N. Jha, Assistant Director General (PE) ICAR, New Delhi are gratefully acknowledged. We express our most sincere greetings to Dr. S. K. Tyagi, Project Coordinator, AICRP on Post Harvest Engineering and Technology, Central Institute of Post-Harvest Engineering & Technology, Ludhiana for their motivating direction, synchronization as well as their keen interest in the activities of the scheme.

We are also greatful 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 25, 2021
Junagadh

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

C O N T E N T S

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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 2019-2020 for which this report is presented**	:	Rs. 18087571/- (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	-	Dr. P. J. Rathod	57700-182400	01.12.2018
3.	Asstt. Entomologist	1	1	-	Prof. R.D.Dhudashia	131400-217100	01.06.1997
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	-	Shri P. R. Mathukiya	38090 (fixed)	01.11.2019
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 2019-2020 (Upto March, 2020)

Head-wise breakup of Receipts, Expenditure and Closing Balances for the financial year 2019-20 (ICAR share-75%)

Period : 01-04-2019 to 31-03-2020

Sr. No.	Budget Head	Opening balance as on 01-04-2019 Rs.	Grant received during the year 2019-20 Rs.	Receipts during the year 2019-20 Rs.	Revalidated amount of Unspent Balances of 2018-19, Rs.	Total grant Rs. (4+5+6)	Expenditure incurred for the councils share during the year 2019-20 Rs.	**Surrender of grant, Rs.	Closing balance at the end of the year 2019-20 as on 31-03-2020 Rs. (7-8-9)
1	2	3	4	5	6	7	8	9	10
1	Pay and Allowances	4,016,555.00	9,500,000.00	--	4,016,555.00	13,516,555.00	9,274,940.00	-	4,241,615.00
2	Travelling Allowance	297,197.00	50,000.00	--	297,197.00	347,197.00	55,619.00	-	291,578.00
3	Recurring Contingencies (Including HRD)	573,006.00	850,000.00	--	573,006.00	1,423,006.00	1,409,965.00	-	13,041.00
4	Non recurring contingencies	370,677.00	775,000.00	--	370,677.00	1,145,677.00	795,896.00	300,000.00	49,781.00
	Total, Rs.	**5,257,435.00**	**11,175,000.00**	**--**	**5,257,435.00**	**16,432,435.00**	**11,536,420.00**	**300,000.00**	**4,596,015.00**
5	Receipts during the year 2018-19	64,464.00	--	--	--	64,464.00	--	-	64,464.00
6	Receipts during the year 2019-20	--	--	4,000.00	--	4,000.00	--	-	4,000.00
	Total, Rs.	**5,321,899.00**	**11,175,000.00**	**4,000.00**	**5,257,435.00**	**16,500,899.00**	**11,536,420.00**	**300,000.00**	**4,664,479.00**

** Non-recurring grant of Rs. 300000/- was surrendered to ICAR in the month of March-2020.

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)
2	PH/JU/2018/02	Design and development of grain treater for enzymatic pre-treatment to pigeon pea grains.
3	PH/JU/2019/01	Low temperature grinding of spices.
4	PH/JU/2020/01	Standardization of process technology for preparation of peanut sauce and peanut wadi (Chunks).
5	PH/JU/2020/02	Application of microwave technology for disinfestations of groundnut kernels.
6	--	Development of biodegradable cutlery from agro industrial waste.

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
3. Prof. D. M. Vyas
4. Er. P. P. Vora

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, Tadka pipaliya and Chotila centre has also deposited installment for the year 2018-19. 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)	40000 kg	-	80000 (@ 2 Rs./kg.)	160000 (@ 4Rs./kg.)	80000
2	Cleaning and grading of wheat,	4200 kg	-	-	4200 (@ 1 Rs/kg.)	4200
3	Groundnut decortication (manually)	-	_	_	320 (@ 20Rs/day x 2 nos.)	320
4	Sesame processing	280 kg	-	8400	16800	8400
5	Groundnut threshing	-	-	-	11400 (@300Rs./hr; Total 38 hrs.)	11400
6	Pulse mill	420 kg	-	840	4200	3360
7	Spice milling	320 kg	-	640	3200	2560
	Loej Agro Processing Centre					
1	Oil milling (groundnut)	82000 kg	-	164000 (@ 2 Rs./kg.)	328000 (@ 4Rs./kg.)	164000
2	Cleaning and grading of wheat,	4700 kg	-	-	4700 (@ 1Rs./kg.)	4700
	Virol Agro Processing Centre					
1	Oil milling (groundnut)	92000 kg	-	184000 (@ 2 Rs./kg.)	368000 (@ 4 Rs./kg.)	184000
2	Cleaning and grading of wheat,	4500kg	-	-	4500 (@ 1 Rs./kg.)	4500
3	Spice milling	600 kg Chilly 108 kg turmeric 124 kg cumin Total 832	-	1664	8320	6656
	Panchal Vikas Mandal, Chotila					
1.	Oil milling	7200 kg	-	14400 (@ 2 Rs./kg.)	28800 (@ 4Rs./kg.)	14400

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.

INVESTIGATION – 2

Title : Low temperature grinding of spices.

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/2019/01
2. Investigators as approved in RPP-I, If any change attach IRC proceedings: Yes

Principal Investigator	CC-PI	Co-PI
Dr. M.N Dabhi	Dr. P. R. Davara	Dr. H. P. Gajera

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

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

15. Signature:

(M. N. Dabhi) (P. R. Davara) (H. P. Gajera)
Project Leader Co-PI Co-PI HOD

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/2019/01
2. Project Title: Low temperature grinding of spices.
3. Key Words: Grinding, spices, low temperature
4. (a) Name of the Lead Institute : AICRP on PHET, Junagadh
(b) Name of Division/ Regional Center/ Section: -
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)

S. 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%	Planning, data collection, statistical analysis and final report Writing
2	Dr. P. R. Davara, Assistant Research Engineeri, AICRP on PHET, Dept. of Processing and Food Engg., College of Agril. Engg. & Tech., Junagadh Agril. University, Junagadh	Co-PI	20%	Helping in analysis and data collection
3	Dr. H. P. Gajera Associate Research Scientist Department of Biotechnology College of Agriculture, Junagadh Agril. University, Junagadh	Co-PI	20%	1. Assessment of biochemical and volatile compound in spiced powder. 2. Data collection and report writing of biochemical and volatile compound available in spice powder through laboratory analysis.

7. Priority Area : Post Harvest Technology

8. Project Duration: Date of Start : 01-03-2019 Date of Completion : 31-03-2021

9. a. Objectives

1. Development of low temperature grinding machine
2. Grinding of spices (Fenugreek seed, Turmeric) at low temperature
3. Assessment of biochemical and volatile compound of spice powder.

a. Practical utility

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

10.1 Experimental details

Experimental design : FCRD

Independent parameters

First Factor **Different Grinding Methods**

A_1 - Ambient grinding

A_2 - By circulating ambient temperature water

A_3 - By circulating chilled water

A_4 - By circulating coolant

Second Factor **Different Feed Temperatures**

B_1 - Ambient temperature feed

B_2 - Low temperature feed (-10 ± 2˚C)

Dependent parameters

Physical Parameters : Size, Sphericity, Bulk density, True density, Porosity, Angle of repose, Coefficient of friction

Mechanical Parameters: Hardness

Biochemical Parameters: Proximate composition (Moisture, Total carbohydrate, Total protein, Crude fat, Total ash) and Other biochemical constituents (Total oil content, Oleoresin, Total phenol concentration, Total flavonoid concentration, Antioxidant activity, Volatile oil, Volatile oil compounds)

10.2Results and Discussions :

10.2.1 Fenugreek seeds.

The results of the experiments carried out to meet the objectives of the present research problem. The study was initiated with the estimation of moisture content of raw fenugreek seeds after cleaning thoroughly. It was followed by measurement of physical properties and hardness of seeds. After modifying an ambient grinding mill into low temperature grinding mill, it was tested for different flow rates at no load condition in order to get an optimum value at which liquid departed with maximum heat absorbed. At that fixed value of flow rate, performance of low temperature grinding mill was evaluated by grinding in eight different treatments. Further, quality of ground fenugreek seed powder obtained through each treatment was assessed by estimating various biochemical parameters. The results obtained in each experiment of this study are presented and discussed in due sequence.

10.2.1.1Moisture content

The values of moisture content of raw fenugreek seeds, estimated with the help of Dean and Stark apparatus. The mean (n=5) moisture content of seeds was found to be 8.129 ± 0.168% (w.b.).

10.2.1.2Physical properties

The mean values obtained for various physical properties of raw fenugreek seeds at moisture content of 8.13% (w.b.) are given in following Table 2.1 and are discussed separately below.

Table 2.1 Physical properties of fenugreek seeds

Sr. No.	Physical property	Mean ± S. D.
1	Size (Geometric mean diameter) (mm)	2.851 ± 0.169
2	Sphericity	0.741 ± 0.079
3	Bulk density (g/cm^3)	0.766 ± 0.005
4	True density (g/cm^3)	1.291 ± 0.084
5	Porosity (%)	40.682
6	Static angle of repose (°)	27.950 ± 0.959
7	Coefficient of external friction (static)	
	1) Metal (Galvanized iron) surface	0.287 ± 0.013
	2) Plywood surface	0.308 ± 0.014
	3) Glass surface	0.335 ± 0.019

Size (Geometric mean diameter)

The mean value for size of fenugreek seeds was determined based on values of length, breadth and thickness of 50 randomly selected seeds. The mean value of size in terms of geometric mean diameter was found to be 2.851 ± 0.169 mm.

Sphericity

The mean value of sphericity of 50 randomly selected seeds was found to be 0.741 ± 0.079.

Bulk density

The mean value of five replication of bulk density of selected seeds was found to be 0.766 ± 0.005 g/cm^3.

True density

The mean value of five replication of true density of randomly selected seeds was found to be 1.291 ± 0.084 g/cm^3.

Porosity

The mean value of five replications of porosity for fenugreek seeds was calculated based on mean values of bulk and true density. It was found to be 40.682%.

Static angle of repose

The mean value of five replications of angle of repose was found to be 27.950 ± 0.959°.

Coefficient of external friction (static)

The mean values five replications were found to be 0.287 ±0.013, 0.335 ± 0.019 and 0.308 ± 0.014 for metal (galvanized iron), glass and plywood surface, respectively.

Hardness of fenugreek seeds

The mean value fifteen replications for hardness of fenugreek seeds was determined based on 15 randomly selected seeds. The mean value obtained was 50.756 ± 7.612 kg force.

10.2.1.3 Performance evaluation of low temperature grinding mill

Performance evaluation of low temperature grinding mill was carried out by observing time to grind the material, temperature profile of liquid entering and leaving the grinding chamber along with temperature profile inside the grinding chamber, temperature inside the grinding chamber at the end of grinding operation, temperature of ground product, sieve clogging, milling and machine loss for each treatment combination. In addition to that, temperature of surrounding was noted every time before starting off grinding operation. Results of this section are discussed separately for each parameter in detail below.

Ambient temperature before grinding

Ambient temperature is an important independent parameter which can affect the conditions and results of grinding operation. Ambient temperature, observed with the help of a glass thermometer before each treatment including three replications. Results showed that the mean value among all the treatments varied from minimum of 33.37℃ to maximum of 35.10 ℃.

Table 2.2 Effect of grinding method and feed temperature on parameters evaluating performance of low temperature grinding mill

Effect	Temperature inside grinding chamber at the end (℃)	Time to grind the material (min)	Temperature of ground product (℃)	Milling loss (%)	Machine loss (%)
Grinding method (L)					
Ambient grinding (L_0)	89.67[a]	20.81[a]	67.65[a]	28.14	14.59
Ambient temperature water circulation (L_1)	84.17[b]	20.55[a]	63.58[b]	28.22	14.64
Chilled water circulation (L_2)	61.00[c]	19.87[b]	56.62[c]	28.46	14.84
Coolant circulation (L_3)	54.17[d]	19.60[b]	51.65[d]	28.54	15.08
S. Em±	0.6124	0.1793	0.2781	0.1439	0.1483
C. D. at 5%	1.8360	0.5375	0.8339	NS	NS
Feed temperature (T)					
Ambient temperature feed (T_0)	73.08[a]	20.42[a]	60.32[a]	27.61[a]	14.27[a]
Low temp. feed (T_1)	71.42[b]	19.99[b]	59.43[b]	29.07[b]	15.30[b]
S. Em±	0.4330	0.1268	0.1967	0.1017	0.1049
C. D. at 5%	1.2982	0.3800	0.5897	0.3050	0.3145
Interaction (L*T)					
S. Em±	0.8660	0.2535	0.3933	0.2035	0.2098
C. D. at 5%	NS	NS	NS	NS	NS
C. V%	2.0761	2.1730	1.1379	1.2435	2.4573

Temperature profile inside the grinding chamber

The values of temperature of liquid entering and leaving the grinding chamber, temperature of liquid inside the refrigeration tank and temperature inside the grinding chamber at every minute during the whole grinding operation for all the treatments are observed. The values were observed once the temperature of grinding chamber lowered as possible as and became constant for nearly 15 minutes by circulation of liquid without load (without feed) condition.

Temperature profile inside the grinding chamber for all the treatments are shown graphically below (Fig. 2.1). Fig. 2.1(a) shows the trend of change in temperature for the treatments involving ambient temperature feed while 10.1(b) shows trend for treatments involving low temperature feed.

From fig. 2.1(a), it can be said that the value of temperature inside the grinding chamber stayed all-time high for control treatment whereas all-time low for coolant circulation treatment compared to all other treatments. In case of rise in temperature, treatment involving ambient temperature water circulation showed nearly positive values compared to control treatment while treatment involving chilled water circulation, just negative compared to coolant circulation treatment. There was considerable gap in the graph between the treatments for which refrigerator remained OFF (control and ambient temperature water circulation) and refrigerator remained ON (chilled water and coolant circulation) during the whole grinding operation. For all the treatments, temperature inside the grinding chamber increased rapidly at initiation of grinding, increased moderately in middle and rose even swiftly at the end. Fig. 2.1(b) shows the same trend for treatment involving low temperature feed. The only difference of changing the feed temperature was slight decrease in temperature inside the grinding chamber on the very next minute of feeding in case of low temperature feed. Overall, the initial and final value of temperature inside the grinding chamber for all the treatments are given in Table 2.3.

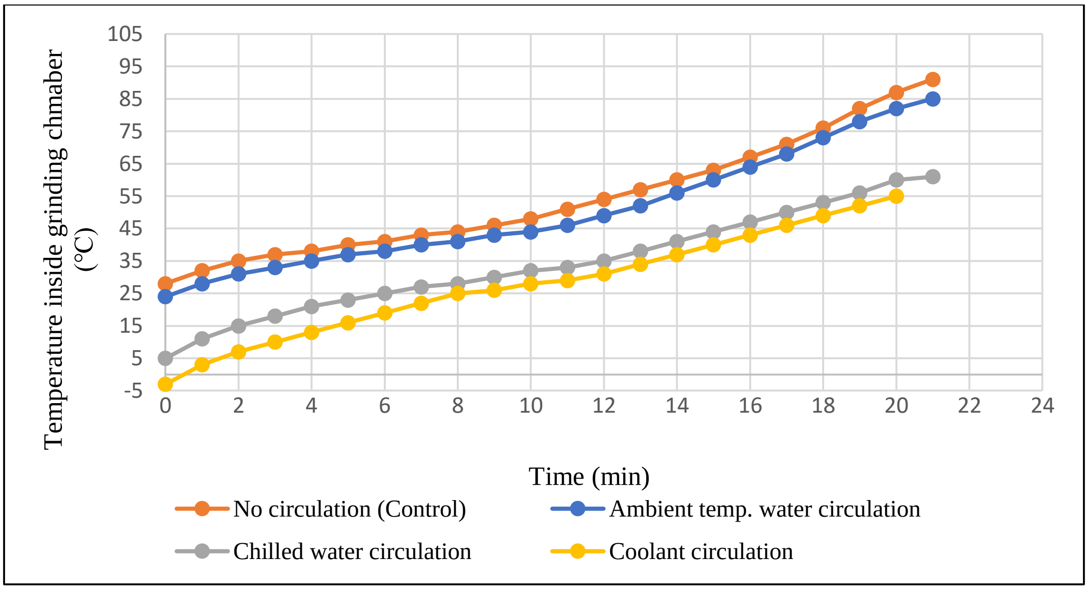


Fig. 2.1(a) Temperature profile of grinding chamber for ambient temperature feed

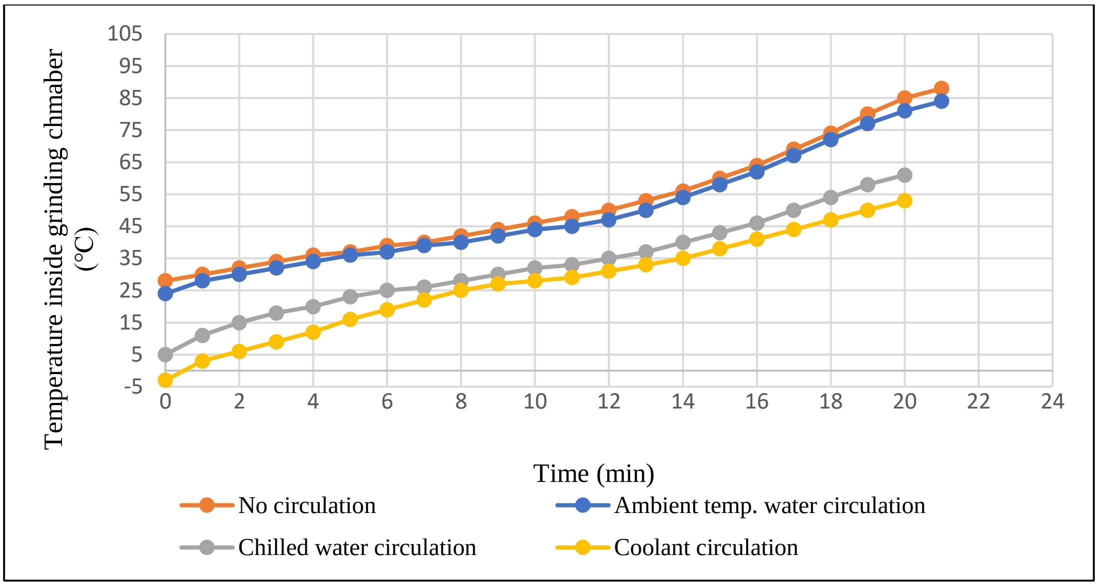


Fig. 2.1(b) Temperature profile of grinding chamber for low temperature feed

Fig. 2.1 Temperature profile of grinding chamber for all the treatments

Table 2.3 Initial and final value of temperature inside the grinding chamber for all the treatments

Treatment	Temperature inside grinding chamber (°C)	
	At beginning of grinding	At the end of grinding
L_0T_0	28	91
L_0T_1	28	88
L_1T_0	24	85
L_1T_1	24	84
L_2T_0	5	61
L_2T_1	5	61
L_3T_0	-3	55
L_3T_1	-3	53

The data of temperature of liquid entering and leaving the grinding chamber and temperature of liquid in refrigeration tank for all the treatments concluded that increase in temperature inside the grinding chamber made increase in temperature of liquid-out from grinding chamber. That higher temperature liquid entering the refrigeration tank increased the temperature of liquid inside tank and ultimately increased the temperature of liquid-in to grinding chamber. In case of chilled water circulation, refrigeration unit tried to maintain the low temperature of liquid inside the tank and that was the reason why increased temperature of liquid in tank and liquid-in to grinding chamber again decreased and so on, in that case. But the same capacity of refrigeration unit seemed to be failed to maintain the temperature of liquid in tank and so as liquid-in to grinding chamber in case of coolant circulation. So, temperature of liquid inside tank and liquid leaving from grinding chamber in case of coolant circulation increased throughout the entire grinding operation. Overall, the initial and final values of temperature of liquid-in and out from grinding chamber and liquid inside refrigeration tank for all the treatments are given in Table 2.4.

Table 2.4 Initial and final value of temperature of circulating liquid for all the treatments

Treatment	Temperature (°C)					
	Liquid-in (Initial)	Liquid-in (Final)	Liquid-out (Initial)	Liquid-out (Final)	Liquid inside tank (Initial)	Liquid inside tank (Final)
L_0T_0	-	-	-	-	-	-
L_0T_1	-	-	-	-	-	-
L_1T_0	31.5	33.4	32.2	34.8	31	33
L_1T_1	32.1	34.1	32.6	35.2	31.6	33.7
L_2T_0	2.8	3.2	3.5	4.8	2.7	3.1
L_2T_1	2.9	3.2	3.6	4.8	2.7	3.2
L_3T_0	-9.5	-7.9	-8.5	-6.3	-9.7	-8
L_3T_1	-9.6	-8.1	-8.6	-6.5	-9.8	-8.2

Temperature inside the grinding chamber at the end of grinding

From Table 2.2, it is clear that grinding method affects significantly on the value of temperature inside the grinding chamber at the end of grinding. The significantly highest temperature (89.67 °C) was found for the grinding method without liquid circulation (L_0). The significantly lowest temperature (54.17 °C) was found for the method having coolant circulation around the grinding chamber (L_3). The effect of feed temperature (at 5% level) on the same parameter was also found significant (Table 2.3). The significantly minimum value found was 71.42 °C for ambient temperature feed (T_1). In addition to that, the interaction effect of grinding method and feed temperature (L*T) on the value of temperature inside the grinding chamber at the end of grinding was found non-significant.

The mean values for this parameter for all the treatments are graphically presented in the following figure (Fig. 2.2). Figure shows that temperature inside the grinding chamber at the end of grinding decreases when moving from left to right *i.e.* treatments involving ambient grinding with ambient feed (L_0T_0 = 91.33 °C) to grinding with coolant circulation with low temperature feed (L_3T_1=53.33 °C) treatment combination. But fall in temperature becomes substantial with the change in grinding method compared to the change in feed temperature keeping the grinding method same, especially when jumping to chilled water and coolant circulation methods from ambient temperature water circulation. Possibly, resting of considerable amount of time in feed hopper increased the temperature of low temperature feed which in turn diminished its effect to some extent.

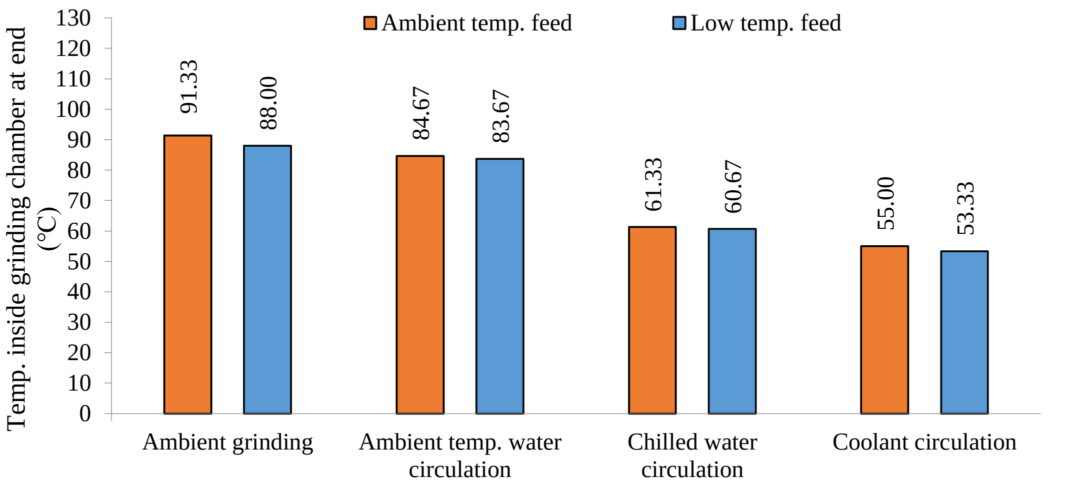


Fig. 2.2 Effect of various treatments on temperature inside the grinding chamber at the end of grinding

From fig. 2.2, it can be concluded that lowering feed temperature as well as circulation of liquid around the grinding chamber positively decreases the final value of temperature inside the grinding chamber. That was caused by continuous absorption of heat generated during grinding operation. Additionally, lowering the temperature of liquid, circulating around the grinding chamber results in appreciable falling of final temperature inside the grinding chamber. That was caused by absorption of more amount of heat generated during grinding operation due to increase in the value of difference in temperature between grinding chamber and circulating liquid around.

Time to grind the material (Grinding time)

From Table (10.2), it is clear that effect of grinding method on the value of grinding time at 5% level is significant. The highest time (20.81 min) was found for the ambient grinding (L_0). While method L_1, involving ambient temperature water circulation was at par with the method L_0. The lowest time (19.60 min) was found for the method having coolant circulation around the grinding chamber (L_3). While method L_2, involving chilled water circulation was at par with the method L_3. The effect of feed temperature on the same parameter was also found significant (Table 2.3). The significant maximum value (20.42 min) was found for ambient temperature feed (T_0). While significantly minimum value (19.99 min) was found in case of low temperature feed (T_1). Additionally, the interaction effect of grinding method and feed temperature (L*T) on the value of time to grind the material was found non-significant.

The mean values for this parameter for all the treatments are graphically presented in the Fig. 2.3. The values varied from 20.97 min for ambient grinding with ambient feed (L_0T_0) to 19.31 min in coolant circulation with low temperature feed

(L_3T_1). From the figure, lowering the feed temperature conclusively lowers the time required for grinding the material. That was possibly due to the fact that lowering feed temperature made fenugreek seeds much brittle which in turn made them easy to be ground.

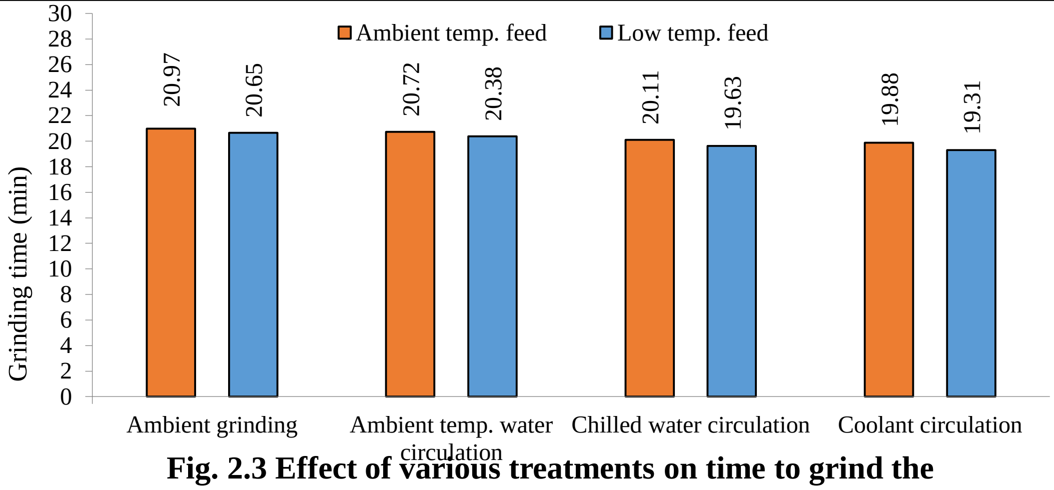


Fig. 2.3 Effect of various treatments on time to grind the material

Fig. 2.3 clears that circulation of liquid and in that also lowering the temperature of circulating liquid decreases the value of grinding time for a same temperature feed. But the difference found was significant when moving on chilled water and coolant circulation methods from ambient temperature water circulation. The possible reason for decrease in grinding time might be the reduction in sieve clogging as a cause of melting of fat present in seeds. Circulation of liquid as well as lowering the temperature of circulating liquid lowered the final temperature inside the grinding chamber which caused reduction in the extent of melting of fat and so as reduction in the extent of sieve clogging. Which in turn reduced the time required for grinding.

Temperature of ground product

From Table (10.2), it is clear that grinding method affects significantly on the value of temperature of ground powder at the end of grinding. The significantly highest temperature (67.65 °C) was found for the ambient grinding (L_0). The lowest temperature (51.65 °C) was found for the method involving coolant circulation around the grinding chamber (L_3). The effect of feed temperature (at 5% level) on the same parameter was also found significant (Table 2.3). The significantly highest value (60.32 °C) found was for ambient temperature feed (T_0). However, significantly lowest value (59.43 °C) was found in case of low temperature feed (T_1). Besides that, the interaction effect of grinding method and feed temperature (L*T) on the value of temperature of ground product was found non-significant.

The mean values for the same parameter for all the treatments are graphically presented in the following figure (Fig. 2.4). Figure shows that temperature of ground product decreases when moving from left to right *i.e.* treatments involving ambient grinding with ambient feed (L_0T_0), chilled water and coolant circulation treatments. The value varied from 68.07 °C for ambient grinding with ambient feed (L_0T_0) to 51.17 °C in coolant circulation with low temperature feed (L_3T_1). But fall in temperature becomes pronounced with the change in grinding method compared to the change in feed temperature keeping the grinding method same.

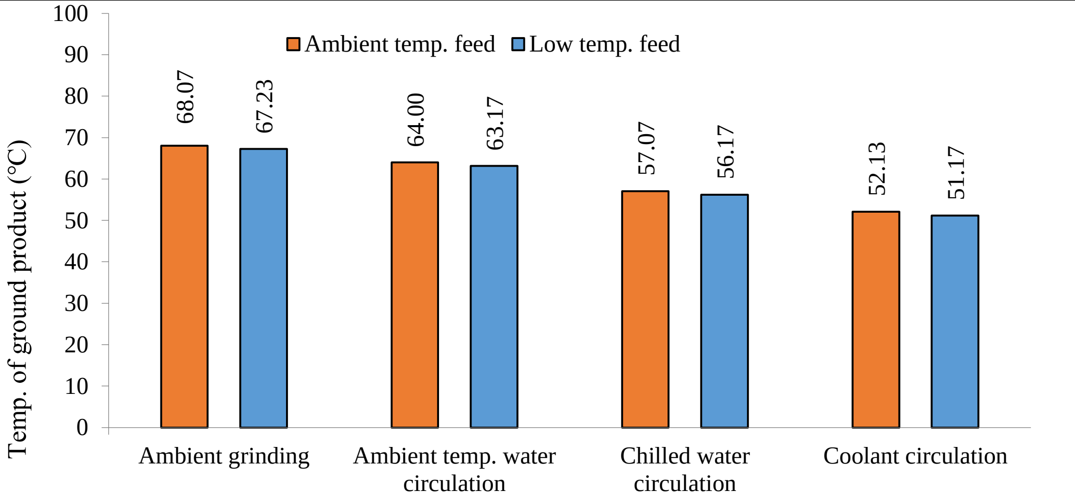


Fig. 2.4 Effect of various treatments on temperature of fenugreek seed product

From fig. 2.4, it can be concluded that lowering feed temperature as well as circulating liquid (and lowering the temperature of circulating liquid) around the grinding chamber positively decreases the value of temperature of ground product. That was caused by reduction in the value of temperature inside the grinding chamber at the end of grinding due to the continuous absorption of heat generated during grinding operation.

Sieve clogging

Observations of sieve clogging revealed more deposition in case of control treatment compared to chilled and coolant circulation methods. High temperature in case of control treatment possibly resulted in melting of fat to a greater extent which in turn caused higher percentages of clogging. However, clogging of sieve was not considerable in any of the treatments and it could easily be cleaned by cleaning-brush.

Milling loss

From Table (10.2), it is clear that effect of grinding method on the value of milling loss at 5% level is non-significant. While the effect of feed temperature on the same parameter was found significant. The value found was 29.07% for low temperature feed (T_1). While value in case of ambient temperature feed (T_0) was above par with that of T_1. Additionally, the interaction effect of grinding method and feed temperature (L*T) on the value of per cent milling loss was found non-significant.

The mean values for this parameter for all the treatments are graphically shown in the following figure (Fig. 2.5). The values did not vary to a considerable extent while changing grinding method, keeping feed temperature same. It varied from 27.45 to 27.76% for ambient temperature feed and 28.83 to 29.31% for low temperature feed among all grinding methods. While from the figure, lowering the feed temperature conclusively increases the value of per cent milling loss. That was attributed to the fact that lowering feed temperature made fenugreek seeds more brittle which in turn made them ground to finer particles comparatively. The formation of finer particles could easily be lost in the form of dust particles. That ultimately increased the value of per cent milling loss in case of low temperature feed.

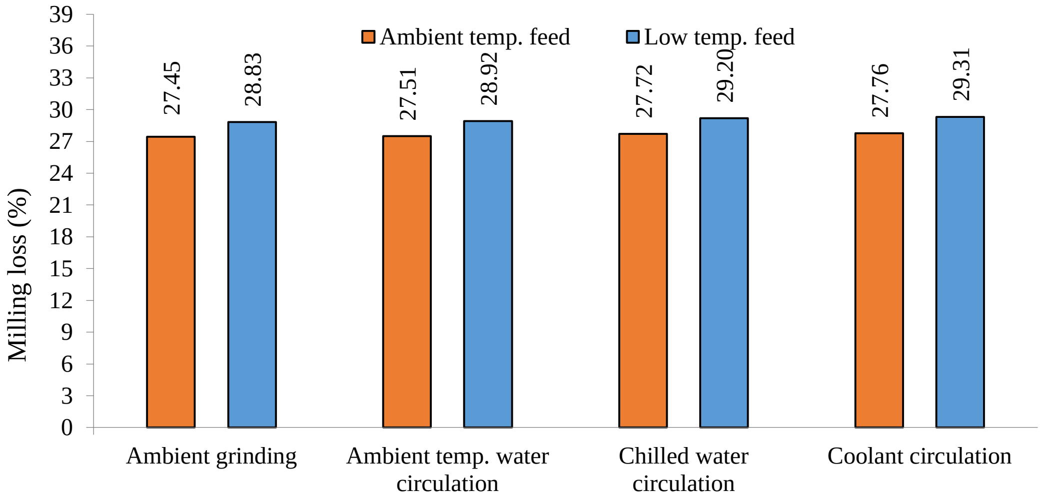


Fig. 2.5 Effect of various treatments on milling loss of fenugreek seed powder

Machine loss

Table (10.2) shows that effect of grinding method on the value of machine loss at 5% level is non-significant. While the effect of feed temperature on the same parameter was found significant. The value found was 15.30% for low temperature feed (T_1). While value in case of ambient temperature feed (T_0) was above par with that of T_1. Additionally, the interaction effect of grinding method and feed temperature (L*T) on the value of per cent machine loss was found non-significant.

The mean values for this parameter for all the treatments are graphically shown in the following figure (Fig. 2.6). The values did not vary to a considerable extent while changing grinding method, keeping feed temperature same. It varied from 14.12 to

14.50% for ambient temperature feed and 15.05 to 15.65% for low temperature feed among all grinding methods. While from the figure, lowering the feed temperature conclusively increases the value of per cent machine loss. This is due to the increase in milling loss in the form of dust in case of low temperature feed. Particles lost in the form of dust stuck to the internal surfaces of product outlet area which in turn increased the value of per cent machine loss.

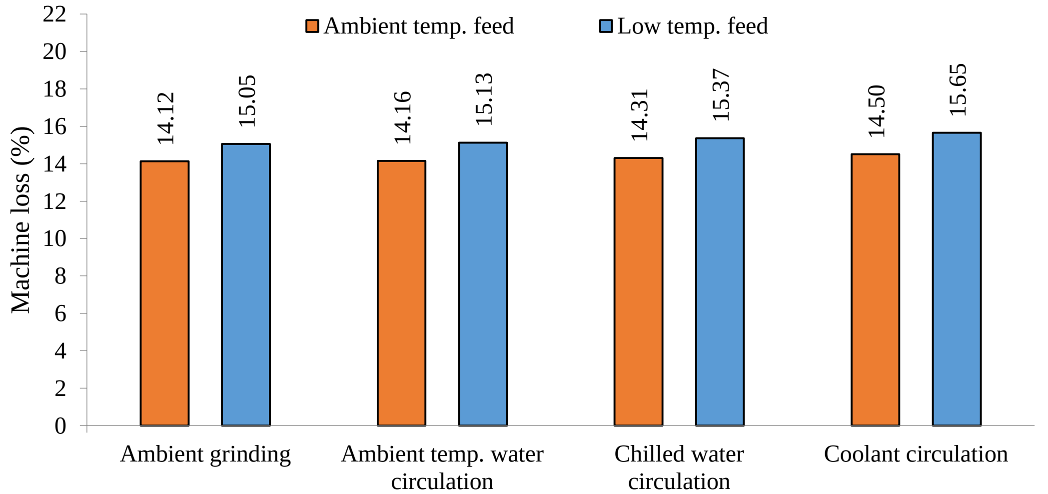


Fig. 2.6 Effect of various treatments on machine loss of fenugreek seed powder

10.2.1.4 Biochemical parameters of ground fenugreek seed powder

The values obtained for various biochemical parameters of ground fenugreek seed powder obtained through different treatments are given in Table 2.5 and are discussed separately below.

Table 2.5 Effect of grinding method and feed temperature on biochemical parameters of ground fenugreek seed powder

Effect	Moisture content (% w.b.)	Total carbohydrate (%)	Crude fibre (%)	Mucilage (%)	True protein (%)	Total oil (%)	Total ash (%)	Total phenol (mg/g)	Total flavonoid (mg QE/g of extract)	Antioxidant activity (DPPH scavenging %)	Volatile oil (%)
Grinding method (L)											
Without liquid circulation (L_0)	4.88	53.40	3.99	26.67	14.44	5.58	3.77	3.96	6.48	8.28	0.32
Ambient temperature water circulation (L_1)	5.20	54.86	4.26	25.95	15.16	5.86	3.70	4.59	7.43	10.39	0.33
Chilled water circulation (L_2)	6.35	57.46	5.37	24.43	16.33	6.75	3.49	6.83	10.67	18.06	0.40
Coolant circulation (L_3)	6.80	58.89	5.68	23.65	17.02	7.13	3.41	7.60	11.91	20.88	0.42
S. Em±	0.0276	0.1780	0.0230	0.1368	0.1006	0.0456	0.0134	0.1003	0.1443	0.2633	0.0020
C. D. at 5%	0.0829	0.5337	0.0691	0.4102	0.3015	0.1367	0.0403	0.3008	0.4327	0.7894	0.0059

Effect	Moisture content (% w.b.)	Total carbohydrate (%)	Crude fibre (%)	Mucilage (%)	True protein (%)	Total oil (%)	Total ash (%)	Total phenol (mg/g)	Total flavonoid (mg QE/g of extract)	Antioxidant activity (DPPH scavenging %)	Volatile oil (%)
Feed temperature (T)											
Ambient temperature feed (T_0)	5.74	55.88	4.78	25.32	15.61	6.28	3.60	5.63	8.95	14.02	0.37
Low temp. feed (T_1)	5.88	56.42	4.87	25.03	15.87	6.38	3.58	5.85	9.30	14.79	0.37
S. Em±	0.0195	0.1259	0.0163	0.0967	0.0711	0.0322	0.0095	0.0710	0.1020	0.1862	0.0014
C. D. at 5%	0.0586	0.3774	0.0489	0.2900	0.2132	0.0966	NS	0.2127	0.3059	0.5582	0.0042
Interaction (L*T)											
S. Em±	0.0391	0.2517	0.0326	0.1935	0.1422	0.0645	0.0190	0.1419	0.2041	0.3724	0.0028
C. D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
C. V%	1.1657	0.7765	1.1702	1.331	1.5654	1.7638	0.9164	4.2795	3.8744	4.4777	1.3105

Moisture content

The values found for moisture content in ground powder of each treatment with three replications are noted. The effect of two factors, *viz*. grinding method and feed temperature on the same parameter is shown in Table 2.5.

From the Table (10.5), it can be observed that grinding method affects significantly on the value of moisture content of ground product at 5% level of significance. The lowest value (4.88%) was found for the grinding method without liquid circulation (L_0) while method involving coolant circulation around the grinding chamber (L_3) exhibited to retain higher percentages of moisture (6.80%). The effect of feed temperature on the value of moisture content was also found significant (at 5% level). The values found were 5.74 and 5.88% for ambient temperature and low temperature feed, respectively. In addition to individual effects, the interaction effect of grinding method and feed temperature (L*T) on the same parameter was found non-significant.

The mean values of moisture content of ground powder for all the treatments are graphically presented in the following figure (Fig. 2.7). Figure reveals that the value of moisture content of ground powder increases when moving from left to right *i.e.* treatments involving ambient grinding to ambient water, chilled water and coolant circulation treatments. Values varied from minimum of 4.79% for ambient grinding (L_0T_0) to maximum of 6.87% in coolant circulation with low temperature feed (L_3T_1). Increase in moisture content of ground powder with moving from no circulation to coolant circulation might be attributed to the condensation of moisture at low temperature. Circulation of liquid around the grinding chamber before starting of grinding operation caused atmospheric moisture to be condensed inside the grinding chamber which in turn added moisture in the ground product. Additionally, rise of the graph seems to be gradual except moving from ambient temperature water to chilled water circulation grinding method. That might be related to more amount of condensation at internal surfaces of grinding chamber due to increase in temperature difference between circulating liquid and surrounding. The same reason of condensation at low temperature can be concluded for increasing moisture content of ground powder with low temperature feed, irrespective of grinding method. Further, lower temperature of ground powder might decrease the loss of moisture in surrounding by evaporation. However, decrease in the value of moisture content in ground powder compared to moisture of raw seeds (8.129%) for all the treatments was observed. That might be due to the loss of moisture at higher temperature generated during grinding operation.

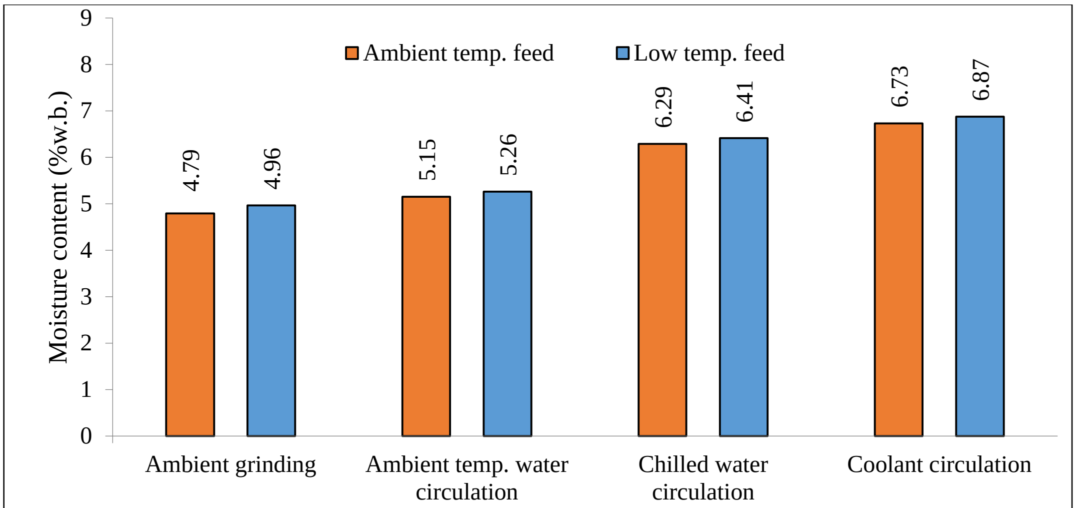


Fig. 2.7 Effect of various treatments on moisture content of fenugreek seed powder

Total carbohydrate content

The Table (10.5) clears that grinding method affects significantly on the value of total carbohydrate of ground product at 5% level of significance. The lowest value (53.40%) was found for the grinding method without liquid circulation (L_0) while method involving coolant circulation around the grinding chamber (L_3) found to retain higher percentages of carbohydrate (58.89%). Besides that, the value found for chilled water circulation method (L_2) was quite competitive with that of method L_3. The effect of feed temperature on the value of total carbohydrate content was also found statistically significant at the same level of significance (Table 2.7). The values found were 55.88 and 56.42% for ambient temperature and low temperature feed, respectively. Further, the interaction effect of grinding method and feed temperature (L*T) on the value of total carbohydrate was found non-significant.

The mean values of total carbohydrate content of ground powder for all the treatments are graphically displayed in the following figure (Fig. 2.8). Figure reveals that the value of total carbohydrate in ground powder increases when moving from treatments involving no circulation to ambient, chilled water and coolant circulation treatments. Values varied from minimum of 53.01% for control treatment (L_0T_0) to maximum of 59.14% in coolant circulation with low temperature feed (L_3T_1). Increase in total carbohydrate content in ground powder with moving from left to right in the graph might be attributed to decrease in elevation of temperature during grinding operation. As higher temperature causes carbohydrate conversion, it decreases the percentages of total carbohydrate.

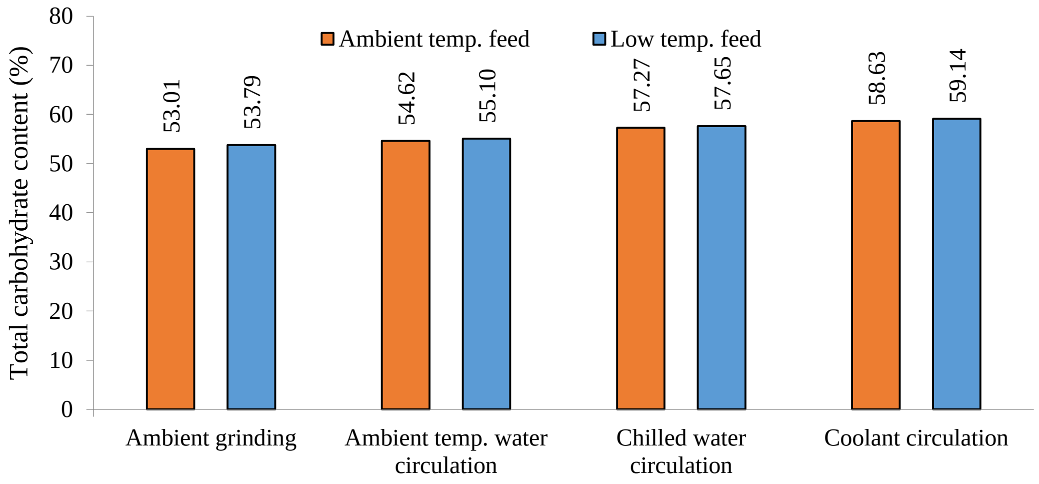


Fig. 2.8 Effect of various treatments on total carbohydrate content of fenugreek seed powder

Crude fibre content

Table (10.5) shows that grinding method affects significantly on the value of crude fibre in ground product at 5% level of significance. The lowest value (3.99%) was found for the grinding method without liquid circulation (L_0). On the other hand, method involving coolant circulation around the grinding chamber (L_3) found to have higher percentages of crude fibre (5.68%). Additionally, value observed in ambient temperature water circulation method (L_1) was fairly above par with that of L_0. Besides grinding method, the effect of feed temperature on the same parameter was also found statistically significant at the same level of significance. The values found were 4.78 and 4.87% for ambient temperature and low temperature feed, respectively. Further, the interaction effect of grinding method and feed temperature (L*T) on the value of crude fibre content was found non-significant.

The mean values of crude fibre of ground powder for all the treatments are graphically demonstrated in the following figure (Fig. 2.9). Figure indicates that the value of crude fibre in ground powder increases when moving from treatments involving no circulation to coolant circulation treatments. The mean values varied from minimum of 3.91% for control treatment (L_0T_0) to maximum of 5.72% in coolant circulation with low temperature feed (L_3T_1). Increase in crude fibre content in ground powder with moving from left to right in the graph might be attributed to decrease in elevation of temperature during grinding operation. Higher temperature developed during grinding operation might cause the conversion of insoluble dietary fibre to soluble dietary fibre which in turn perhaps decreased the percentages of crude fibre in ground powder, as crude fibre is composed of insoluble cellulose and lignin. Rise in temperature breaks the weak bonds between polysaccharide chains and split glycosidic linkages in the dietary fibre polysaccharides. So, the architecture of the fibre matrix may be modified and insoluble fibre changes to soluble dietary fibre.

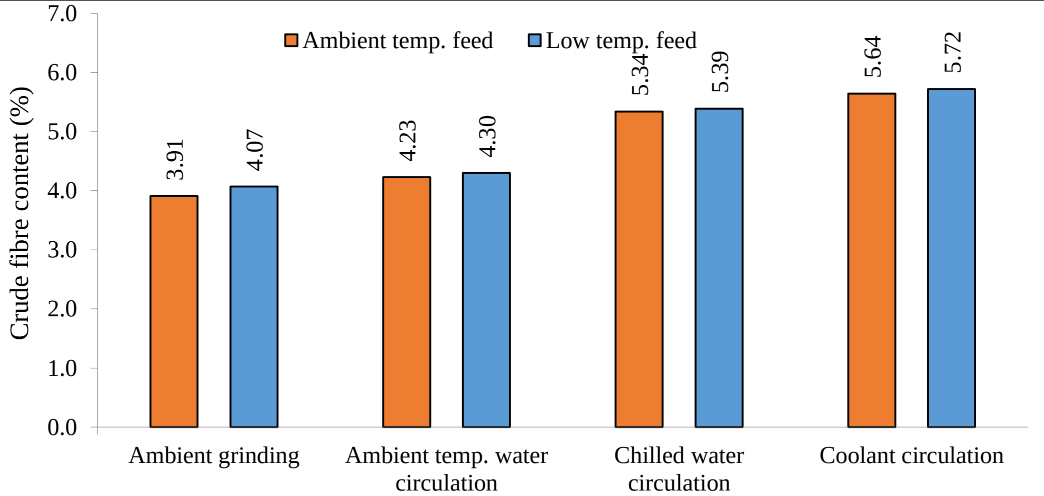


Fig. 2.9 Effect of various treatments on crude fibre content of fenugreek seed powder

Mucilage

Table (10.5) shows that grinding method affects significantly on the value of mucilage in ground product at 5% level of significance. For the grinding method, the lowest value (23.65%) was found for the method involving coolant circulation around the grinding chamber (L_3) and highest in case of no circulation (26.67%). Besides grinding method, the effect of feed temperature on the same parameter was also found statistically significant at the same level of significance. The values found were 25.32 and 25.03% for ambient temperature and low temperature feed, respectively. Further, the interaction effect of grinding method and feed temperature (L*T) on the value of mucilage content was found non-significant.

The mean values of mucilage of ground powder for all the treatments are graphically shown in the following figure (Fig. 2.10). Figure indicates that the value of mucilage in ground powder decreases when moving from treatments involving no circulation to ambient, chilled water and coolant circulation treatments. The mean values varied from maximum of 26.87% for control treatment (L_0T_0) to minimum of 23.49% in coolant circulation with low temperature feed (L_3T_1). The same reason of decrease in elevation of grinding chamber temperature during grinding operation could be given for decrease in mucilage content in ground powder with moving from left to right. Higher temperature developed during grinding operation might cause the conversion of insoluble dietary fibre to soluble dietary fibre which in turn possibly increased the percentages of mucilage in ground powder, as mucilage is a kind of soluble dietary fibre. As a cause of rise in temperature, the architecture of the fibre matrix may be modified and insoluble fibre changes to soluble dietary fibre.

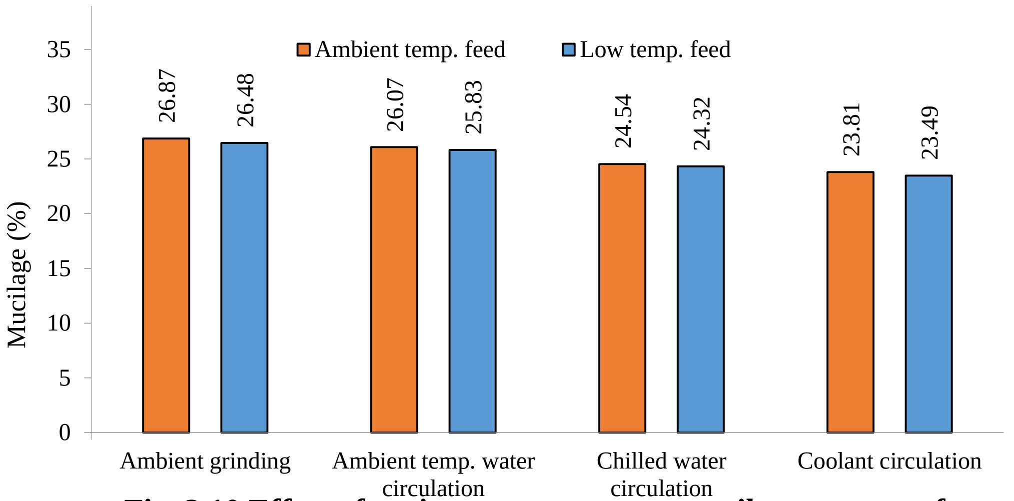


Fig. 2.10 Effect of various treatments on mucilage content of fenugreek seed powder

True protein content

Effect of grinding method on the value of true protein content of ground powder was found significant at 5% level of significance (Table 2.5). The lowest value (14.44%) was found for the grinding method without liquid circulation (L_0) while method involving coolant circulation around the grinding chamber (L_3) found to produce powder having higher percentages of true protein (17.02%). The effect of feed temperature on the value of true protein was also found statistically significant at 5% level of significance. The value found for low temperature feed (15.87%) was just above par with that of ambient temperature feed (15.61%). Additionally, the interaction effect of grinding method and feed temperature (L*T) on the value of true protein content was found non-significant at the same level of significance.

The mean values of true protein of ground powder for all the treatments are graphically displayed in the following figure (Fig. 2.11). Figure indicates that the value of true protein of ground powder increases when moving from treatments involving no circulation to ambient, chilled water and coolant circulation treatments. Values ranged from minimum of 14.23% for control treatment (L_0T_0) to maximum of 17.15% in coolant circulation with low temperature feed (L_3T_1). Increase in true protein content of ground powder with moving from left to right in the graph might be attributed to the decrease in elevation of temperature during grinding operation. As higher temperature causes protein denaturation, it decreases the percentages of true protein.

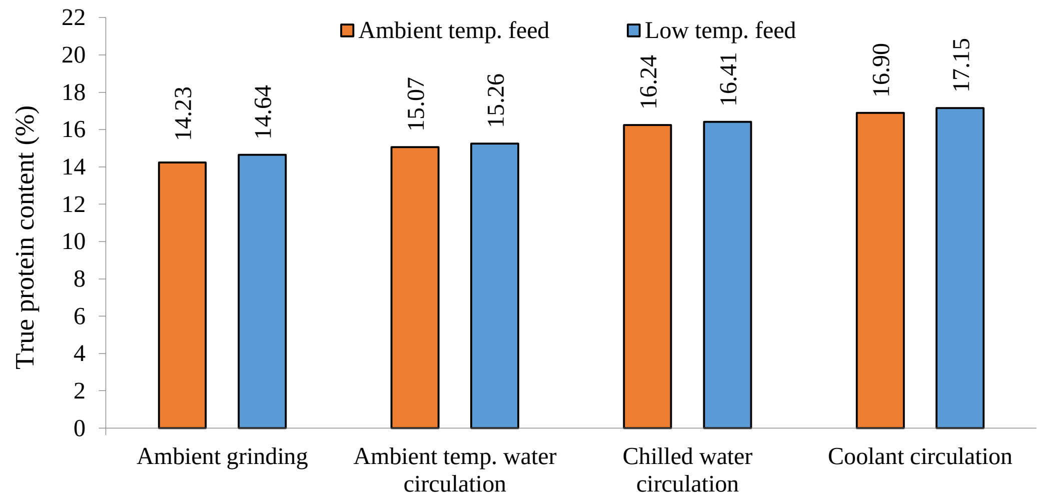


Fig. 2.11 Effect of various treatments on true protein content of fenugreek seed powder

Total oil content

From the Table (10.5), it can be seen that grinding method affects significantly on the value of total oil content of ground product at 5% level of significance. The lowest value (5.58%) was found for the grinding method without liquid circulation (L_0). While the method incorporating coolant circulation (L_3) exhibited to produce powder containing comparatively higher percentages of fixed oil (7.13%). Additionally, the value observed in case of chilled water circulation method (6.75%) was fairly competitive with that of found in L_3. The effect of feed temperature (at 5% level) on the same parameter was also found significant. The values found were 6.28 and 6.38% for ambient temperature and low temperature feed, respectively. In addition to individual effects, the interaction effect of grinding method and feed temperature (L*T) on the value of total oil content in ground powder was found non-significant at the same level of significance.

The mean values of total oil of ground powder for all the treatments are graphically presented in the following figure (Fig. 2.12). Figure shows that the value of total oil in ground powder increases when moving from left to right *i.e.* treatments involving no circulation to ambient temperature, chilled water and coolant circulation treatments. Values varied from minimum of 5.51% for control treatment (L_0T_0) to maximum of 7.19% in coolant circulation with low temperature feed (L_3T_1). Increase in oil percentages in ground powder with moving from no circulation to coolant circulation might be attributed to the reduction in the degree of melting of fat present in the seeds. Moving from left to right in the graph decreased the value of temperature inside the chamber at the end of grinding operation which in turn decreased the extent of melting and sticking of fat on grinding surfaces and sieve. That caused increase in the oil percentages in ground powder. While higher temperature developed during grinding operation caused reduction in the value of total oil in control treatment.

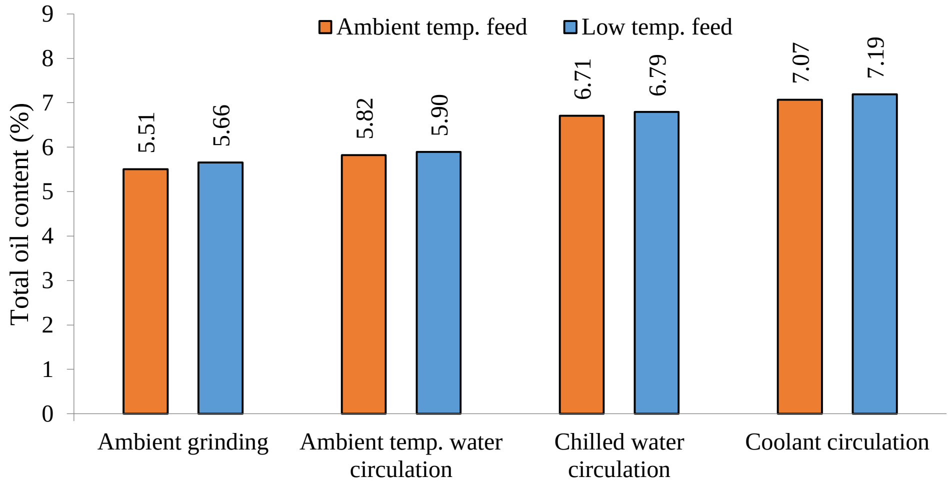


Fig. 2.12 Effect of various treatments on total oil content of fenugreek seed powder

Total ash content

From the Table (10.5), it can be concluded that grinding method affects significantly on the value of total ash content of ground product at 5% level of significance while feed temperature does not do so. For the grinding method, the lowest value (3.41%) was found for the method involving coolant circulation around the grinding chamber (L_3) and highest in case of no circulation (3.77%). Besides that, the interaction effect of grinding method and feed temperature (L*T) on the same parameter was also found non-significant at the same level of significance.

The mean values of total ash of ground powder for all the treatments are graphically shown in the following figure (Fig. 2.13). Figure indicates that the value of total ash in ground powder decreases when moving from treatments involving no circulation to ambient, chilled water and coolant circulation treatments. Values ranged from maximum of 3.79% for control treatment (L_0T_0) to minimum of 3.39% in coolant circulation with low temperature feed (L_3T_1). Decrease in total ash content of ground powder with moving from left to right in the graph might be attributed to the increased value of moisture in ground powder. Proceeding from no circulation to coolant circulation grinding treatments, temperature of grinding chamber decreased which caused increase in the moisture content of ground powder. Increased moisture caused decrease in the solid percentages of ground powder which in turn caused reduction in the value of ash content. So, grinding method did not affect the value of total ash of the ground powder directly, instead variation in the moisture due to different grinding methods engendered variation in the value of ash content.

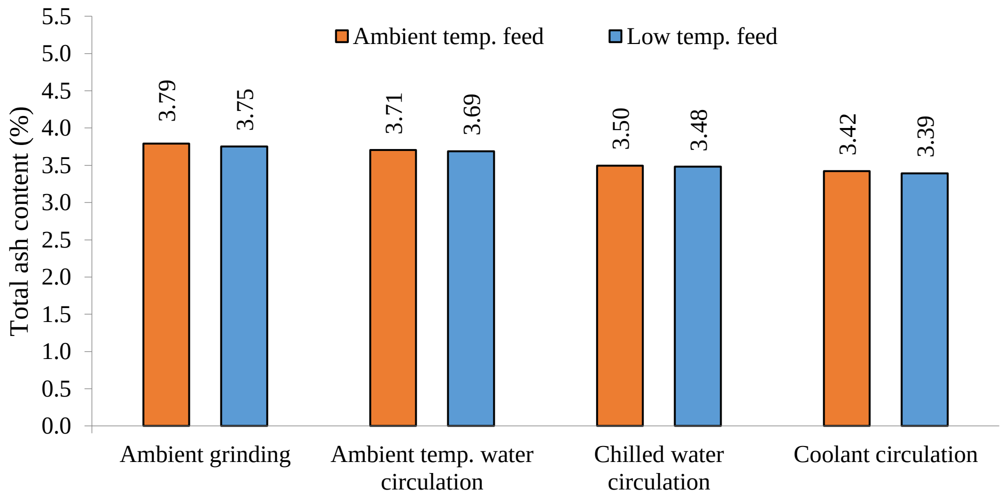


Fig. 2.13 Effect of various treatments on total ash content of fenugreek seed powder

Total phenol content

From the Table (10.5), it can be observed that grinding method affects significantly (at 5% level) on the value of total phenol content of ground product. The lowest value (3.96 mg/g) was found for the grinding method without liquid circulation (L_0) while method having coolant circulation around the grinding chamber (L_3) found to have highest value of total phenol (7.60%) in ground powder. The value obtained in ambient temperature water circulation was above par with that of method L_0 and value in the case of chilled water circulation was below par with that of method L_3. Additionally, the effect of feed temperature on the value of total phenol was also found significant statistically at 5% level of significance. The value found in case of low temperature feed (5.63 mg/g) was just above par with that of ambient temperature feed (5.85 mg/g). Besides that, the interaction effect of grinding method and feed temperature (L*T) on the value of total phenol content of ground powder was found non-significant at the same level of significance.

The mean values of total phenol of ground powder for all the treatments are graphically displayed in the following figure (Fig. 2.14). Figure shows that the value of total phenol of ground powder increases when moving from treatments involving no circulation to coolant circulation treatments. Values ranged from minimum of 3.78% for control treatment (L_0T_0) to maximum of 7.71% in coolant circulation with low temperature feed (L_3T_1). Increase in total phenol of ground powder with moving from left to right in the graph might be due to the fall in the value of temperature inside the grinding chamber at the end of grinding operation. As higher temperature causes degradation of phenolic compounds, it decreases total phenol content in ground powder. Additionally, a sudden rise in the graph is observed when moving from ambient temperature water to chilled water circulation grinding method. This might be ascribed to the increase in temperature difference of grinding chamber between two treatments.

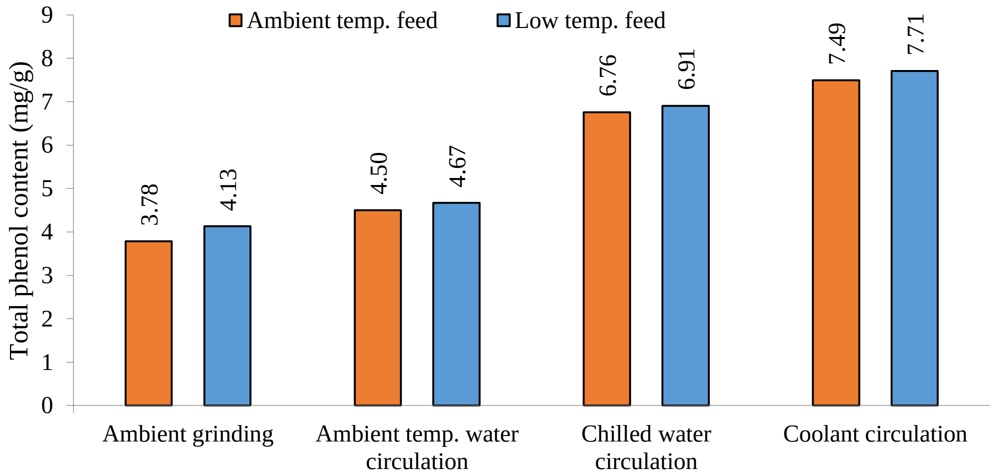


Fig. 2.14 Effect of various treatments on total phenol content of fenugreek seed powder

Total flavonoid content

Table (10.5) shows that grinding method affects significantly on the value of total flavonoid content of ground product at 5% level of significance. The lowest value (6.48 mg QE/g extract) was found for the grinding method without liquid circulation (L_0) while the highest (11.91 mg QE/g extract) for the method involving coolant circulation around the grinding chamber (L_3). Additionally, the value obtained in ambient temperature water circulation was above par with the method L_0 and value in the case of chilled water circulation was below par with the method L_3. The effect of feed temperature on the value of total flavonoid was also found statistically significant (at 5% level). The values found in case of ambient and low temperature feed were 8.95 and 9.30 mg QE/g extract, respectively. Besides that, the interaction effect of grinding method and feed temperature (L*T) on total flavonoid content of ground powder was found non-significant at the same level of significance.

The mean values of total flavonoid of ground powder for all the treatments are graphically shown in the following figure (Fig. 2.15). Figure indicates that the value of total flavonoid of ground powder increases when moving from treatments involving no circulation to ambient, chilled water and coolant circulation treatments. Values ranged from minimum of 6.22 mg QE/g extract for control treatment (L_0T_0) to maximum of 12.08 mg QE/g extract in coolant circulation with low temperature feed (L_3T_1). Increase in total flavonoid of ground powder with moving from left to right in the graph might be due to the decrease in the elevation of temperature inside the grinding chamber at the end of grinding operation. As flavonoids are the largest group of phenolic compounds (naturally occurring) (Sulaiman and Balachandran, 2012), higher temperature engenders degradation of flavonoids and it decreases total flavonoid content in ground powder. Further, a sudden rise in the graph occurs when moving from ambient temperature water to chilled water circulation grinding method. This might be attributed to the rise in temperature difference of grinding chamber.

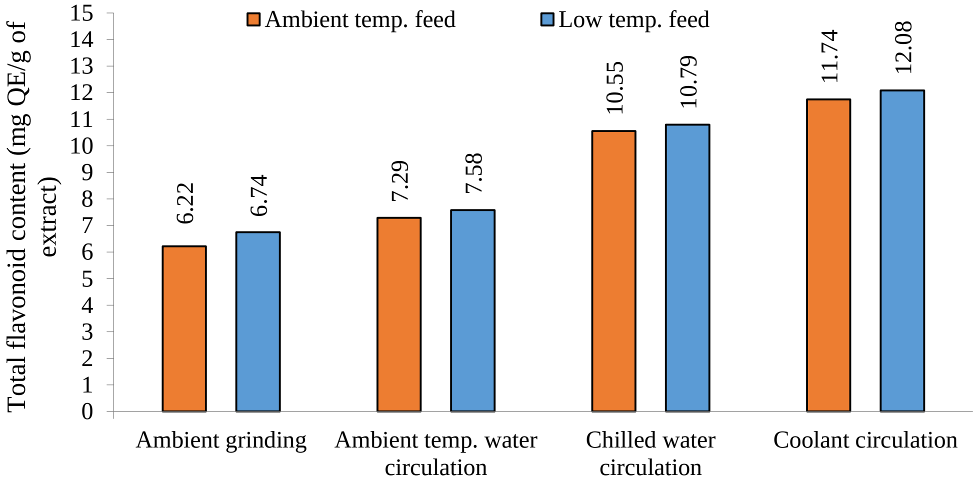


Fig. 2.15 Effect of various treatments on total flavonoid content of fenugreek seed powder

Antioxidant activity

From the Table (10.5), it is clear that grinding method affects significantly on the value of antioxidant activity of ground product at 5% level of significance. The lowest value (8.28 %) was found for the grinding method without liquid circulation (L_0) while the highest (20.88 %) for the method involving coolant circulation around the grinding chamber (L_3). Additionally, the value obtained in ambient temperature water circulation was above par with that of method L_0 and value in the case of chilled water circulation was below par with that of method L_3. The effect of feed temperature on the value of same parameter was also found statistically significant at 5% level of significance. The value found in case of low temperature feed (14.79%) was above par with that of ambient temperature feed (14.02%). Besides that, the interaction effect of grinding method and feed temperature (L*T) on the value of antioxidant activity was found non-significant at the same level of significance.

The mean values of antioxidant activity of ground powder for all the treatments are graphically demonstrated in the following figure (Fig. 2.16). Figure shows that the value of antioxidant activity of ground powder increases when moving from treatments involving no circulation to ambient, chilled water and coolant circulation treatments. Values ranged from minimum of 7.72 % DPPH scavenging for control treatment (L_0T_0) to maximum of 21.29 % DPPH scavenging in coolant circulation with low temperature feed (L_3T_1). The same reason of increase in grinding chamber temperature can be concluded for decrease in DPPH scavenging per cent when moving from right to left in the graph. As phenolics are the largest group of phytochemicals which account for most of the antioxidant activity in plants (Sulaiman and Balachandran, 2012), degradation of phenolic compounds at higher temperature also caused decrease in antioxidant activity percentages in ground fenugreek seed powder. Besides that, Dixit et al. (2005) and Bukhari et al. (2008) also reported antioxidant activity to be correlated with polyphenols present in fenugreek seed extract. In addition to that, a sudden rise in the graph occurs when moving from ambient temperature water to chilled water circulation grinding method. This might also be due to the increase in temperature difference of grinding chamber which caused trigger rise in antioxidant activity percentages.

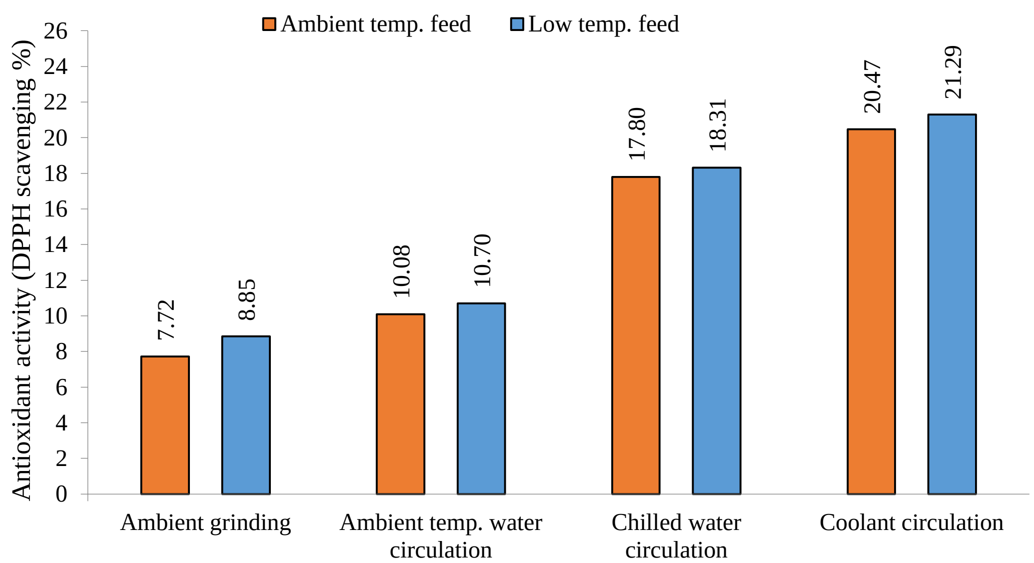


Fig. 2.16 Effect of various treatments on antioxidant activity of fenugreek seed powder

Volatile oil content

From the Table (2.5), it can be concluded that grinding method affects significantly on the value of volatile oil content of ground product at 5% level of significance. The lowest value (0.32%) was found for the grinding method without liquid circulation (L_0) while the highest (0.42%) for the method involving coolant circulation around the grinding chamber (L_3). Additionally, the value obtained in the case of chilled water circulation was competitive with the value of L_3. The effect of feed temperature on the value of volatile oil per cent was also found statistically significant at 5% level of significance. The value found was 0.37% for both, ambient and low temperature feed. Besides that, the interaction effect of grinding method and feed temperature (L*T) on the same parameter was found non-significant at the same level of significance.

The mean values of volatile oil content of ground powder for all the treatments are graphically displayed in the following figure (Fig. 2.17). Figure shows that the value of volatile oil in ground powder increases when moving from treatments involving no circulation to ambient, chilled water and coolant circulation treatments. Values ranged from minimum of 0.313 % for control treatment (L_0T_0) to maximum of 0.429 % in coolant circulation with low temperature feed (L_3T_1). Increase in volatile oil yield of ground powder with moving from left to right in the graph may be credited to the fall of temperature inside the grinding chamber. As higher temperature developed during ambient grinding process causes loss of volatile oil (Singh and Goswami, 1997), powder obtained through control treatment showed the lowest percentages of volatile oil. The trend of reduction in volatile oil percentages with increase in grinding chamber temperature has also been reported by many researchers previously.

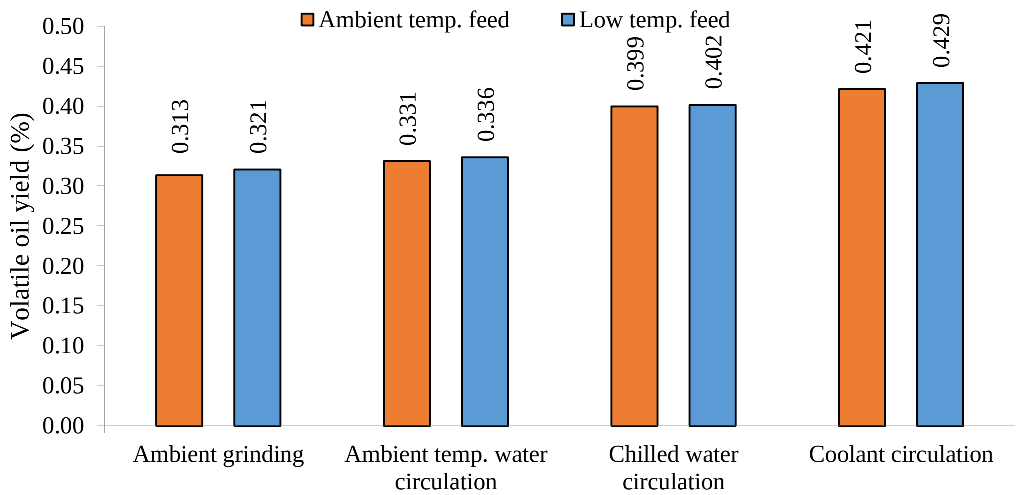


Fig. 2.17 Effect of various treatments on volatile oil content of fenugreek seed powder

Volatile metabolites

Volatile components present in ground powder of fenugreek seeds were identified using GC-MS QTOF. The chromatograms obtained in the analysis of extract of ground powder, obtained through ambient grinding with ambient temperature feed (L_0T_0) and coolant circulation with low temperature feed (L_3T_1) are shown in following figures (Fig. 2.18 and Fig. 2.19).

There were 30 compounds present in the extract of treatment L_0T_0 while in case of treatment L_3T_1, total 48 compounds were identified. The compounds found from the extract L_0T_0 and L_3T_1 are given in Table 2.6 and Table 2.7 respectively. Out of all the compounds, 13 compounds were common in extracts of both the treatments. There were 35 compounds which were identified in the extract of treatment L_3T_1 but were not detected in case of control treatment.

In addition to that, a compound named 3-Amino-4, 5-dimethyl-2(5H)-furanone was identified in the extract of treatment L_3T_1, which is the precursor of sotolone (characteristic and dominant impact flavour compound of fenugreek seeds). This compound was absent in case of extract of control treatment.

Table 2.6: Compounds found in extract of seed powder of treatment L_0T_0 (Ambient grinding + Ambient temperature feed)

Sr. No.	Name of compound	Mass	RT (Min)	Relative amount (% Area)
1.	Vitamin E	430.4	75.051	0.68
2.	Hexadecanoic acid, methyl ester	270.3	55.159	0.76
3.	2,6-Difluorobenzoic acid, 4-nitrophenyl ester	279.0	43.851	0.70
4.	9,12-Octadecadienoic acid, methyl ester	294.3	58.566	1.09
5.	1,8,11-Heptadecatriene, (Z,Z)-	234.2	59.362	3.45

6.	Pentanoic acid, 5-hydroxy-, 2,4-di-t-butylphenyl esters	306.2	44.349	0.69
7.	7,9-Di-tert-butyl-1-oxaspiro(4,5)deca-6,9-diene-2,8-dione	276.2	54.999	1.06
8.	n-Hexadecanoic acid	256.2	55.945	2.77
9.	Epicubenol	222.2	47.405	1.35
10.	2-n-Propylaziridine	85.1	21.11	30.89
11.	Hexadecanoic acid, 2-hydroxy-1-(hydroxymethyl)ethyl ester	330.3	65.862	1.43
12.	2-n-Propylaziridine	85.1	18.88	14.13
13.	Dodecane, 5-methyl-	184.2	50.204	1.08
14.	(S)-(-)-1-Amino-2-(methoxymethyl)-pyrrolidine	130.1	18.885	4.56
15.	5-Nonadecen-1-ol	282.3	59.47	2.82
16.	9,12,15-Octadecatrienoic acid, methyl ester, (Z,Z,Z)-	292.2	58.689	0.72
17.	2,5-Pyrrolidinedione, 1-ethyl-	127.1	27.366	0.46
18.	7-Octylidenebicyclo[4.1.0]heptane	206.2	68.688	2.08
19.	9-Octadecenoic acid	282.3	68.737	1.17
20.	Decanamide, N-(2-hydroxyethyl)-	215.2	62.687	0.68
21.	1-Methyl-2-methylene-trans-decalin	164.2	73.203	1.17
22.	3-Penten-2-one, 4-methoxy-	114.1	45.418	1.16
23.	Fumaric acid, 2-nitrophenyl cyclohexylmethyl ester	333.1	45.087	3.88
24.	Decanamide, N-(2-hydroxyethyl)-	215.2	62.579	0.90
25.	Hexazinone	252.2	70.656	0.54
26.	Ethanone, 1-(4-amino-2-methylaminothiazol-5-yl)-	171	70.742	0.37
27.	4-Pentenoic acid, 2-(formylamino)-, ethyl ester	171.1	73.22	1.08
28.	.beta.-d-Glucopyranoside, methyl 2,3,4-tris-O-(phenylmethyl)-	464.2	75.826	11.62
29.	Pyridine, 2-tridecyl-	261.2	73.342	1.41
30.	Fumaric acid, monoamide, N-(2,5-dimethoxyphenyl)-, undecyl ester	405.3	75.3	1.68
31.	Glycine, 2-cyclohexyl-N-(but-3-yn-1-yl)oxycarbonyl-, dodecyl ester	421.3	75.667	3.28
32.	phenol, 4-[[4-[[4-(phenylamino)phenyl]amino]phenyl]amino]-	367.2	75.659	0.34

Loss of compounds in case of control treatment might be attributed to the increase in the temperature of grinding chamber throughout the whole operation as compared to the treatment involving coolant circulation and low temperature feed.

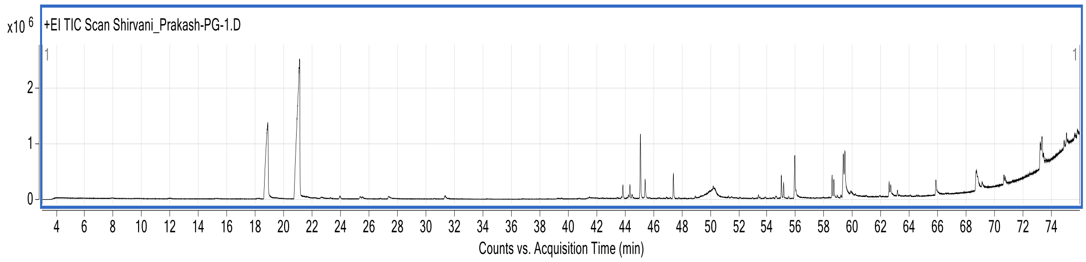


Fig. 2.18 GC-MS chromatogram of fenugreek seed powder extract of ambient grinding with ambient temperature feed treatment (L_0T_0)

Table 2.7 Compounds found in extract of seed powder of treatment L_3T_1 (Coolant circulation + Low temperature feed)

Sr. No.	Name of compound	Mass	RT (Min)	Relative amount (% Area)
1.	Tetradecanoic acid	228.2	51.549	2.19
2.	Vitamin E	430.4	75.048	0.42
3.	9,12-Octadecadienoic acid, methyl ester	294.3	58.562	2.99
4.	2,6-Difluorobenzoic acid, 4-nitrophenyl ester	279	43.849	0.59
5.	Phthalic acid, di(6-methylhept-2-yl) ester	390.3	66.526	0.17
6.	Undecane, 3,8-dimethyl-	184.2	50.201	0.39
7.	9,12-Octadecadienoyl chloride, (Z,Z)-	298.2	58.687	2.39
8.	n-Hexadecanoic acid	256.2	55.957	2.41
9.	7,9-Di-tert-butyl-1-oxaspiro(4,5)deca-6,9-diene-2,8-dione	276.2	55	0.83
10.	Phthalic acid, hept-4-yl isobutyl ester	320.2	53.872	0.14
11.	Hexadecanoic acid, 2-hydroxy-1-(hydroxymethyl)ethyl ester	330.3	65.866	3.06
12.	Hexadecanoic acid, methyl ester	270.3	55.148	1.14
13.	Pentanoic acid, 5-hydroxy-, 2,4-di-t-butylphenyl esters	306.2	44.351	0.41
14.	1,8,11,14-Heptadecatetraene, (Z,Z,Z)-	232.2	68.836	6.21
15.	3-Amino-4,5-dimethyl-2(5H)-furanone	127.1	27.336	0.44
16.	Methyl stearate	298.3	59.187	0.21
17.	2-Pentadecanone, 6,10,14-trimethyl-	268.3	53.382	0.17
18.	1,8,11,14-Heptadecatetraene, (Z,Z,Z)-	232.2	64.759	1.86
19.	Linoelaidic acid	280.2	59.417	6.52
20.	2-n-Propylaziridine	85.1	18.89	8.35
21.	9,12-Octadecadienoic acid, methyl ester	294.3	64.637	1.28
22.	Myo-Inositol, 4-C-methyl-	194.1	50.105	2.44
23.	Epicubenol	222.2	47.404	0.71
24.	2-n-Propylaziridine	85.1	21.03	11.25
25.	Hexadecanoic acid, 2-hydroxy-1-(hydroxymethyl)ethyl ester	330.3	61.648	0.83

26.	Carbonic acid, 2-dimethylaminoethyl ethyl ester	161.1	65.004	0.22
27.	Octadecanoic acid, 2,3-dihydroxypropyl ester	358.3	69.114	0.57
28.	cis-3-Methyl-endo-tricyclo[5.2.1.0(2.6)]decane	150.1	68.705	12.33
29.	3-Penten-2-one, 4-methoxy-	114.1	31.335	0.32
30.	(1S,4aS,4bS,7S,8aS,10aS)-7-Isopropyl-1,4a-dimethyltetradecahydrophenanthrene	262.3	73.199	2.02
31.	Cyclopropane, 1-ethenyl-2-hexenyl-, [1.alpha.,2.beta.(E)]-(.+/-.)-	150.1	64.876	0.21
32.	delta.-Nonalactone	156.1	25.502	0.21
33.	3,6-Heptanedione	128.1	49.995	0.13
34.	Bicyclo[5.2.0]nonane, 4-methylene-2,8,8-trimethyl-2-vinyl-	204.2	73.331	2.08
35.	Oxazolidine, 2,2-diethyl-3-methyl-	143.1	11.962	0.13
36.	3-Penten-2-one, 4-methoxy-	114.1	45.415	0.78
37.	Palmitic acid vinyl ester	282.3	61.761	0.28
38.	Propanoyl chloride, 3-chloro-	126.0	23.948	0.15
39.	Cholest-5-en-3-ol, (3.alpha.)-	386.4	74.882	0.17
40.	Oleic anhydride	546.5	68.758	6.81
41.	Phthalic acid, 2,2,2-trifluoroethyl propylester	290.1	54.657	0.13
42.	Decanamide, N-(2-hydroxyethyl)-	215.2	62.686	1.52
43.	Decanamide, N-(2-hydroxyethyl)-	215.2	62.578	1.59
44.	Thiophene-2-acetic acid, 2-dimethylaminoethyl ester	213.1	65.133	0.30
45.	Fumaric acid, 2-nitrophenyl cyclohexylmethyl ester	333.1	45.086	3.59
46.	Lupeol	426.4	70.596	1.75
47.	Nonanedioic acid, bis(2-ethylhexyl) ester	412.4	70.644	1.01
48.	Stigmasta-3,5-diene	396.4	72.774	0.20
49.	Acrylic acid, 4-cyclopropylidenebutyl ester	166.1	59.505	1.64
50.	Propanoic acid, anhydride	130.1	48.118	0.28
51.	Cyclohexyl methylphosphonofluoridate	180.1	44.24	0.20
52.	(7R)-cis-anti-cis-Tricyclo[7.3.0.0(2,6)]dodecan-7-ol	180.2	70.64	1.40
53.	Stigmast-8(14)-en-3.beta.-ol	414.4	67.443	2.39
54.	3H,6H-Thieno[3,4-c]isoxazole, 3a,4-dihydro-6-(1-methylethyl)-	171.1	73.587	0.19

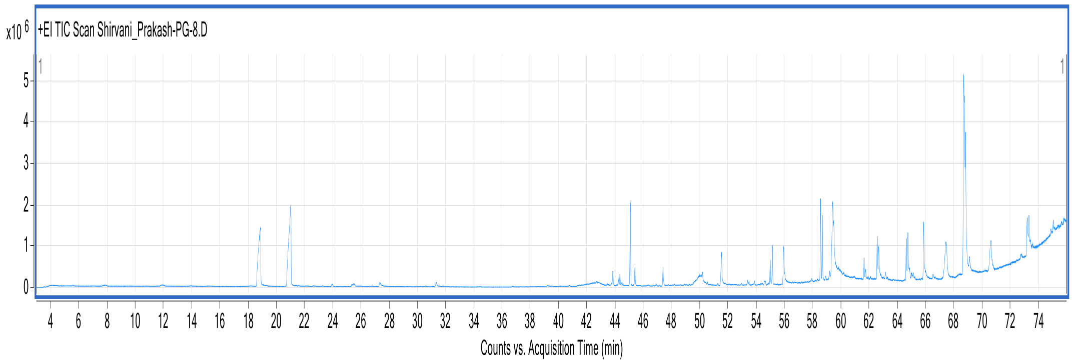


Fig. 2.19 GC-MS chromatogram of fenugreek seed powder extract of in coolant circulation with low temperature feed treatment L_3T_1

Particle size analysis

The values obtained for the effect of two factors, *viz*. grinding method and feed temperature on average particle size of ground powder of each treatment the same parameter is shown in the Table 2.8.

From the Table 2.8, it can be observed that grinding method affects significantly on the value of average particle size of ground product at 5% level of significance. Additionally, a significant difference was found among all the methods. The finest value (407.35 µ) was found for the grinding method involving coolant circulation around the grinding chamber (L_3) while the coarsest value (485.25 µ) for the method without liquid circulation (L_0). Further, the effect of feed temperature on the value of average particle size was also found statistically significant (at 5% level). The value found was 450.24 µ for ambient temperature feed. Comparing with that, the value (442.19) found in case of low temperature feed was significantly less. Besides that, the interaction effect of grinding method and feed temperature (L*T) on the same parameter was found non-significant at the same level of significance.

Table 2.8 Effect of grinding method and feed temperature on other particle size of fenugreek seed powder

Effect	Average particle size (µ)
Grinding method (L)	
Without liquid circulation (L_0)	485.25
Ambient temperature water circulation (L_1)	467.87
Chilled water circulation (L_2)	424.41
Coolant circulation (L_3)	407.35
S. Em±	0.5846
CD at 5%	1.7527
Feed temperature (T)	
Ambient temperature feed (T_0)	450.24
Low temp. feed (T_1)	442.19
S. Em±	0.4134

CD at 5%	1.2393
Interaction (L*T)	
S. Em±	0.8267
CD at 5%	NS
CV%	0.3209

The mean values of particle size of ground powder for all the treatments are graphically demonstrated in the following figure (Fig. 2.20). Figure shows that the value of average particle size in ground powder decreases when moving from treatments involving ambient grinding to ambient, chilled water and coolant circulation treatments. Values ranged from maximum of 489.04 µ for control treatment (L_0T_0) to minimum of 402.97 µ in coolant circulation with low temperature feed (L_3T_1). Reduction in average particle size of ground powder with moving from left to right in the graph might be attributed to the fall of temperature inside the grinding chamber. Additionally, lowering the feed temperature made fenugreek seeds more brittle which in turn made them ground to finer particles comparatively.

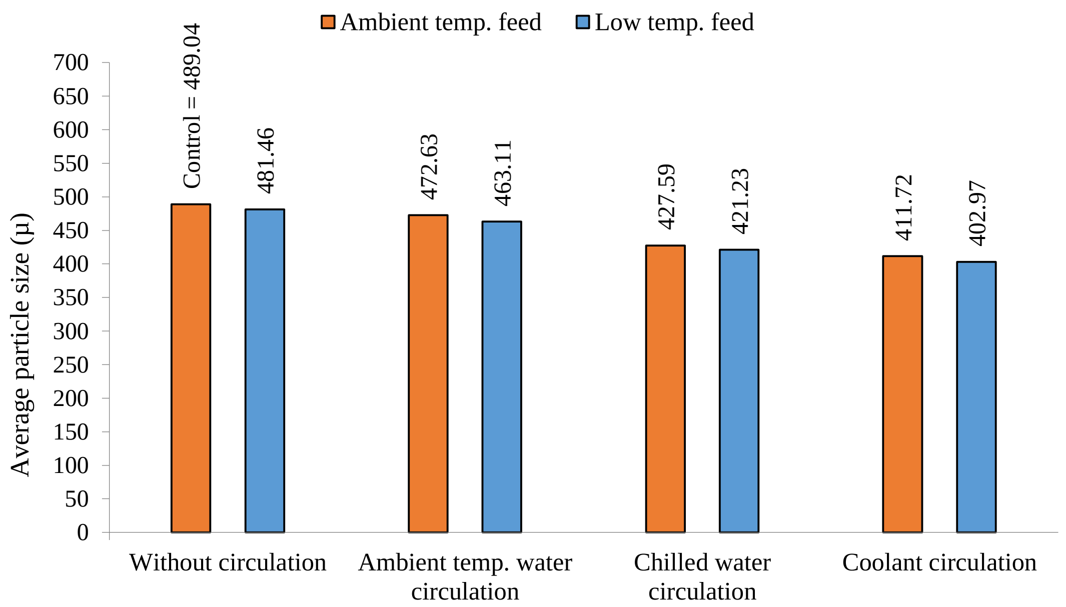


Fig. 2.20 Effect of various treatments on particle size of fenugreek seed powder

10.2.2 Turmeric:

10.2.2.1 Moisture content of turmeric rhizomes

The values of moisture content of rhizomes, estimated with the help of Dean and Stark apparatus are shown in the following table (Table 2.9).

Table 2.9 Moisture content of cleaned turmeric rhizomes

Moisture content % (w.b.)					Mean % (w.b.)	S. D. % (w.b.)
R-1	R-2	R-3	R-4	R-5		
7.924	7.799	7.93	8.024	8.323	8.000	0.176

The mean moisture content of seeds was found to be 8.000 ± 0.176% (w.b.).

10.2.2.2 Physical properties of turmeric

The mean values obtained for various physical properties of raw turmeric at moisture content of 8.00 % (w.b.) are given in following table (Table 2.10) and are discussed separately below.

Table 2.10 Physical properties of turmeric

Sr. No.	Physical property	Mean ± S. D.
1	Size (Geometric mean diameter) (mm)	20.099 ± 0.169
2	Sphericity	0.365 ± 0.079
3	Bulk density (g/cm^3)	0.558 ± 0.820
4	True density (g/cm^3)	1.345 ± 1.820
5	Porosity (%)	58.51
6	Static angle of repose (°)	36.55 ± 0.13
7	Coefficient of external friction (static) Metal (Galvanized iron) surface	0.252 ± 0.001

Size (Geometric mean diameter)

The mean value for size of turmeric was determined based on values of length, breadth and thickness of 50 randomly selected seeds. The mean value of size in terms of geometric mean diameter was found to be 20.099 ± 0.169 mm.

Sphericity

The mean value of sphericity of 50 randomly selected seeds was found to be 0.365 ± 0.079.

Bulk density

The mean value of four replication of bulk density of selected turmeric rhizomes was found to be 0.558 ± 0.820 g/cm^3.

True density

The mean value of four replication of true density of randomly selected turmeric rhizomes was found to be 1.345 ± 1.820 g/cm^3.

Porosity

The mean value of four replications of porosity for turmeric was calculated based on mean values of bulk and true density. It was found to be 58.51.

Static angle of repose

The mean value of four replications of angle of repose was found to be 36.55 ± 0.13°.

Coefficient of external friction (static)

The mean values four replications was found to be 0.252 ± 0.001for metal (galvanized iron) surface.

Rupture force of turmeric rhizomes

Compressive force or rupture force of turmeric rhizomes was observed 116.68±8.58 kg.

10.2.2.3 Performance evaluation of low temperature grinding mill

Performance evaluation of low temperature grinding mill was carried out by observing time to grind the material, temperature profile of liquid entering and leaving the grinding chamber along with temperature profile inside the grinding chamber, temperature inside the grinding chamber at the end of grinding operation, temperature of ground product, sieve clogging, milling and machine loss for each treatment combination. In addition to that, temperature of surrounding was noted every time before starting off grinding operation. The mean values of each parameter for all the treatments and the effect of two factors, *viz*. grinding method and feed temperature on all the dependent parameters are shown in following tables (Table 2.11 and 4.4 respectively). Results of this section are discussed separately for each parameter in detail below.

Table 2.11 Mean values of parameters evaluating performance of low temperature grinding mill

Treatment	Ambient temperature (°C)	Temp. inside grinding chamber at end (°C)	Time to grind the material (min)	Temp. of ground product (°C)	Milling loss (%)	Machine loss (%)
L_0T_0	31.67	33.67	8.08	38.67	11.64	6.92
L_0T_1	32.67	34.33	8.72	37.67	14.44	8.65
L_1T_0	32.33	35.67	8.25	37.50	13.82	9.36
L_1T_1	28.67	34.33	7.48	35.83	14.44	9.28
L_2T_0	28.33	30.67	7.41	34.33	13.67	8.47
L_2T_1	28.67	29.67	7.37	35.00	13.16	6.51
L_3T_0	34.33	17.67	9.23	33.33	11.09	7.34
L_3T_1	33.33	19.00	8.67	32.33	13.36	9.28

Ambient temperature before grinding

Ambient temperature is an important independent parameter which can affect the conditions and results of grinding operation. Ambient temperature, observed with the help of a glass thermometer before each treatment including three. Results showed that the mean value among all the treatments varied from minimum of 28.33℃ to maximum of 34.33 ℃. For all the treatments which include ambient temperature as feed temperature, the values of feed temperature can be found from these ambient temperature itself for the respective treatments.

Table 2.12 Effect of grinding method and feed temperature on parameters evaluating performance of low temperature grinding mill

Effect	Temperature inside grinding chamber at the end (°C)	Time to grind the material (min)	Temperature of ground product (°C)	Milling loss (%)	Machine loss (%)
Grinding method (L)					
Ambient temperature grinding(L_0)	34.00[a]	8.40	38.17[a]	13.04	7.78
Ambient temperature water circulation (L_1)	35.00[a]	7.86	36.67[b]	14.07	9.32
Chilled water circulation (L_2)	30.17[b]	7.39	34.67[c]	13.42	7.49
Coolant circulation (L_3)	18.33[c]	8.78	32.83[d]	12.25	8.31
S. Em±	0.3632	0.3544	0.25	0.4346	0.458
C. D. at 5%	1.089	NS	0.7495	NS	NS
Feed temperature (T)					
Ambient temperature feed (T_0)	29.42	8.24	35.96	12.54	8.02
Low temp. feed (T_1)	29.33	7.97	35.21	13.85	8.43
S. Em±	0.2569	0.2506	0.1967	0.3073	0.3239
C. D. at 5%	NS	NS	0.5897	0.9214	NS
Interaction (L*T)					
S. Em±	0.5137	0.5012	0.3536	0.6146	0.6477
C. D. at 5%	NS	NS	1.06	NS	1.9419
C. V%	**3.029**	**10.7067**	**1.721**	**8.0673**	**13.6369**

Temperature profile inside the grinding chamber

The values of temperature of liquid entering and leaving the grinding chamber, temperature of liquid inside the refrigeration tank and temperature inside the grinding chamber at every minute during the whole grinding operation for all the treatments are recorded. The values were observed once the temperature of grinding chamber lowered as possible as and became constant for nearly 15 minutes by circulation of liquid without load (without feed) condition.

Temperature profile inside the grinding chamber for all the treatments are shown graphically below (Fig. 2.21). Fig. 2.21(a) shows the trend of change in temperature for the treatments involving ambient temperature feed while 10.21(b) shows trend for treatments involving low temperature feed.

From fig. 2.21(a), it can be said that the value of temperature inside the grinding chamber stayed all-time high for ambient temperature water circulation grinding treatment whereas all-time low for coolant circulation treatment compared to all other treatments. In case of rise in temperature, treatment involving ambient grinding treatment has lesser rise of temperature (7.34 ^{o}C) as there is already initial temperature is high. Even it was reported that continuous circulation of ambient water increases the temperature inside the grinding chamber and hence there was more rise of temperature (9.00 ^{o}C) compared to ambient grinding treatment. While treatment involving chilled water circulation, have high rise of temperature (25.67 ^{o}C) compared to coolant circulation treatment (18.67 ^{o}C). There was considerable gap in the graph between the treatments for which refrigerator remained OFF (ambient grinding and ambient temperature water circulation) and refrigerator remained ON (chilled water and coolant circulation) during the whole grinding operation. For all the treatments, temperature inside the grinding chamber increased rapidly at initiation of grinding, increased moderately in middle and rose even swiftly at the end. Fig. 2.21(b) shows the same trend for treatment involving low temperature feed. The only difference of changing the feed temperature was slight decrease in temperature inside the grinding chamber on the very next minute of feeding in case of low temperature feed. Overall, the initial and final value of temperature inside the grinding chamber for all the treatments are given in following table (Table 2.13).

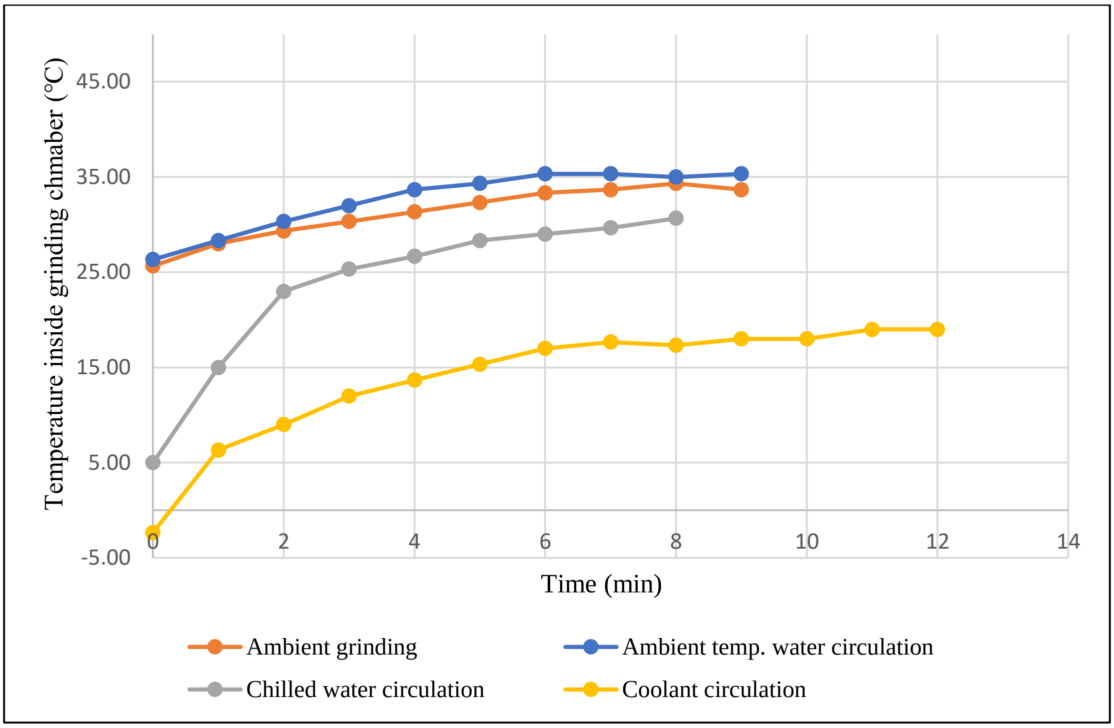


Fig. 2.21(a) Temperature profile of grinding chamber for ambient temperature feed

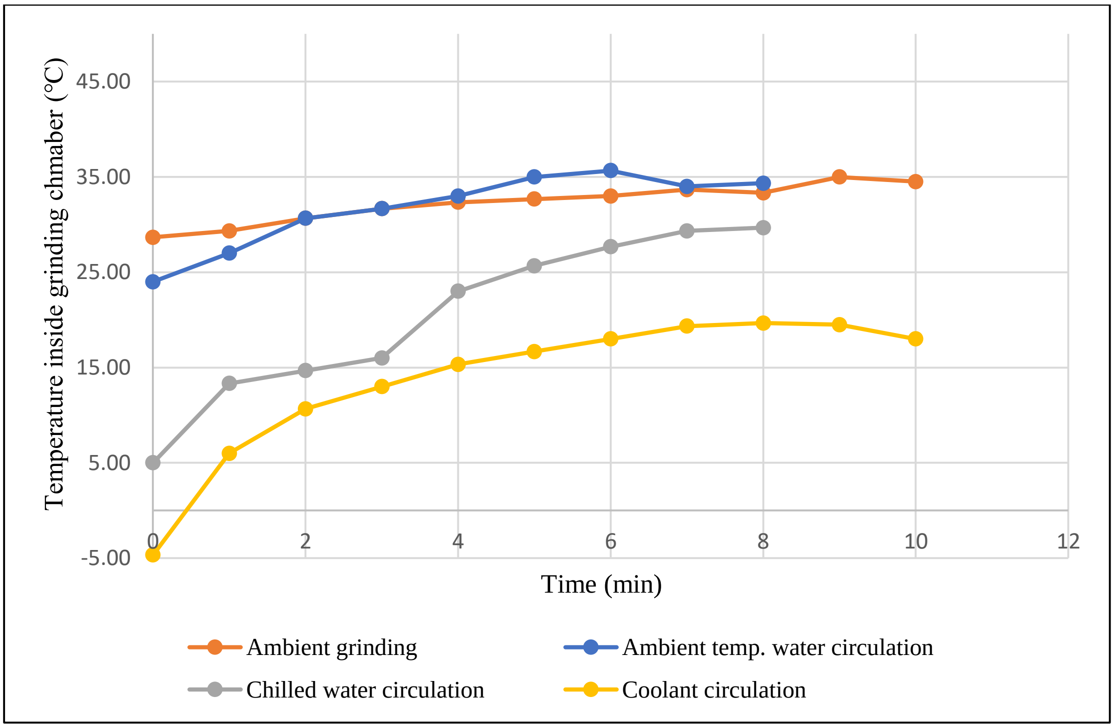


Fig. 2.21(b) Temperature profile of grinding chamber for low temperature feed

Fig. 2.21 Temperature profile of grinding chamber for all the treatments

Table 2.13 Initial and final value of temperature inside the grinding chamber for all the treatments

Treatment	Temperature inside grinding chamber (℃)	
	At beginning of grinding	At the end of grinding
L_0T_0	25.67	33.67
L_0T_1	28.67	34.50
L_1T_0	26.33	35.33
L_1T_1	24	34.33
L_2T_0	5	30.67
L_2T_1	5	29.67
L_3T_0	-2.33	18.33
L_3T_1	-4.67	19.67

Temperature inside the grinding chamber at the end of grinding

From table 2.12, it is clear that grinding method affects significantly on the value of temperature inside the grinding chamber at the end of grinding. The highest temperature (34.50 ℃) was found for the grinding method ambient temperature water circulation (L_1). While method L_0, involving ambient grinding was at par with the method L_1. The significantly lowest temperature (18.33 ℃) was found for the method having coolant circulation around the grinding chamber (L_3). The effect of feed temperature (at 5% level) on the same parameter was found non-significant (Table 2.12). The value found was 29.33 ℃ for ambient temperature feed (T_1). The value in case of low temperature feed (T_1) was just at par with that of T_0. In addition to that, the interaction effect of grinding method and feed temperature (L*T) on the value of temperature inside the grinding chamber at the end of grinding was found non-significant.

The mean values for this parameter for all the treatments are graphically presented in the following figure (Fig. 2.22). It varied from 35.33 ℃ for ambient water circulation grinding with ambient temperature feed to 18.33 ℃ in coolant circulation with ambient temperature feed (L_3T_0). But fall in temperature becomes substantial with the change in grinding method compared to the change in feed temperature keeping the grinding method same, especially when jumping to chilled water and coolant circulation methods from ambient temperature water circulation. Possibly, resting of considerable amount of time in feed hopper increased the temperature of low temperature feed which in turn diminished its effect to some extent.

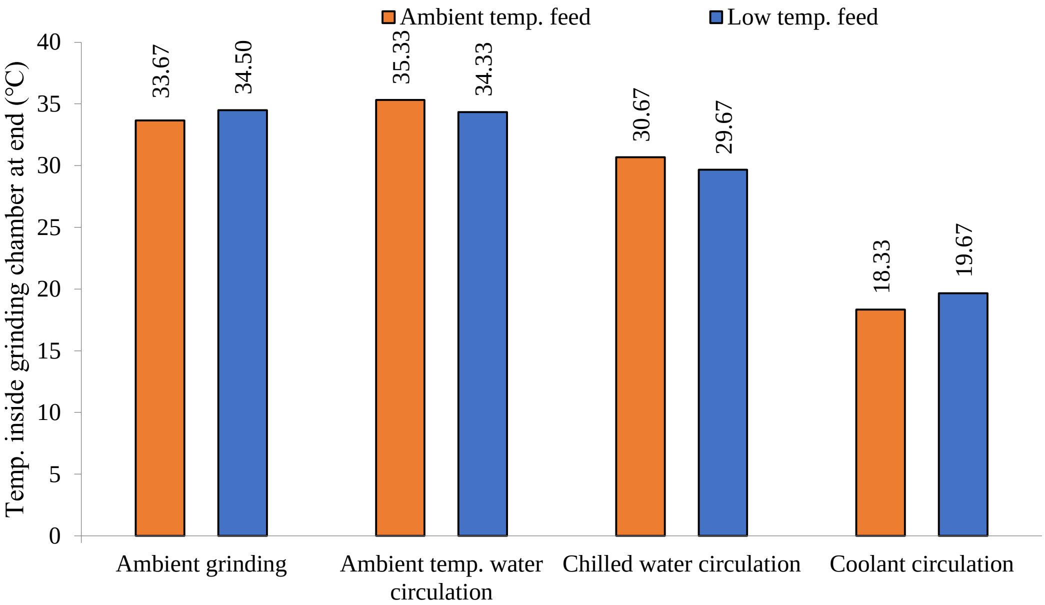


Fig. 2.22 Effect of various treatments on temperature inside the grinding chamber at the end of grinding

From fig. 2.22, it can be concluded that lowering feed temperature as well as circulation of coolant around the grinding chamber positively decreases the final value of temperature inside the grinding chamber. That was caused by continuous absorption of heat generated during grinding operation. Additionally, lowering the temperature of liquid, circulating around the grinding chamber results in appreciable falling of final temperature inside the grinding chamber. That was caused by absorption of more amount of heat generated during grinding operation due to increase in the value of difference in temperature between grinding chamber and circulating liquid around.

Time to grind the material (Grinding time)

From table 2.12, it is clear that effect of grinding method on the value of grinding time was non-significant. The highest time (11.08 min) was found for the grinding method without liquid circulation (L_3). The lowest time (7.39 min) was found for the method having coolant circulation around the grinding chamber (L_2). The effect of feed temperature on the same parameter was also found non-significant (Table 2.12). The value found was 8.24 min for ambient temperature feed (T_0). While value in case of low temperature feed (T_1) was above par with that of T_1. Additionally, the interaction effect of grinding method and feed temperature (L*T) on the value of time to grind the material was found non-significant.

The mean values for this parameter for all the treatments are graphically displayed in the following figure (Fig. 2.23). The values varied from 9.23 min for coolant circulation with ambient temperature feed (L_3T_0) to 7.37 min for chilled water circulation with low temperature feed (L_2T_1). From the figure, lowering the feed temperature conclusively lowers the time required for grinding the material except for ambient grinding case. That was possibly due to the fact that lowering feed temperature made turmeric rhizome much brittle which in turn made them easy to be ground.

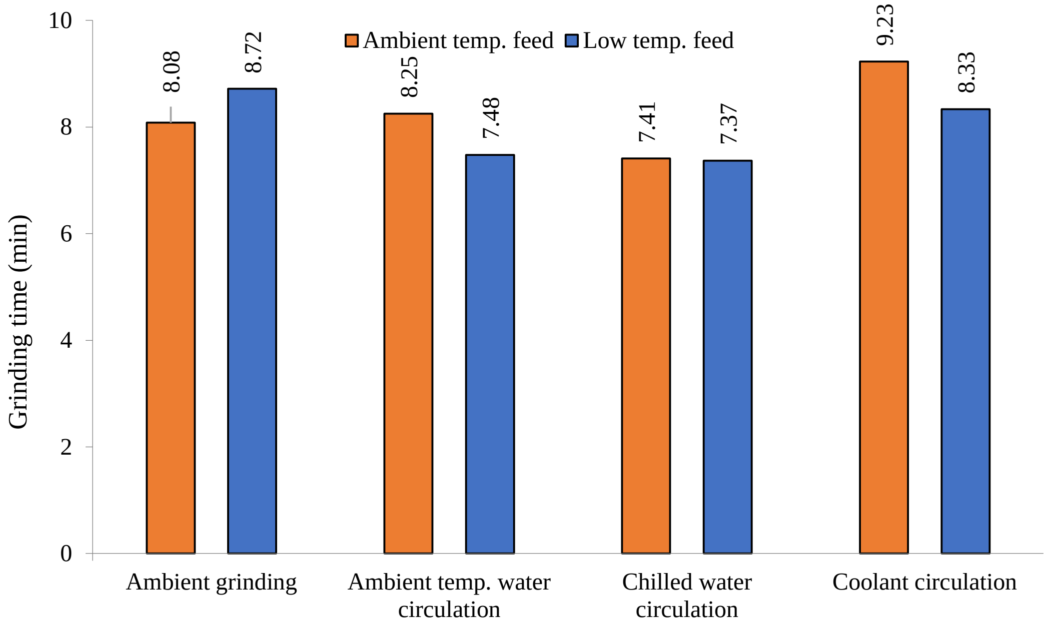


Fig. 2.23 Effect of various treatments on time to grind the material

Fig. 2.23 clears that circulation of chilled water decreases the value of grinding time for an ambient temperature feed. There was very less difference in grinding time for chilled water circulation with ambient feed and low temperature feed. The higher difference was found for the coolant circulation with ambient feed and low temperature feed. At very low temperature of grinding may increase the hardness of turmeric rhizome which increase the time for grinding.

Temperature of ground product

From table, it is clear that grinding method affects significantly on the value of temperature of ground powder at the end of grinding. The significantly highest temperature (38.17 °C) was found for the ambient grinding method (L_0). The significantly lowest temperature (32.83 °C) was found for the method involving coolant circulation around the grinding chamber (L_3). The effect of feed temperature (at 5% level) on the same parameter was also found significant (Table 2.12). The significantly highest value 35.96 °C was found for ambient temperature feed (T_0). Besides that, the interaction effect of grinding method and feed temperature (L*T) on the value of temperature of ground product was also found significant.

The mean values for the same parameter for all the treatments are graphically presented in the following figure (Fig. 2.24). Figure shows that temperature of ground product decreases when moving from left to right *i.e.* treatments involving ambient grinding to ambient water, chilled water and coolant circulation treatments. The value varied from 38.67 °C for ambient grinding treatment (L_0T_0) to 32.33 °C in coolant circulation with low temperature feed (L_3T_1). But fall in temperature becomes pronounced with the change in grinding method compared to the change in feed temperature keeping the grinding method same.

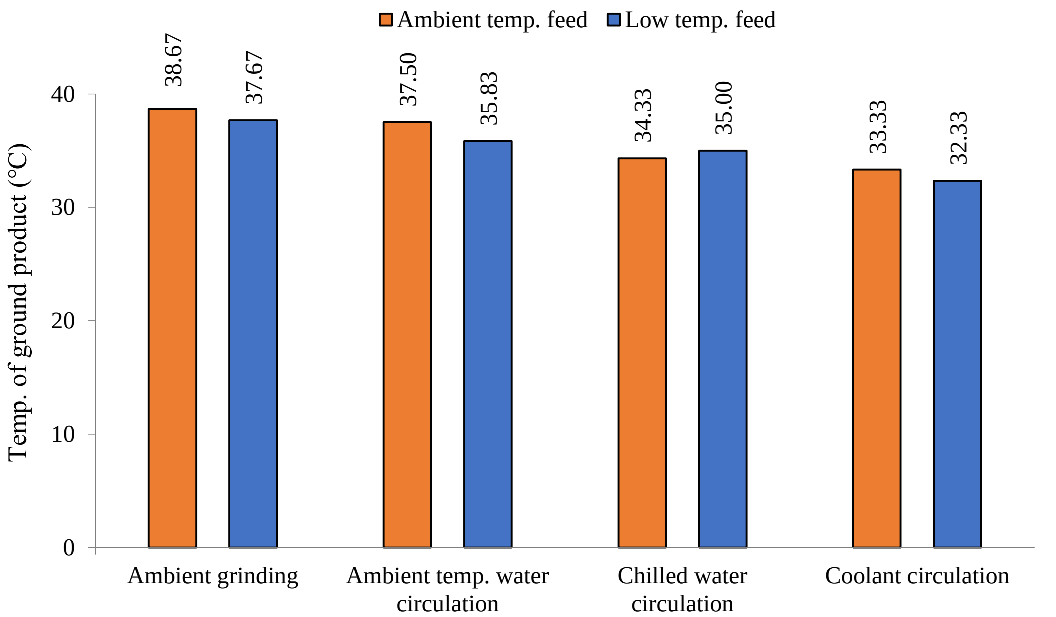


Fig. 2.24 Effect of various treatments on temperature of turmeric powder

From fig. 2.24, it can be concluded that lowering feed temperature as well as circulating liquid (and lowering the temperature of circulating liquid) around the grinding chamber positively decreases the value of temperature of ground product. That was caused by reduction in the value of temperature inside the grinding chamber at the end of grinding due to the continuous absorption of heat generated during grinding operation.

Milling loss

From table, it is clear that effect of grinding method on the value of milling loss at 5% level is non-significant. While the effect of feed temperature on the same parameter was found significant. The significantly high value (13.85%) was found for low temperature feed (T_1). While significantly lowest value in case of ambient temperature feed (T_0) was 13.85%. Additionally, the interaction effect of grinding method and feed temperature (L*T) on the value of per cent milling loss was found non-significant.

The mean values for this parameter for all the treatments are graphically shown in the following figure (Fig. 2.25). The values did not vary to a considerable extent while changing grinding method, keeping feed temperature same. It varied from 11.15% to 13.71% for ambient temperature feed and 13.17 to 14.44% for low temperature feed among all grinding methods. While from the figure, lowering the feed temperature conclusively increases the value of per cent milling loss. That was attributed to the fact that lowering feed temperature made turmeric rhizomes more brittle which in turn made them ground to finer particles comparatively. The formation of finer particles could easily be lost in the form of dust particles. That ultimately increased the value of per cent milling loss in case of low temperature feed.

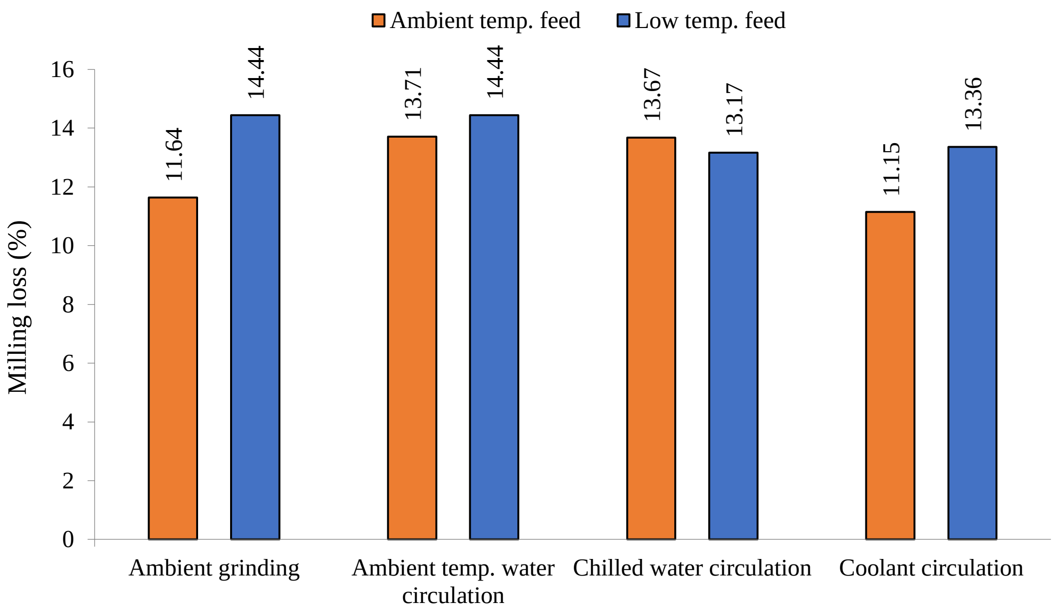


Fig. 2.25 Effect of various treatments on milling loss of turmeric powder

Machine loss

Table shows that effect of grinding method as well as effect of feed temperature on the value of machine loss at 5% level is non-significant. The value found was 8.43% for low temperature feed (T_1). While value in case of ambient temperature feed (T_0) was 8.02%. Additionally, the interaction effect of grinding method and feed temperature (L*T) on the value of per cent machine loss was found significant.

The mean values for this parameter for all the treatments are graphically shown in the following figure (Fig. 2.26). The values did not vary to a considerable extent while changing grinding method, keeping feed temperature same. It varied from 6.92 to 9.35% for ambient temperature feed and 6.51 to 9.28% for low temperature feed among all grinding methods. While from the figure, lowering the feed temperature conclusively increases the value of per cent machine loss. This is due to the increase in milling loss in the form of dust in case of low temperature feed. Particles lost in the form of dust stuck to the internal surfaces of product outlet area which in turn increased the value of per cent machine loss.

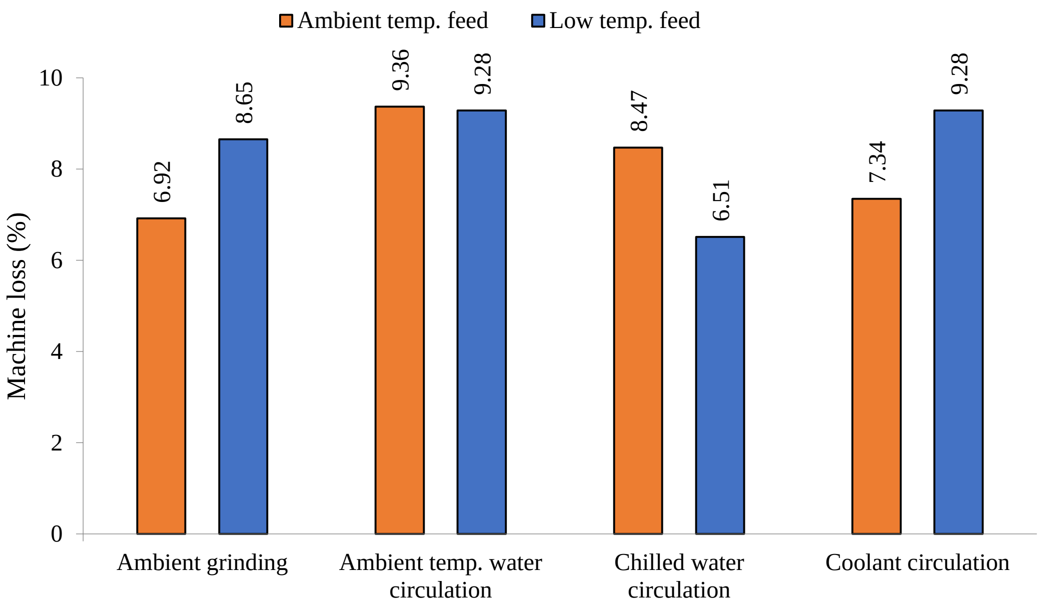


Fig. 2.26 Effect of various treatments on machine loss of turmeric powder

10.2.2.4 Biochemical parameters of turmeric powder

The values obtained for various biochemical parameters of ground turmeric powder obtained through different treatments are given in table 2.13 and are discussed separately below.

Table 2.14 Mean value of biochemical parameters of turmeric powder obtained through various treatments.

Treatment	Biochemical parameters						
	Moisture content (%w.b.)	Total carbo-hydrate (%)	Crude fibre (%)	True protein (%)	Total oil (%)	Total ash (%)	Volatile oil yield (%)
L_0T_0	6.49	60.90	5.91	6.01	6.31	5.54	2.87
L_0T_1	6.83	61.31	5.79	6.23	6.38	5.29	2.97
L_1T_0	6.33	60.33	5.97	6.36	6.33	5.47	3.20
L_1T_1	6.50	60.98	6.27	6.49	6.43	5.47	3.30
L_2T_0	6.08	61.34	6.11	6.55	7.03	5.70	3.53
L_2T_1	6.24	62.52	6.30	6.93	7.21	5.36	3.67
L_3T_0	5.99	61.95	5.93	6.89	7.09	5.39	3.83
L_3T_1	6.07	62.28	6.11	7.47	7.34	5.39	4.00

Table 2.15 Effect of grinding method and feed temperature on biochemical parameters of turmeric powder

Effect	Moisture content (%w.b.)	Total carbo-hydrate (%)	Crude fibre (%)	True protein (%)	Total oil (%)	Total ash (%)	Volatile oil yield (%)
Grinding method (L)							
Without liquid circulation (L_0)	6.66[b]	61.10	5.85	6.12[a]	6.35	5.41	2.92
Ambient temperature water circulation (L_1)	6.41[ab]	60.66	6.12	6.43[ab]	6.38	5.47	3.25
Chilled water circulation (L_2)	6.16[a]	61.93	6.20	6.74[bc]	7.12	5.53	3.60
Coolant circulation (L_3)	6.03[a]	62.11	6.02	7.18[c]	7.22	5.39	3.92
S. Em±	0.1456	0.81	0.2025	0.1853	0.1737	0.1225	0.0514
C. D. at 5%	0.4366	NS	NS	0.5556	0.5209	NS	0.1541
Feed temperature (T)							
Ambient temperature feed (T_0)	6.22	61.13	5.98	6.45	6.69	5.52	3.36
Low temp. feed (T_1)	6.41	61.77	6.12	6.78	6.84	5.38	3.48
S. Em±	0.1030	0.5727	0.1432	0.1310	0.1228	0.0866	0.0363
C. D. at 5%	NS	NS	NS	NS	NS	NS	0.109
Interaction (L*T)							
S. Em±	0.2059	1.1455	0.2863	0.2621	0.2457	0.1733	0.0727
C. D. at 5%	NS	NS	NS	NS	NS	NS	NS
C. V%	**5.6477**	**3.2287**	**8.2001**	**6.8597**	**6.2894**	**5.507**	**3.6808**

Moisture content

From the table 2.15, it can be observed that grinding method affects significantly on the value of moisture content of ground product at 5% level of significance. The highest value (6.66%) was found for the grinding method ambient grinding (L_0) while method involving coolant circulation around the grinding chamber (L_3) exhibited to retain lower percentages of moisture (6.03%). The effect of feed temperature on the value of moisture content was found non-significant (at 5% level). The values found were 6.22 and 6.41% for ambient temperature and low temperature feed, respectively. In addition to individual effects, the interaction effect of grinding method and feed temperature (L*T) on the same parameter was found non-significant.

The mean values of moisture content of ground powder for all the treatments are graphically presented in the following figure (Fig. 2.27). Figure reveals that the value of moisture content of ground powder decreases when moving from left to right *i.e.* treatments involving ambient grinding to ambient, chilled water and coolant circulation treatments. Values varied from maximum of 6.50% for ambient grinding with ambient water circulation and low temperature feed (L_1T_1) to minimum of 6.07% in coolant circulation with low temperature feed (L_3T_1). Increase in moisture content of ground powder for low temperature feed with moving from ambient grinding to coolant circulation might be attributed to the condensation of moisture at low temperature. Inversely, for ambient temperature feed moisture content decreases from ambient grinding to coolant circulation. Further, lower temperature of ground powder might decrease the loss of moisture in surrounding by evaporation. However, decrease in the value of moisture content in ground powder compared to moisture of turmeric rhizome (8.00%) for all the treatments was observed. That might be due to the loss of moisture at higher temperature generated during grinding operation.

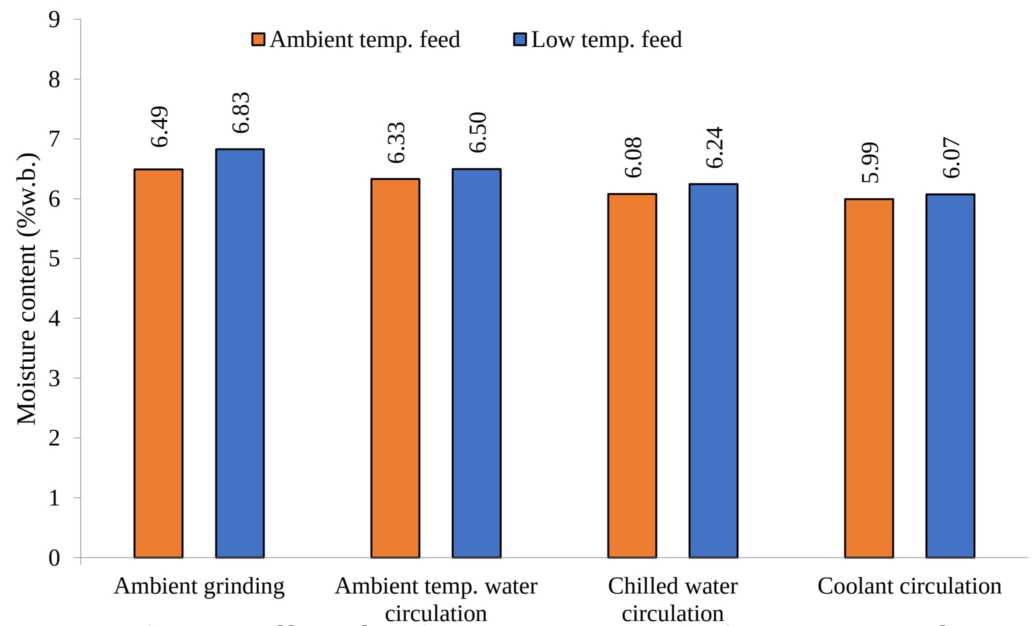


Fig. 2.27 Effect of various treatments on moisture content of turmeric powder

Total carbohydrate content

The table clears that grinding method affects non-significantly on the value of total carbohydrate of ground product at 5% level of significance. The lowest value (60.10%) was found for the grinding method with ambient water (L_0) while method involving coolant circulation around the grinding chamber (L_3) found to retain higher percentages of carbohydrate (62.11%). The effect of feed temperature on the value of total carbohydrate content was also found statistically non-significant at the same level of significance (Table 2.14). The values found were 61.13 and 61.77% for ambient temperature and low temperature feed, respectively. Further, the interaction effect of grinding method and feed temperature (L*T) on the value of total carbohydrate was found non-significant.

The mean values of total carbohydrate content of ground powder for all the treatments are graphically displayed in the following figure (Fig. 2.28). Figure reveals that the value of total carbohydrate in ground powder decreases from ambient grinding to ambient water circulation for ambient feed then continuously increases when moving from treatments involving ambient water to chilled water and coolant circulation treatments. Values varied from minimum of 60.33% for control treatment (L_1T_0) to maximum of 62.52% in chilled water with low temperature feed (L_3T_1).

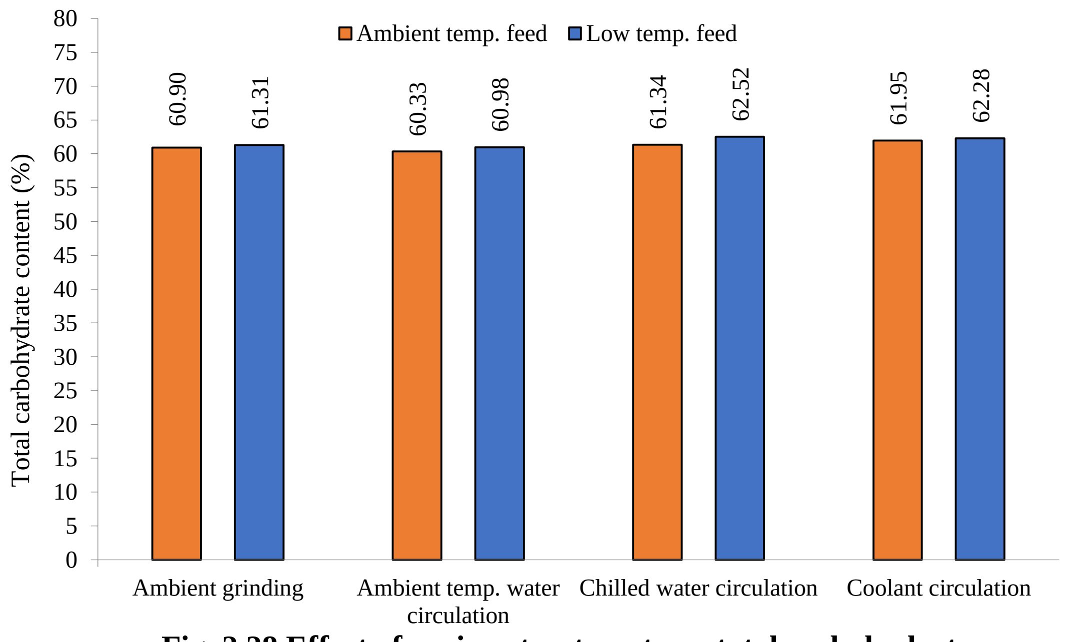


Fig. 2.28 Effect of various treatments on total carbohydrate content of turmeric powder

Crude fibre content

The table clears that grinding method affects non-significantly on the value of crude fibre in ground product at 5% level of significance. The lowest value (5.85%) was found for the grinding method ambient grinding (L_0). On the other hand, method involving chilled water circulation around the grinding chamber (L_2) found to have higher percentages of crude fibre (6.20%). Besides grinding method, the effect of feed temperature on the same parameter was also found statistically non-significant at the same level of significance. The values found were 5.98 and 6.12% for ambient temperature and low temperature feed, respectively. Further, the interaction effect of grinding method and feed temperature (L*T) on the value of crude fibre content was found non-significant.

The mean values of crude fibre of ground powder for all the treatments are graphically demonstrated in the following figure (Fig. 2.29). Figure indicates that the value of crude fibre in ground powder increases when moving from treatments involving ambient grinding to chilled water circulation treatments in the both the case ambient temperature feed and low temperature feed. The mean value for the treatment coolant circulation again the crude fibre content decreases but it is more than ambient grinding treatment. The mean values varied from minimum of 5.91% for ambient grinding treatment (L_0T_0) to maximum of 6.27% in chilled water circulation with ambient temperature feed (L_2T_1). Increase in crude fibre content in ground powder with moving from left to right in the graph might be attributed to decrease in elevation of temperature during grinding operation. But lowering the more temperature crude fibre decreases. Higher temperature developed during grinding operation might cause the conversion of insoluble dietary fibre to soluble dietary fibre which in turn perhaps decreased the percentages of crude fibre in ground powder, as crude fibre is composed of insoluble cellulose and lignin. Rise in temperature breaks the weak bonds between polysaccharide chains and split glycosidic linkages in the dietary fibre polysaccharides. So, the architecture of the fibre matrix may be modified and insoluble fibre changes to soluble dietary fibre. This may be the case for more lowering temperature.

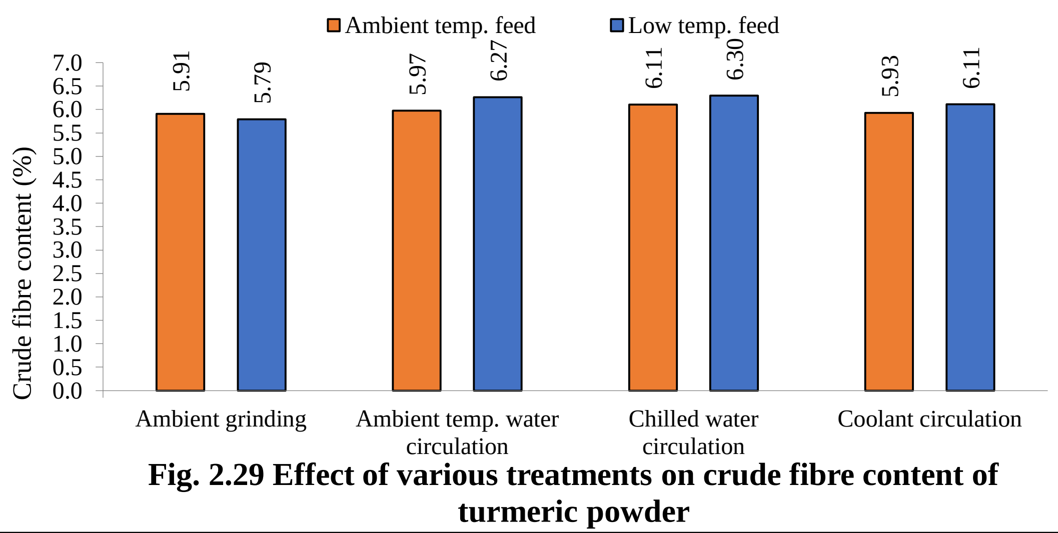


Fig. 2.29 Effect of various treatments on crude fibre content of turmeric powder

True protein content

Effect of grinding method on the value of true protein content of ground powder was found significant at 5% level of significance (Table 2.14). The lowest value (6.12%) was found for the grinding treatment ambient grinding (L_0) while method involving coolant circulation around the grinding chamber (L_3) found to produce powder having higher percentages of true protein (7.18%). The effect of feed temperature on the value of true protein was found statistically non-significant at 5% level of significance. The value found for low temperature feed (6.45%) and that of ambient temperature feed (6.78%). Additionally, the interaction effect of grinding method and feed temperature (L*T) on the value of true protein content was found non-significant at the same level of significance.

The mean values of true protein of ground powder for all the treatments are graphically displayed in the following figure (Fig. 2.30). Figure indicates that the value of true protein of ground powder increases when moving from treatments involving ambient grinding to ambient, chilled water and coolant circulation treatments. Values ranged from minimum of 6.01% for ambient grinding treatment (L_0T_0) to maximum of 7.47% in coolant circulation with low temperature feed (L_3T_1). Increase in true protein content of ground powder with moving from left to right in the graph might be attributed to the decrease in elevation of temperature during grinding operation. As higher temperature causes protein denaturation, it decreases the percentages of true protein.

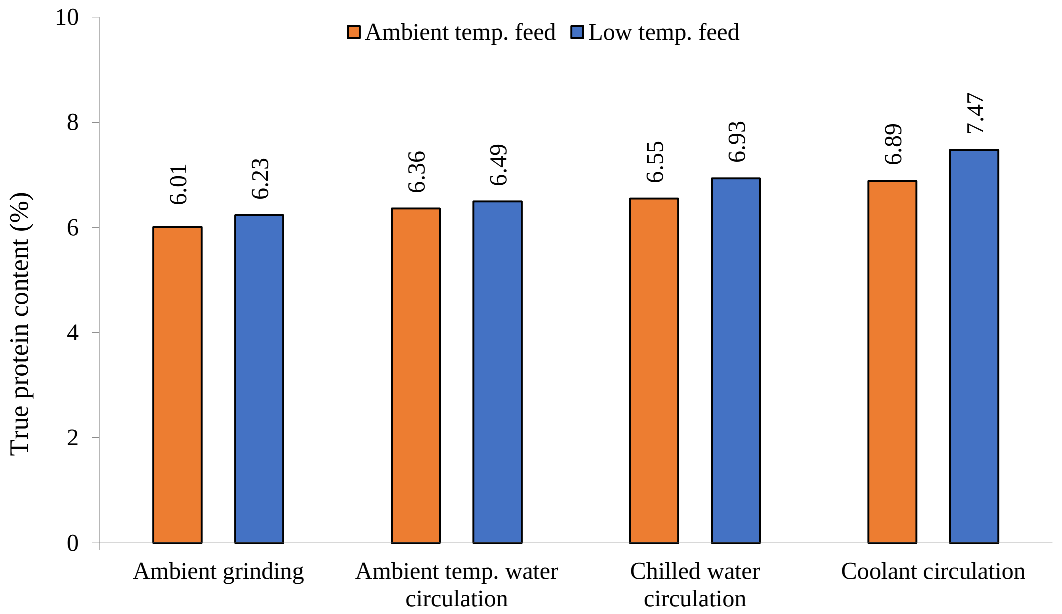


Fig. 2.30 Effect of various treatments on true protein content of turmeric powder

Total oil content

From the table, it can be seen that grinding method affects significantly on the value of total oil content of ground product at 5% level of significance. The lowest value (6.35%) was found for the grinding method without liquid circulation (L_0). While the method incorporating coolant circulation (L_3) exhibited to produce powder containing comparatively higher percentages of fixed oil (7.22%). Additionally, the value observed in case of chilled water circulation method (7.12%) was at par with L_3. Similarly, the ambient grinding treatment and ambient water circulation resulted at par for total oil content. The effect of feed temperature (at 5% level) on the same parameter was found non-significant. The values found were 6.69 and 6.84% for ambient temperature and low temperature feed, respectively. In addition to individual effects, the interaction effect of grinding method and feed temperature (L*T) on the value of total oil content in ground powder was found non-significant at the same level of significance.

The mean values of total oil of ground powder for all the treatments are graphically presented in the following figure (Fig. 2.31). Figure shows that the value of total oil in ground powder increases when moving from left to right *i.e.* treatments involving ambient grinding to ambient, chilled water and coolant circulation treatments. Values varied from minimum of 6.31% for ambient grinding treatment (L_0T_0) to maximum of 7.34% in coolant circulation with low temperature feed (L_3T_1). Increase in oil percentages in ground powder with moving from ambient grinding to coolant circulation might be attributed to the reduction in the degree of melting of fat present in the rhizomes. Moving from left to right in the graph decreased the value of temperature inside the chamber at the end of grinding operation which in turn decreased the extent of melting and sticking of fat on grinding surfaces and sieve. That caused increase in the oil percentages in ground powder. While higher temperature developed during grinding operation caused reduction in the value of total oil in ambient grinding treatment.

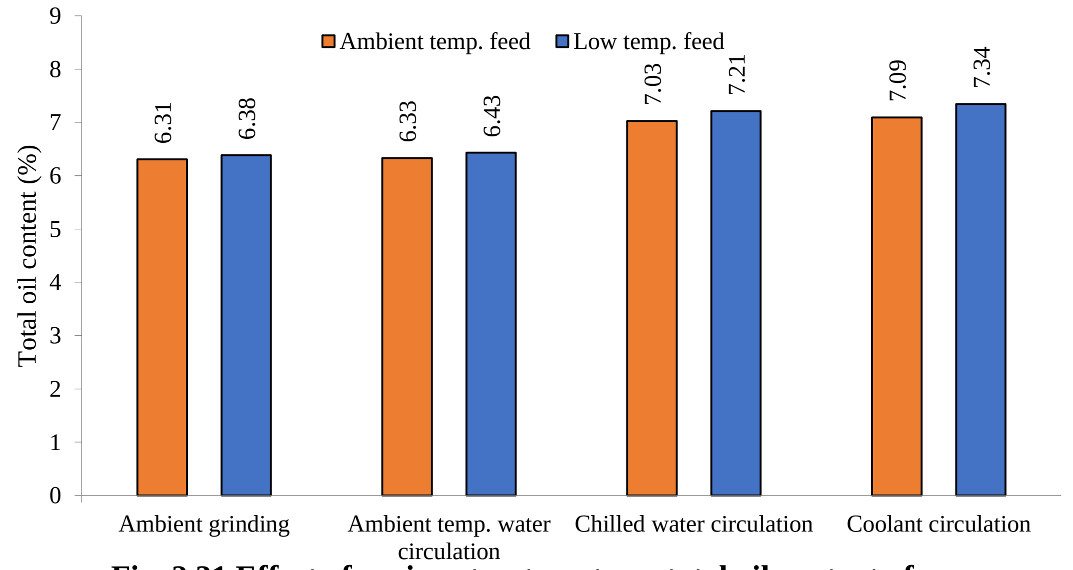


Fig. 2.31 Effect of various treatments on total oil content of turmeric powder

Total ash content

From the table, it can be concluded that grinding method and feed temperature individually affected non-significantly on the value of total ash content of ground product at 5% level of significance. For the grinding method, the lowest value (5.39%) was found for the method involving coolant circulation around the grinding chamber (L_3) and highest in case of chilled water circulation (5.53%). Besides that, the interaction effect of grinding method and feed temperature (L*T) on the same parameter was also found non-significant at the same level of significance.

The mean values of total ash of ground powder for all the treatments are graphically shown in the following figure (Fig. 2.32). Figure indicates that the value of total ash in ground powder decreases when moving from treatments involving ambient water circulation while again it increases for chilled water circulation and again decreases for coolant circulation treatment. Values ranged from minimum of 5.29% for control treatment (L_0T_1) to maximum of 5.70% in chilled water circulation with ambient temperature feed (L_3T_1). Decrease or no change in total ash content of ground powder was found for low temperature feed as compared ambient temperature feed for all grinding treatment. Increased moisture of low temperature feed caused decrease in the solid percentages of ground powder which in turn caused reduction in the value of ash content. So, grinding method did not affect the value of total ash of the ground powder directly, instead variation in the moisture due to different grinding methods engendered variation in the value of ash content.

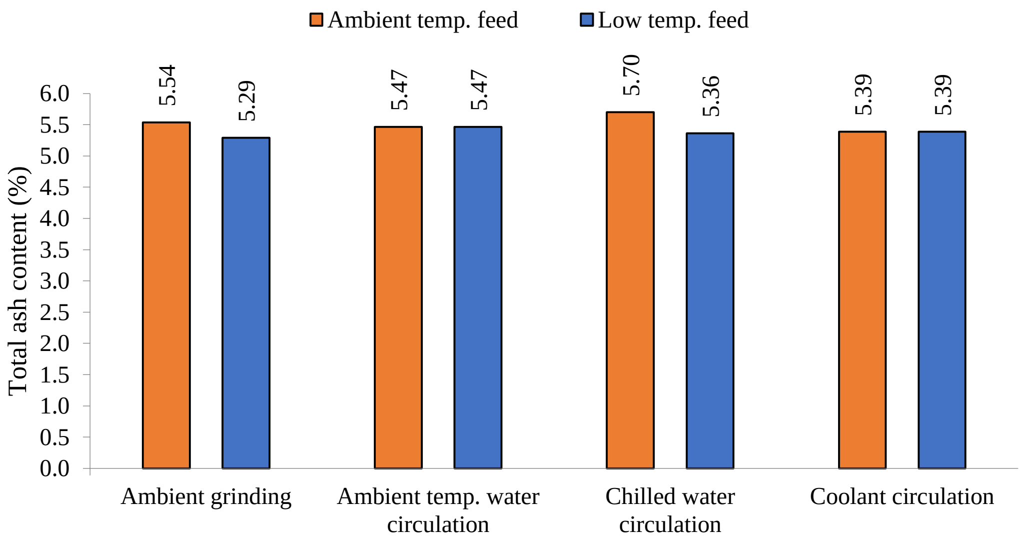


Fig. 2.32 Effect of various treatments on total ash content of turmeric powder

Volatile oil content

From the table, it can be concluded that grinding method affects significantly on the value of volatile oil content of ground product at 5% level of significance. The lowest value (2.92%) was found for the grinding method without liquid circulation (L_0) while the highest (3.92%) for the method involving coolant circulation around the grinding chamber (L_3). The effect of feed temperature on the value of volatile oil per cent was also found statistically significant at 5% level of significance. The value found was 3.36% and 3.48% for both, ambient and low temperature feed respectively. Besides that, the interaction effect of grinding method and feed temperature (L*T) on the same parameter was found non-significant at the same level of significance.

The mean values of volatile oil content of ground powder for all the treatments are graphically displayed in the following figure (Fig. 2.33). Figure shows that the value of volatile oil in ground powder increases when moving from treatments involving ambient grinding to ambient, chilled water and coolant circulation treatments. Values ranged from minimum of 2.87 % for control treatment (L_0T_0) to maximum of 4.00 % in coolant circulation with low temperature feed (L_3T_1). Increase in volatile oil yield of ground powder with moving from left to right in the graph may be credited to the fall of temperature inside the grinding chamber. As higher temperature developed during ambient grinding process causes loss of volatile oil. Powder obtained through ambient grinding treatment showed the lowest percentages of volatile oil.

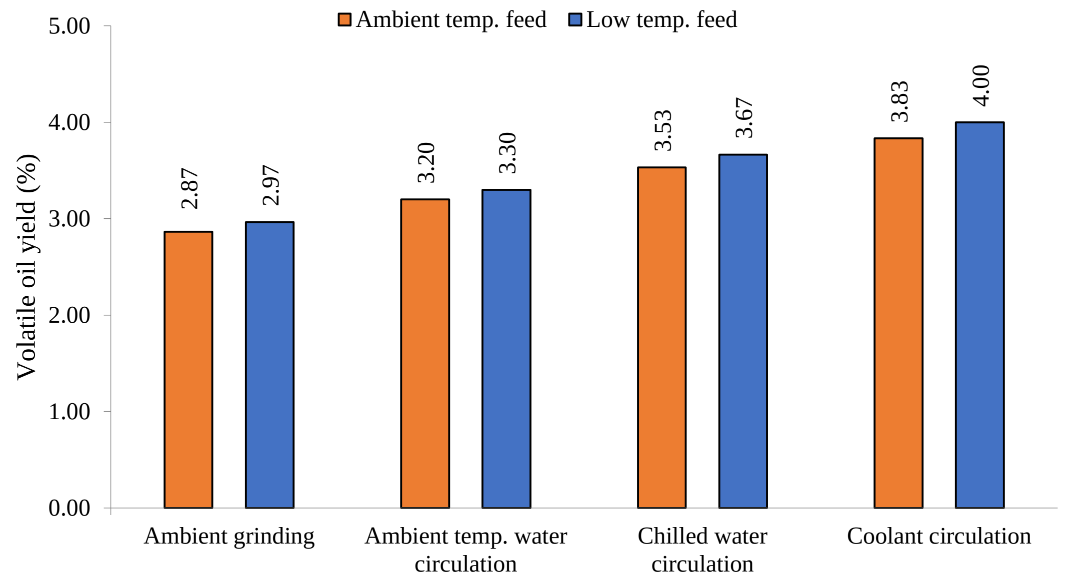


Fig. 2.33 Effect of various treatments on volatile oil content of turmeric powder

Volatile metabolites

Volatile components present in ground powder of turmeric rhizomes were identified using GC-MS QTOF. The chromatograms obtained in the analysis of extract of ground powder, obtained through all the treatments are shown in figures. There were 35 compounds present in the extract raw rhizome and treatment L_0T_0, while in case of treatments L_0T_1 and L_2T_0 there were 40 compounds, in treatment L_1T_0 there were 49 compounds, in treatments L_1T_1 and L_3T_1, there were 31 compounds, in treatment L_2T_1 30 compounds, in treatment L_3T_0 there was 34 compounds.

The essential oil of turmeric is a mixture of ~75 compounds, some of them are identified and some not. Turmerone is principle flavouring compound of turmeric (Curcuma longa L.).The turmerone in harvested rhizome accounted for almost 90% of the oil composition. It has been reported that the major compounds found in turmeric oil, up to 50-60%, are the sesquiterpene ketones, ß-, and ar-turmerone. In all treatments turmerone was found except coolant circulation with both ambient temperature and low temperature feed. Maximum content of turmerone was found in L_2T_0 followed by L_1T_0 and L_0T_1.

11. Financial Implications (Rs. in Lakhs)

11.1 Expenditure on

(a) Manpower : Rs. 25.50 lakh
(b) Research/Recurring Contingencies: Rs. 1.50 lakh
(c) Non-Recurring Cost (Including cost of equipment) : Rs 35000/-
(d) Any Other Expenditure Incurred : -Nil-

11.2 Total Expenditure : 27.35 lakh

Cumulative Output

a. Special attainments/innovations : Reduction of post harvest losses
b. List of Publications (one copy each to be submitted if not already submitted)
    i. Research papers: Shelake P. S., M. N. Dabhi. 2019. Development of cooling system assisted grinding mechanism for spices. Journal of Food Process Engineering. 42(8):DOI:101111/jfpe.13288.Reports/Manuals: -Nil-
    ii. Working and Concept Papers: -Nil-
    iii. Popular articles: -Nil-
    iv. Books/Book Chapters: -Nil-
    v. Extension Bulletins: -Nil-
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
   (relevant to the project in which scientists have participated):
e. Details of technology developed : **Crop-based**
   Low temperature grinding machine was developed for 20-25 kg per hour capacity of spices.

   (Crop-based; Animal-based, including vaccines; Biological – biofertilizer, biopesticide, etc; IT based – database, software; Any other – please specify)
f. Trainings/demonstrations organized **:** -Nil-
g. Training received: -Nil-
h. Any other relevant information: -Nil-

(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. Development of low temperature grinding machine	1. March - Dec 2019- Development of low temperature grinding machine	Achieved	Fully matched	100%
2. Grinding of spices (Chilly, Turmeric) at low temperature	2. Jan – Mar 2020 Grinding of spices.	Grinding of fenugreek is completed by Sept. 2020 and	Achieved	100%

		for turmeric it is completed by Nov. 2020.		
3. Assessment of biochemical and volatile compound of spice powder.	3. April-Dec 2020: Biochemical analysis of ground powder	Achieved	Fully matched	100%

(b) Reasons of shortfall, if any: Due to pandemic covid 19 the grinding operation was late and in odd season.

Efforts made for commercialization/technology transfer:-

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

1.The outcome of this project helps to retain biochemical metabolites in ground powder.

(b) How it will help in knowledge creation?

Low temperature grinding retain the important volatile compounds as compared to ambient temperature grinding.

Expected benefits and economic impact(if any)

The ground powder of Fenugreek seed and turmeric will contain important volatile compounds

Specify whether the project requires submission of RPP-IV for up scaling of research output. -Nil-

Future line of research work/other identifiable problems

1. The varietal research on curing system is needed.

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

As in point 10.

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

(M. N. Dabhi) Principal Investigator	(P. R. Davara) Co-PI	(H. R. Sojaliya) Co-PI

Signature of Head of Division

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

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 ☐

ANNEXURE - VIII

INDIAN COUNCIL OF AGRICULTURAL RESEARCH

(For Guidelines Refer ANNEXURE – XI(H))

PROFORMA FOR RESEARCH PERFORMANCE EVALUATION OF INDIVIDUAL SCIENTIST

1. Institute Project Code : PH/JU/2019/01

2. Evaluation by PI on the contribution of the team in the project including self

S. 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	9

3. Signature of PI :

M. N. Dabhi
Principal Investigator

ANNEXURE - VIII

INDIAN COUNCIL OF AGRICULTURAL RESEARCH

(For Guidelines Refer ANNEXURE – XI(H))

PROFORMA FOR RESEARCH PERFORMANCE EVALUATION OF INDIVIDUAL SCIENTIST

1. Institute Project Code: PH/JU/2019/01

2. Evaluation by PI on the contribution of the team in the project including self

S. No.	Name	Status in the project (PI/CC-PI/Co-PI)	Rating in the scale of 1 to 10
1	Dr. P. R. Davara	Co-PI	9

3. Signature of PI :

M. N. Dabhi
Principal Investigator

ANNEXURE - VIII

INDIAN COUNCIL OF AGRICULTURAL RESEARCH

(For Guidelines Refer ANNEXURE – XI(H))

PROFORMA FOR RESEARCH PERFORMANCE EVALUATION OF INDIVIDUAL SCIENTIST

1. Institute Project Code: PH/JU/2019/01

2. Evaluation by PI on the contribution of the team in the project including self

S. No.	Name	Status in the project (PI/CC-PI/Co-PI)	Rating in the scale of 1 to 10
1	Er. H. P. Gajera	Co-PI	9

3. Signature of PI :

M. N. Dabhi
Principal Investigator

ANNEXURE – V

INVESTIGATION – 3

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/2018/02
2. Project Title : Design and development of grain treater for enzymatic pre-treatment to pigeon pea grains.
3. Reporting Period : 01-03-2018 to 31-12-2019
4. Project Duration: Date of Start –01-03-2018 LikelyDate of Completion– 31-03-2020
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

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. Designing of grain treater 2. Development and fabrication of grain treater 3. Laboratory experiments 4. Modifications in the grain treater 5. Data collection and its analysis 6. 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 all above aspects

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.To design and develop the grain treater for enzymatic pre-treatment to pigeon pea grains	1. Review collection	Dr. P. R. Davara	100%	100%
	2. Designing of grain treater	Dr. P. R. Davara Dr. M. N. Dabhi	100%	100%
	3. Fabrication of drum	Dr. P. R. Davara Dr. M. N. Dabhi	100%	100%
	4. Fabrication of gate for loading and unloading	Dr. P. R. Davara Dr. M. N. Dabhi	100%	100%
	5. Fabrication of stand for grain treater	Dr. P. R. Davara Dr. M. N. Dabhi	100%	100%
	6. Fabrication of side gates is completed	Dr. P. R. Davara Dr. M. N. Dabhi	100%	100%
	7. Fitting of flights inside the drum	Dr. P. R. Davara Dr. M. N. Dabhi	100%	100%
	8. Fitting of rollers to support the drum	Dr. P. R. Davara Dr. M. N. Dabhi	100%	100%
	9. Fitting of centre shaft assembly	Dr. P. R. Davara Dr. M. N. Dabhi	100%	100%

	10. Fitting of spray nozzles inside the drum for spraying of enzyme solution	Dr. P. R. Davara Dr. M. N. Dabhi	100%	100%
	11. Fitting of heating assembly (heater and temperature sensor) inside the drum	Dr. P. R. Davara Dr. M. N. Dabhi	100%	100%
	12. Fitting of electric motor and driving mechanism	Dr. P. R. Davara Dr. M. N. Dabhi	100%	100%
	13. Auto on-off system for heater for temperature control	Dr. P. R. Davara Dr. M. N. Dabhi	100%	100%
	14. Fitting of Variable speed drive (VSD) to adjust the rpm of drum	Dr. P. R. Davara Dr. M. N. Dabhi	100%	100%
	15. Fitting of spray pump along with the spray nozzle	Dr. P. R. Davara Dr. M. N. Dabhi	100%	100%
2. To evaluate the performance of developed grain treater	To test the developed machine for treating the pigeon pea grains with enzyme solution	Dr. P. R. Davara Dr. M. N. Dabhi	100%	50%
3. To study the effect of different machine parameters on enzyme incubation efficacy	To study the feasibility of the machine for effective enzyme incubation	Dr. P. R. Davara Dr. M. N. Dabhi	100%	50%
4. To optimize the machine parameters for maximizing enzyme incubation efficacy on pigeon pea grains	Different machine parameters, viz. Filled volume and drum speed are to be optimized for maximizing the enzyme incubation efficacy on pigeon pea grains	Dr. P. R. Davara Dr. M. N. Dabhi	100%	0%

5. To estimate the cost of developed machine	Total cost of the machine is to be derived considering all the expenditure incurred during development of the machine	Dr. P. R. Davara Dr. M. N. Dabhi	100%	0%

(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)

- **Objectives**

4. To design and develop the grain treater for enzymatic pre-treatment to pigeon pea grains.
5. To evaluate the performance of developed grain treater.
6. To study the effect of different machine parameters on enzyme incubation efficacy.
7. To optimize the machine parameters for maximizing enzyme incubation efficacy on pigeon pea grains.
8. To estimate the cost of developed machine.

- **Justification :**

Pigeon pea (*Cajanus cajan* L.) is one of the important pulse crops of India contributing 20.87 % to the total production of all pulses. India accounts for 90 % of the total world production of pigeon pea (Goyal *et al.*, 2008). It is mostly consumed after dehulling in the form of dhal (decorticated split cotyledon). Pigeon pea is mainly consumed as dhal because it takes less time to cook and has acceptable appearance, texture, palatability, digestibility, and overall nutritional quality. The pigeon pea grain is considered as most difficult for dehulling as compared to other pulses owing to its seed coat which is more firmly attached with the cotyledons through a layer of gum and mucilage (Rout *et al.*, 2007). Due to the presence of gummy layer and hard seed coat, it is difficult to dehull.

Pre-milling treatments are generally employed to loosen the seed coat to remove husk without losing any edible portion. There are many milling methods like wet milling, dry milling, CFTRI method, Pantnagar process, CIAE method and IIPR method developed for pigeon pea milling. There are various pre milling treatments, with respect to different milling methods, carried out before dehulling for loosening of seed coat of pigeon pea grain. All these mentioned treatments are time consuming, require almost 4 to 7 days for the complete milling of pigeon pea. But, all these pre-treatments do not permit easy removal of seed coat during the subsequent processing operation of pigeon pea milling. Moreover, these pre-treatments lead to higher processing cost, longer processing time and labour consuming for pigeon pea milling (Patel *et al.*, 2001). Enzymatic pre-treatment to pigeon pea can significantly reduce the processing time and increase the husk removal (Deshpande *et al.*, 2007; Sreerama *et al.*, 2009). The enzymatic process as reported by Sangani *et al.,* (2014) involves incubation of enzyme (xylanse:pectinase:cellulase – 2:1:1) treated grains at 48.5 °C temperature for 8.69 h followed by drying and dehulling. This process resulted the increase in dehulling efficiency of enzyme treated pigeon pea grain as compared to oil treated grains. Continuous mixing of grains at uniform temperature till the end of process is the basic requirement for better efficacy of incubation. Further, incubation time and temperatures varies with variety of pigeon pea (Anon., 2017). No any machine or equipment with such facilities is available to give the enzymatic pre-treatment to the pigeon pea. Therefore, the research work has undertaken to develop the grain treater for enzymatic pre-treatment to pigeon pea grains on large scale.

- **Status (review) :**

Saxena *et al.* (1993) used food grade mixed activity enzymes (i.e. xylanase and cellulase) as husk loosening agent. He reported a maximum hulling efficiency of 88.93 % at an enzyme concentration of 0.08 g protein per 260 g pigeon pea grain. Grains were treated with the enzyme and allowed to incubate. During this period of incubation, enzymatic hydrolysis took place which brought about the biodegradation of complex molecules of the grain. The complex gums were degraded which resulted in easy dehusking. It established that a lesser force was required to bring about the dehusking of enzyme treated grain. The action of enzyme also disturbed the microstructure of the grain affecting its strength. They further reported an increase in the protein digestibility and 37.03 % reduction in cooking time. Further, this dhal was reported to cause less gastritis due to fermentation which broke down the polysaccharides responsible for causing gastritis in many people.

Zambre (1994) reported a decrease in gum content after enzyme treatment. The protein digestibility of the treated dhal was more than that of untreated dhal. He also reported that enzyme treatment caused grain to split at a lesser force and deformation. This was due to change in microstructure which affected the strength of the grain.

Deshpande (2003) treated 60 kg pigeon pea grains with 4 % soy oil and 4 % CIRCOT enzyme. The samples treated with soy oil and enzymes were mixed thoroughly to achieve uniform application of enzyme to the grains. The treated grains were than pitted. These samples were then soaked in water for varying duration, i.e., 45, 60, 75 and 90 minutes followed by drying to 10 % moisture content. The results indicated the dhal recovery in the range of 81.11 to 84.58 % for 75 minutes subsequent soaking compared to other soaking treatments.

- **Technical programme**

Machine parts :

1. Rotating drum with internal flights
2. Atomizers for water spray
3. Heating accessories (heating elements and thermocouple)
4. Airtight discharge gate
5. Drum speed regulator

Machine features :

1. Internal mixing flights create a gentle, four-way mixing action that tumbles, folds and turns the material.
2. Openable air tight gate fitted at the surface of drum makes easy discharge of grains after treatment.
3. Hollow pipe act as a shaft as well as facilitate the fitting of atomizers and heating accessories to create and maintain the internal condition for enzyme incubation.
4. The consistent and efficient flow pattern of grains assists in creation of ideal conditions for uniform application of water and exposure to heat for achieving homogeneous treatment.
5. Speed regulator assists to adjust the speed of drum.

Experimental design : Response Surface Methodology : CCRD (2 factors)

Independent parameters :

Sr. No.	Parameters	Code	Coded levels				
			-2	**-1**	**0**	**+1**	**+2**
1	Drum speed (rpm)	X_1	5	7.5	10	12.5	15
2	Drum occupied volume (%)	X_2	25	28.75	32.5	36.25	40

Treatment combinations :

Treatment No.	Coded variables		Uncoded variables	
	X_1	**X_2**	**Drum speed (rpm)**	**Drum occupied volume (%)**
1	-1	-1	7.5	28.75
2	1	-1	12.5	28.75
3	-1	1	7.5	36.25
4	1	1	12.5	36.25
5	-2	0	5	32.5
6	2	0	15	32.5
7	0	-2	10	25
8	0	2	10	40
9	0	0	10	32.5
10	0	0	10	32.5
11	0	0	10	32.5
12	0	0	10	32.5
13	0	0	10	32.5

Dependent parameters :

1. Machine capacity (kg/batch), 2. Hulling efficiency (%)

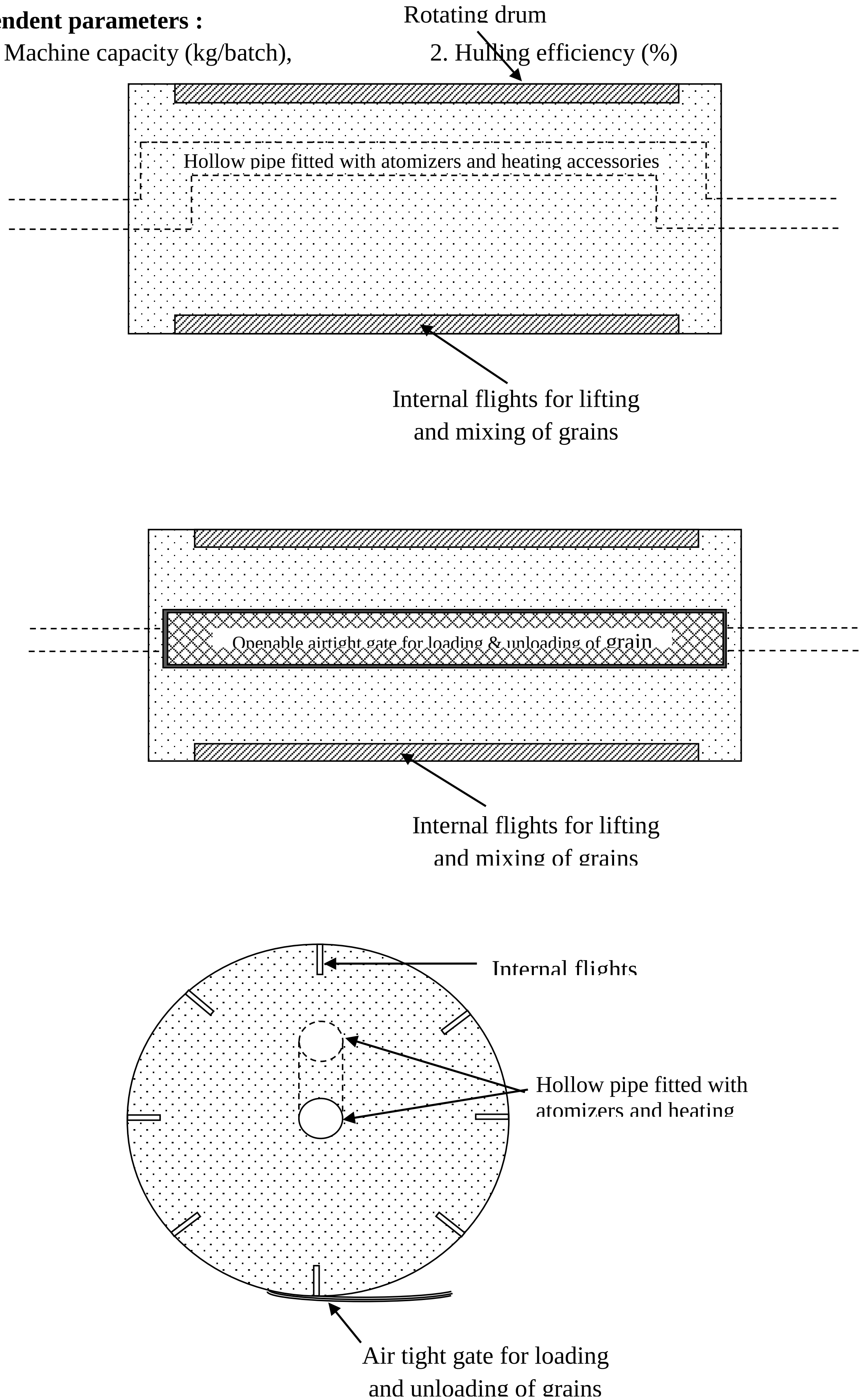
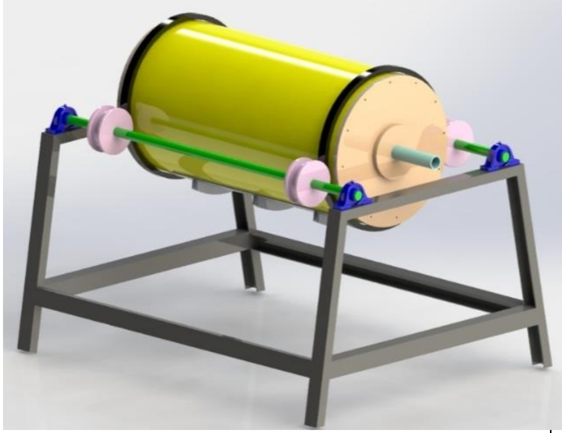
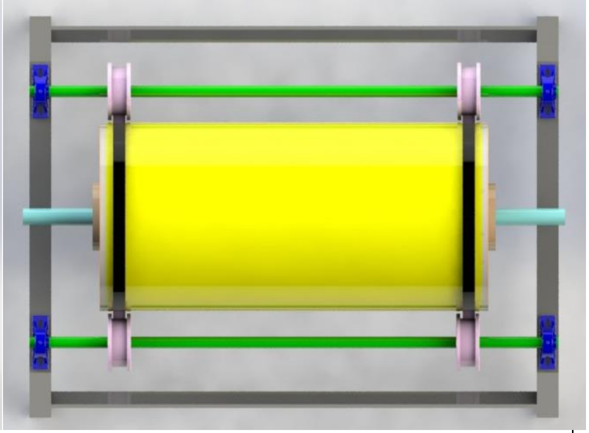
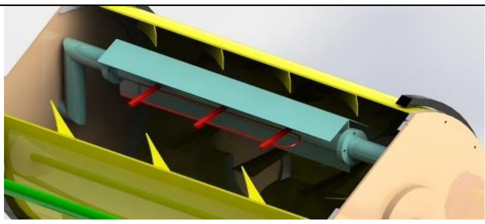
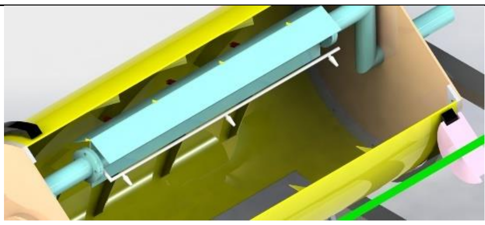
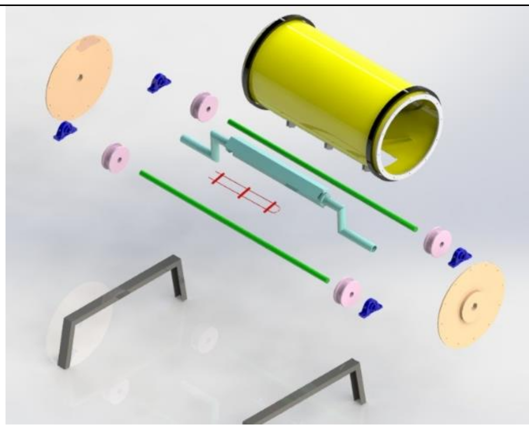


Fig. 3.1 : Conceptual design of small-scale peanut roaster

➢

	
Side view	**Top view**
 	
Spray and heater assembly	**Segmented view**
Fig. 3.2 : Computerized conceptual layouts of the machines	

➢ **<u>Results and Discussion</u>**

- **Fabrication of grain treater**

Fabrication of grain treater is under progress as shown in below given Photographs.

Plate 3.1 Fabrication of Drum for grain treater

Plate 3.2 Fabrication of side gates for grain treater

Plate 3.3 Fabrication of gate for loading and unloading

Plate 3.4 Fabrication of stand for grain treater

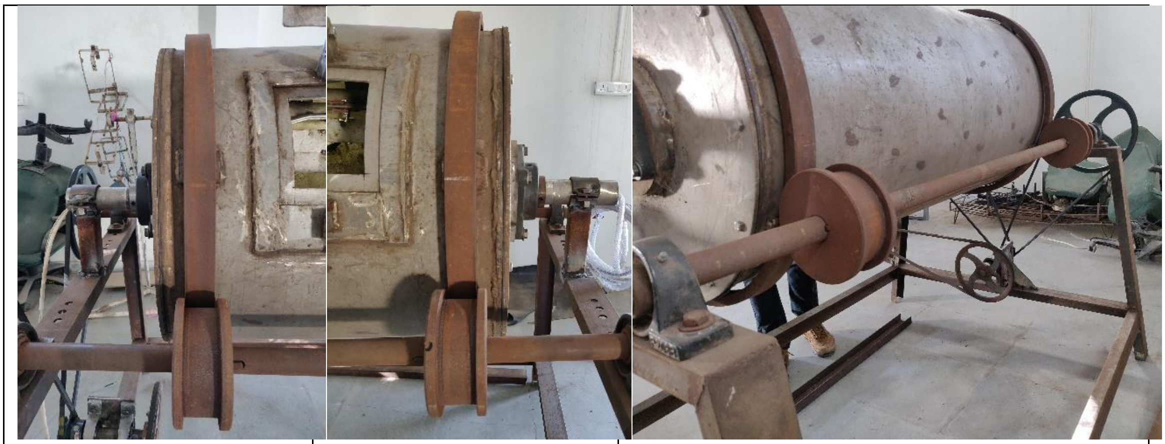


Plate 3.5 Fitting of rollers to support the drum

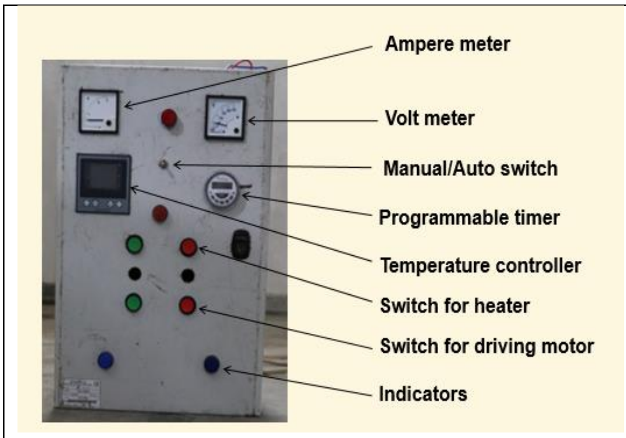
Plate 3.6 Fitting of flights inside the drum

Plate 3.7 Fitting of centre shaft assembly of the drum

Plate 3.8 Fitting of spray nozzles inside the drum

Plate 3.9 Fitting of heater assembly inside the drum

Plate 3.10 Fitting of electric motor and driving mechanism to rotate the drum



Control Panel

Variable speed drive

Plate 3.11 Control panel

Plate 3.12 Fitting of enzyme solution tank and spray pump

Plate 3.13 Complete setup of grain treater

- **Work to be done**

1. Laboratory experiments for setting up of machine parameters are under progress
2. Performance evaluation of machine
3. Cost evaluation of machine
4. Cost economics of the process
5. Report writing

References :

1. Anonymous (2017). Enzymatic pre-treatment in the processing of pigeon pea. A project report submitted to Dept. of Agriculture and Cooperation, Govt. of India under National Food Security Mission by Dept. of Food Processing, College of Agril. Engg. & Technology, Junagadh Agril. University, Junagadh (Gujarat).
2. Deshpande SD (2003) Optimization of pre milling treatments to enhance recovery of dhal. Annual Report 2001-03. AICRP on Post Harvest Technology, Bhopal Center, Presented in the 24th Annual workshop, held at GBPUA & T, Pantnagar (Feb. 12-14, 2003)

3. Deshpande, S. D., Balasubramanya, R. H., Khan, S., Bhatt, D. K. (2007) Influence of pre milling treatments on dhal recovery and cooking characteristics of pigeon pea. Journal of Agricultural Engineering, 44: 53-56.
4. Goyal, R. K., Vishwakarma, R. K., Wanjari, O. D. (2008) Optimisation of pigeon pea dehulling process. Biosystems Eng 99: 56-61.
5. Patel, N. C, Dabhi, M. N., Chandegara, V. K., Mehta, M. H. (2001) Pulse milling industry technology up gradation: Pilot scale mill approach for R & D and application. Presented in the National seminar on emerging trends in processing, handling, storage and by-product utilization of pulses and soybean, GBPUA&T, Pantnagar (Jan. 18-19, 2001).
6. Rout, B., Sahoo, S., Senapati, P. K. (2007) Effect of pre milling treatment on protein and carbohydrate content in tribal pulses. Indian J Traditional Knowledge 6: 69-71.
7. Sangani, V. P., Patel, N. C., Davara, P. R., Antala, D. K. and Akbari, P. D. (2014). Optimization of Enzymatic Hydrolysis Parameters of Pigeon Pea for Better Recovery of Dhal. International Journal of Agricultural Science and Technology, 2(4):97-105.
8. Saxena RP, Verma P, Sarkar BC, More PK (1993) Enzymatic pre treatment of pigeon pea (*Cajanus cajan* L.) grain and its interaction with milling.Journal of Food Science and Technology, 30: 368-370
9. Sreerama, Y. N., Shashikala, V. B., Pratape, V. M. (2009) Effect of enzyme pre-dehulling treatments on dehulling and cooking properties of legumes. Journal of Food Engineering, 92: 389-395.
10. Zambre SS (1994) Enzymatic pretreatment of pigeon pea (*Cajanus cajan* L) grain : Its effect on milling, cooking and digestibility. Thesis M.Tech., Agril. Engg., G.B. Pant University of Agricultural and Technology, Pantnagar

8. Output During Period Under Report

   i. Special attainments/innovations

   j. List of Publications (one copy each to be submitted with RPP-II)
      - i. Research papers - Nil
      - ii. Reports/Manuals - Nil
      - iii. Working and Concept Papers - Nil
      - iv. Popular articles - Nil
      - v. Books/Book Chapters - Nil
      - vi. Extension Bulletins - Nil

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

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

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

n. Trainings/demonstrations organized - Nil
o. Training received - Nil
p. Any other relevant information – Project is under progress

9. Constraints experienced, if any
 - Nil
10. Lessons Learnt
 - Nil
11. Evaluation
 Self evaluation of the project for the period under report by the PI with rating in the scale of 1 to 10 — 8

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

S.No.	Name	Status in the project (PI/CC-PI/Co-PI)	Rating in the scale of 1 to 10
1	Dr. P. R. Davara	PI	8
2	Dr. M. N. Dabhi	Co-PI	8

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

ANNEXURE - V

INVESTIGATION – 4

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/2020/01
2. Project Title : Standardization of process technology for preparation of peanut sauce and peanut wadi (Chunks).
3. Reporting Period : 01-02-2020 to 31-01-2021
4. Project Duration: Date of Start – 01-02-2020 LikelyDate of Completion– 31-03-2022
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 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. P. J. Rathod Assistant Biochemist, AICRP on PHET, Dept. of Bio-Technology, JAU, Junagadh	Co-PI-II	15%	1. To assist the PI to carry out biochemical analysis of the product
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

21. (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. To develop a process technology for preparation of peanut sauce and peanut wadi.	1. Review collection/literature survey	Dr. P. R. Davara	100%	100%
	2. Designing of the experiment	Dr. P. R. Davara	100%	100%
	3. Procurement of raw materials	Dr. P. R. Davara Dr. M. N. Dabhi	100%	10%
	4. Procurement of microbial cultures and chemicals required to conduct the research trials	Dr. P. R. Davara Prof. A. M. Joshi Dr. M. N. Dabhi	100%	10%
	5. Quality analysis of the raw materials	Dr. P. R. Davara	100%	50%
	6. Preliminary trials for production of peanut sauce and peanut wadi	Dr. P. R. Davara Prof. A. M. Joshi	100%	10%
	7. Final trials for development of peanut sauce and peanut wadi using defatted peanut flour/kernels as per the different treatments	Dr. P. R. Davara Prof. A. M. Joshi	50%	0%

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 2. Microbilogical analysis of the peanut sauce	Dr. P. R. Davara Dr. P. J. Rathod Prof. A. M. Joshi	50%	00%
3. To standardize the process parameters for preparation of peanut sauce and peanut wadi	1. Data collection and its analysis 2. Optimization of process parameters based on the experimental data	Dr. P. R. Davara Dr. M. N. Dabhi	50%	0%

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

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

- Defatted peanut flour is purchased from the Nutrinity Foundation, Junagadh to test its feasibility for the preparation of peanut wadi.
- Quality analysis of defatted peanut flour was done. Values of different biochemical characteristics of defatted peanut flour are presented as under.

Sr. No.	Characteristic	Average values	SD
1.	Moisture content % (w.b.)	5.64	0.09
2.	Carbohydrate (%)	23.59	0.57
3.	Protein (%)	61.98	0.77
4.	Fat (%)	3.96	0.19
5.	Ash (%)	4.76	0.17

- Preliminary trials were conducted for preparation of peanut wadi using the Twin Screw Extruder. But, results were obtained are not upto expectation. Hence, the trials will be repeated in the coming time.

- **Work to be done**

1. Procurement of defatted peanut kernels is still awaited from the supplier
2. Quality analysis of raw material for peanut sauce preparation
3. Procurement of *Aspergillus oryzae (Koji mold)*
4. Procurement of *Pediococcus halophilus and Saccharomyces rouxii*
5. Preliminary trials for production of peanut sauce will be carried out as soon the raw materials and microbial cultures is obtained
6. Final trials for development of peanut sauce and peanut wadi using defatted peanut flour/kernels as per the different treatments
7. Physico-chemical and sensory analysis of the products
8. Data collection and its analysis
9. Optimization of process parameters based on the experimental data
10. Report writing

13. Output During Period Under Report
    q. Special attainments/innovations
    r. List of Publications (one copy each to be submitted with RPP-II)
        i. Research papers - Nil
        ii. Reports/Manuals - Nil
        iii. Working and Concept Papers - Nil
        iv. Popular articles - Nil
        v. Books/Book Chapters - Nil
        vi. Extension Bulletins - Nil
    s. Intellectual Property Generation
    (Patents - filed/obtained; Copyrights- filed/obtained; Designs-filed/obtained; Registration details of variety/germplasm/accession if any)
    t. Presentation in Workshop/Seminars/Symposia/Conferences
    (relevant to the project in which scientists have participated)
    u. Details of technology developed
    (Crop-based; Animal-based, including vaccines; Biological – biofertilizer, biopesticide, etc; IT based – database, software; Any other – please specify)
    v. Trainings/demonstrations organized - Nil
    w. Training received - Nil
    x. Any other relevant information – Project is under progress

14. Constraints experienced, if any
- No any supplier is there in India who can provide the *Pediococcus halophilus* bacteria required for the fermentation process in the preparation of peanut sauce. It is expected to be purchased from the ATCC, USA.

15. Lessons Learnt
- Nil

16. Evaluation
Self evaluation of the project for the period under report by the PI with rating in the scale of 1 to 10 [8]

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

S. No.	Name	Status in the project (PI/CC-PI/Co-PI)	Rating in the scale of 1 to 10
1	Dr. P. R. Davara	PI	8
2	Prof. A. M. Joshi	Co-PI	8
3	Dr. P. J. Rathod	Co-PI	8
4	Dr. M. N. Dabhi	Co-PI	8

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

18. 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 [ ]

19. Comments of IRC

20. 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 ☐

ANNEXURE – V

INVESTIGATION – 5

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/2020/02
2. Project Title: Application of microwave technology for disinfestations of groundnut kernels.
3. Reporting Period: May 2020 to December 2020
4. Project Duration: Date of Start –May 2020
   LikelyDate of Completion–December 2021

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.	R.D.Dhudashia Assistant Entomologist, AICRP on PHET, College of Agril. Engg. & Tech., Junagadh Agril. University, Junagadh	PI	60%	Planning, data collection, statistical analysis and final report Writing
2.	A.M.Joshi, Assistant Moicrobiologist, AICRP on PHET, College of Agril. Engg. & Tech., Junagadh Agril. University, Junagadh	Co-PI	20%	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	20%	Supervision and Co-ordination

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.	Planning the experiment	R.D.Dhudashia M.N.Dabhi	Planning the experiment	100%
2.	Data collection	R.D.Dhudashia A.M.joshi	Data collection was achieved 60%	60%
3	Statistical analysis and Report writing	R.D.Dhudashia M.N.Dabhi	Statistical analysis and Report writing is completed	100%

(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)

(Experiment was completed for first year and presented in 36th workshop.)

Back ground information:

Groundnut is an important oilseed crop in India. In India, groundnut occupies 4.77million hectares area with total production of 4.75 million tonnes in year 2012-13.(anonymous 2015). Groundnut when stored is often attacked by number of pests, viz. groundnut bruchid, rust red flour beetle, rice moth etc. Among this, groundnut bruchid (*Caryedon serratus* Olivier.) is one of the major and important storage insect species, causing more damage to groundnut (Dick,K.M. 1987a). 20% dry weight loss of kernals due to bruchid infestation in warehouse in Andra Pradesh was reported by Dick K.M.(1987b). Pest infestation reduces the market value and germination of seeds. High Moisture content is also increase the risk of mould growth which indirectly spoils the quality of groundnut. Hence farmers and exporter have a problem for storing of groundnut. Various scientists were tested different methods for minimizing storage losses of groundnut. Among these,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 groundnut. The use of microwave technology is safe to environment and effective against storage pest. Various scientists were tested microwave technology for disinfestations. However, Very little information is available effect of microwave energy on pest incidence in during storage of groundnut. Thus it is necessary to find out the effective microwave treatment for safe storage of groundnut.

Objectives:

1. To evaluate the effect of microwave treatment against storage insect pest of groundnut kernels.
2. To study on moisture content and aflatoxin level of groundnut kernels in different microwave treatments.
3. To evaluate the effect of microwave treatment on germination of groundnut kernels.

Technical programme:

(a) Design: CRD

(b) Replication: 3

(c) Treatments: 10

1. Microwave treatment @power level 360 W for 30 second expose time
2. Microwave treatment @power level 360 W for 60 second expose time
3. Microwave treatment @power level 360 W for 90 second expose time
4. Microwave treatment @power level 480 W for 30 second expose time
5. Microwave treatment @power level 480 W for 60 second expose time
6. Microwave treatment @power level 480 W for 90 second expose time
7. Microwave treatment @power level 600 W for 30 second expose time
8. Microwave treatment @power level 600 W for 60 second expose time
9. Microwave treatment @power level 600 W for 90 second expose time
10. Control (Untreated)

Observation recorded:

(A) Entomological Parameters:

i. Pest population

ii. Percent kernels damage

(B) Physical parameters

i. Germination percentage

ii. Moisture content percentage

(C) Microbial parameters

(i) Aflatoxin level

Methodology: A good quality groundnut kernels was procured from seed processers. Initial Observation viz, moisture content, germination percent and insect infestation, damage etc. were recorded at time of storage.10 kg grains was stored in different bags after treatment of microwave and kept at room temperature in laboratory. Monthly observations were recorded on entomological and physical parameters during storage. The observations were recorded from groundnut samples of 250 g.

Initial observation:

Germination % 80.00,

Moisture % 6.61,

Insect damage and live insect: Nil

Aflatoxin :Nil

Results of project:

(I)Pest population:

(a): Pest population builds up of groundnut bruchid: Nil

The infestation of bruchid was not found in all the treatments during the storage time.

(b)Pest populations build up of Red rust flour beetle:

Table 5.1: Pest population build up of Red rust flour beetle during storage of groundnut kernels.

Treatments	**Av.No.of Tribolium Adult/250gram sample**			
	After 1 month	**After 2 month**	**After 3 month**	**After 4 month**
1. Microwave treatment @power level 360 W for 30 second expose time	0	1.46*(1.64)**	2.11(3.96)	2.40(5.27)
2. Microwave treatment @power level 360 W for 60 second expose time	0	1.34(1.31)	2.03(3.62)	2.54(5.97)
3. Microwave treatment @power level 360 W for 90 second expose time	0	1.56(1.93)	2.20(4.32)	2.48(5.66)
4. Microwave treatment @power level 480 W for 30 second expose time	0	1.68(2.31)	2.11(3.96)	2.53(5.92)
5. Microwave treatment @power level 480 W for 60 second expose time	0	1.46(1.64)	2.04(3.65)	2.48(5.66)
6. Microwave treatment @power level 480 W for 90 second expose time	0	1.46(1.64)	1.95(3.32)	2.40(5.27)
7. Microwave treatment @power level 600 W for 30 second expose time	0	1.56(1.93)	2.04(3.65)	2.48(5.63)
8. Microwave treatment @power level 600 W for 60 second expose time	0	1.05(0.61)	1.95(3.32)	2.41(5.29)
9. Microwave treatment @power level 600 W for 90 second expose time	0	1.17(0.87)	1.86(2.95)	2.34(4.97)
10.Control (Untreated)	0	1.56(1.93)	2.20(4.32)	2.61(6.63)
S. Em ±	-	0.16	0.11	0.14
CD at 5%	-	NS	NS	NS
CV%	-	19.69	9.49	9.58

* $\sqrt{x+0.5}$ transformation value; **figure in parenthesis are retransformed value

The results showed in Table 5.1 indicated that the Pest population was not recorded in all treatments after one month of storage. The infestation of Red rust flour beetle was found after two month and increase up to four month of storage in all treatments. The effect of microwave treatment was found non significant after two, three and four month of storage of groundnut kernels.

(ii) Percent grain damage due to red rust flour beetle:

Table 5.2 : Percent kernels damage on number base due to red rust flour beetle during storage.

Treatments	% kernels damage on number bases			
	After 1 month	After 2 month	After 3 month	After 4 month
1. Microwave treatment @power level 360 W for 30 second expose time	0	9.27*(2.59)**	17.08(8.62)	25.08(17.98)
2. Microwave treatment @power level 360 W for 60 second expose time	0	7.33(1.63)	16.41(7.98)	24.04(16.59)
3. Microwave treatment @power level 360 W for 90 second expose time	0	7.95(1.91)	16.05(7.64)	25.59(18.66)
4. Microwave treatment @power level 480 W for 30 second expose time	0	8.74(2.31)	16.77(8.33)	25.57(18.63)
5. Microwave treatment @power level 480 W for 60 second expose time	0	7.95(1.91)	15.99(7.58)	24.04(16.59)
6. Microwave treatment @power level 480 W for 90 second expose time	0	8.74(2.31)	16.41(7.98)	25.06(17.95)
7. Microwave treatment @power level 600 W for 30 second expose time	0	9.36(2.64)	17.12(8.66)	24.83(17.64)
8. Microwave treatment @power level 600 W for 60 second expose time	0	7.33(1.63)	16.41(7.98)	25.32(18.29)
9. Microwave treatment @power level 600 W for 90 second expose time	0	7.95(1.91)	16.74(8.29)	25.06(17.95)
10.Control (Untreated)	0	9.27(2.59)	17.44(8.98)	26.55(19.97)
S. Em ±	-	0.97	0.74	1.04
CD at 5%	-	NS	NS	NS
CV%	-	20.12	7.69	7.20

*arcsin √percentage transformation value **figure in parenthesis are retransformed value

The results showed in Table 5.2 indicated that the damage of kernels on number base was not recorded in all treatments after one month of storage. The damage of kernels was found after two month and increase up to four month of storage. The effect of microwave treatment was found non significant after two, three and four month of storage of groundnut kernels.

Table 5.3: Percent kernels damage on weight base due to red rust flour beetle during storage.

Treatments	% kernels damage on weight bases			
	After 1 month	After 2 month	After 3 month	After 4 month
1. Microwave treatment @power level 360 W for 30 second expose time	0	8.57*(2.2)**	16.71(8.26)	24.27(16.90)
2. Microwave treatment @power level 360 W for 60 second expose time	0	8.27(2.07)	16.27(7.85)	24.43(17.11)
3. Microwave treatment @power level 360 W for 90 second expose time	0	8.33(2.10)	15.81(7.42)	24.87(17.69)
4. Microwave treatment @power level 480 W for 30 second expose time	0	8.12(2.00)	16.52(8.08)	24.34(16.99)
5. Microwave treatment @power level 480 W for 60 second expose time	0	7.62(1.76)	15.96(7.56)	23.07(15.35)
6. Microwave treatment @power level 480 W for 90 second expose time	0	8.18(2.03)	16.08(7.67)	23.61(16.04)
7. Microwave treatment @power level 600 W for 30 second expose time	0	8.67(2.27)	17.10(8.65)	22.86(15.09)
8. Microwave treatment @power level 600 W for 60 second expose time	0	7.79(1.84)	16.08(7.67)	24.12(16.70)
9. Microwave treatment @power level 600 W for 90 second expose time	0	7.38(1.65)	16.65(8.21)	23.70(16.15)
10.Control (Untreated)	0	9.12(2.51)	17.07(8.62)	24.95(17.80)
S. Em ±	-	0.80	0.73	0.49
CD at 5%	-	NS	NS	NS
CV%	-	16.87	7.73	3.53

*arcsin √percentage transformation value **figure in parenthesis are retransformed value

The results showed in Table 5.3 indicated that the damage of kernels on weight base was not recorded in all treatments after one month of storage. The damage of kernels was found after two month and increase up to four month of storage. The effect of microwave treatment was found non significant after two, three and four month of storage of groundnut kernels.

(iii) Percent moisture content:

Table 5.4: Percent moisture content of groundnut kernels during storage

Treatments	**%Moisture content of kernels**				
	After microwave treatment	**After 1 month**	**After 2 month**	**After 3 month**	**After 4 month**
1. Microwave treatment @power level 360 W for 30 second expose time	6.52	6.88	7.67	8.09	7.50
2. Microwave treatment @power level 360 W for 60 second expose time	6.41	6.79	7.65	8.08	7.43
3. Microwave treatment @power level 360 W for 90 second expose time	6.30	6.78	7.61	8.06	7.42
4. Microwave treatment @power level 480 W for 30 second expose time	6.40	6.88	7.63	8.05	7.43
5. Microwave treatment @power level 480 W for 60 second expose time	6.32	6.71	7.61	7.97	7.27
6. Microwave treatment @power level 480 W for 90 second expose time	6.21	6.62	7.62	8.00	7.39
7. Microwave treatment @power level 600 W for 30 second expose time	6.31	6.67	7.65	7.99	7.39
8. Microwave treatment @power level 600 W for 60 second expose time	6.19	6.63	7.61	7.93	7.43
9. Microwave treatment @power level 600 W for 90 second expose time	6.11	6.57	7.60	7.90	7.31
10.Control (Untreated)	6.61	7.04	7.68	8.09	7.59
S. Em ±	0.01	0.03	0.03	0.06	0.08
CD at 5%	0.03	0.08	NS	NS	NS
CV%	0.30	0.66	0.65	1.30	1.91

The results showed in Table 5.4 indicated that the effect of microwave treatment on moisture content was found significant after given microwave treatment at storage time. Moisture content was found significant after one month of storage of groundnut kernels. The effect of microwave treatment on moisture content was found non significant after two ,three and four month of storage, which may be due to high humidity during monsoon season.

(iv) Percent Germination:

Table 5.5: Percent Germination of groundnut kernels during storage

Treatments	**Germination % of groundnut Kernel**	
	after microwave treatment	**after 4th month**
1. Microwave treatment @power level 360 W for 30 second expose time	62.29*(78.38)**	49.81(58.35)
2. Microwave treatment @power level 360 W for 60 second expose time	63.55(80.16)	49.99(58.67)
3. Microwave treatment @power level 360 W for 90 second expose time	61.14(76.71)	49.80(58.34)
4. Microwave treatment @power level 480 W for 30 second expose time	60.07(75.11)	50.19959.00)
5. Microwave treatment @power level 480 W for 60 second expose time	63.55(80.16)	50.78(60.02)
6. Microwave treatment @power level 480 W for 90 second expose time	62.48(78.65)	50.39(59.34)
7. Microwave treatment @power level 600 W for 30 second expose time	62.78(79.08)	50.19(59.00)
8. Microwave treatment @power level 600 W for 60 second expose time	61.22(76.82)	50.77(60.01)
9. Microwave treatment @power level 600 W for 90 second expose time	60.07(75.11)	50.97(60.34)
10.Control (Untreated)	63.55(80.16)	49.61(58.01)
S. Em ±	2.39	0.87
CD at 5%	NS	NS
CV%	6.68	3.01

*arcsin √percentage transformation value**figure in parenthesis are retransformed value

The results showed in Table 5.5 indicated that the effect of microwave treatment on germination was found non-significant after given microwave treatment at storage time and four month of storage of groundnut kernels. Germination percent was found non- significant it means no adverse effect of microwave treatment on germination. The germination was decreased after four month of storage, which may be due to pest infestation and storage period.

Conclusion: Looking to the above data, the pest population, kernels damage, moisture content and germination, the treatment of microwave was found not effective against insect-pest of groundnut kernels up to four month of storage, which may be due to late storage. Conducting the experiment was late due to lock down, Pest infestation and damage of kernels was recorded very high due to monsoon season during storage, hence results not obtained satisfactory. Experiment will be carried out next year.

8. Output during Period under Report

y. Special attainments/innovations

z. 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

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

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

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

dd. Trainings/demonstrations organized

ee. Training received

ff. Any other relevant information

9. Constraints experienced, if any: Conducting the experiment was late due to lock down, hence results not obtained satisfactory. Experiment will be carried out next year.

10. Lessons Learnt

11. Evaluation

(a) Self evaluation of the project for the period under report by the PI with ratin 9 in the scale of 1 to 10

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

S. No.	Name	Status in the project (PI/CC-PI/Co-PI)	Rating in the scale of 1 to 10
1	Prof. R.D. Dhudashia	PI	9
2	Prof. A.M. Joshi	Co PI	7
3	Dr. M. N. Dabhi	Co PI	9

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

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 : Junagadh Agricultural University, Junagadh-362001
2. Title of the project : Development of biodegradable cutlery from agro industrial waste.
3. Type of research project : ~~Basic/~~Applied~~/Extension/Farmer Participatory/Other~~ (specify)

4. Genesis and rationale of the project :

Cutlery has been one of the most simple but very useful devices that has been created and used in a world over for consuming food. It is believed that spoons are one of the oldest eating equipment that have been utilised by human beings and were made with natural elements like wood, animal bones, seashells. Stainless steel became the preferred metal for most of the cutlery as it was easy to maintain, non-reactive and sturdy. With the introduction of plastics into the market, it brought down the prices of cutlery drastically and at the same time made its availability very easy. A lot of varieties and sizes were introduced for people to choose from, like cups, plates, spoons, forks, knives, etc. Today the cost of the stainless steel cutlery is higher as well such cutleries cannot disposable. The plastic industry is worth 3000-4000 crores in India itself and as per the Central pollution control board in 2016 India produced more than 15000 tons of plastic waste everyday of which around 9000 tons are recycled and the remaining is not collected or remains littered. This increased to around 25000 tons in 2017. The use of this plastics and the problem of disposing them is a way big problem that is being observed in our country today. (Patil *et al.* 2018)

The post plastic era induces several industries, such as, biomedical, building and packaging industries, to move towards the use of biodegradable items. Biodegradable items prepared from biopolymers and containing reinforcing lignocellulosic particles not only have a big potential to replace petroleum-based films, but also form an essential part of the bioeconomy.

For replacement of plastic cutleries, edible cutleries are now available in a market. Edible cutleries are made out of dried millets (jowar or sorgum), rice and wheat flours. The spoons and chopsticks do not get soggy if placed in water and food. They only soften after some time (10-15 minutes), and can be easily eaten at the end of the meals. Even if discarded, they decompose within 5 to 6 days since they are bio-degradable. (Natarajan N. *et al*, 2019)

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

The area and production of mango fruits are 162.77 '000 Ha and 1207.78 '000 MT respectively in Gujarat state (Horticultural statistics at a glance, 2018) and almost 30-40% mango fruits are processed every year (according to Virat Farm Fresh Products, makhiyala, Tal. & Dist. Junagadh). The peel constitutes about 15 to 20 percent of the whole mango fruit. So, tonnes of mango wastes are generated and it has a great problem of disposal and it creates environmental pollution.

An attractive research area is the production of biodegradable cutleries from mango fruit wastes i.e. peels which are mainly discarded after pulp removal. Mango peels are good source of nutrients i.e. Fat – 3.59 %, Minerals - 3.49 %, crude fiber - 10.61 %, carbohydrates – 26.50 %, protein – 3.9 %, Pectin – 12.9 % etc. possess various beneficial effects on human health (Deepa M. *et al*, 2017). The Mango peels, as food wastes are able to compete with commodity plastics that can be used to form biodegradable cutleries. By choosing the right additives, biopolymers can be dissolved, plasticized or kept undissolved in order to perform the required function as cutleries.

The method for production of edible cutleries is already been well known. But, very negligible information is available for utilization of bio-wastes i.e. mango peels for biodegradable cutleries manufacturing. Hence, the experiment is adopted in this study to develop the process technology for the production of biodegradable cutleries and to generate the information about the interaction between process parameters to optimize their levels for production of good quality cutleries.

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

Deepa M Madalageri, Pushpa Bharati & Udaykumar Kage in their research paper "Physicochemical properties, nutritional and antinutritional composition of pulp and peel of three mango varieties" (2017) compare the three different varieties of mango i.e. *Totapuri, Alphonso & Kesar*. According to this paper, total waste generation which are comparatively higher in Totapuri (76.50 g). Then the data regarding fat, crude fiber, total minerals, Calcium, phosphorous, zinc, iron, manganese and copper were significantly higher in peel compared to pulp irrespective of varieties also obtained.

Fransisco Razza, maurizio fieschi, Francesco Degli Innocent (2009) in their research "compostable cutlery and waste management: An LCA approach" says about the use of disposable cutlery in fast food restaurants and canteens in the current management scenario generate mixed heterogeneous waste. This waste is not recyclable and is disposed without any energy recovery. It says that using by biodegradable and compostable plastic cutlery and alternative management scenario is possible. The resulting mixed waste can be recycled through organic recovery.

NM dana Gopal, P Phebe, EVS Kumar in their research paper "Impact Of Plastic Leading Environmental Pollution" (2014) state that The environmental pollution is defined as the undesirable changes in physical chemical and biological characteristics of our air land and water as a result of overpopulation rapid industrialisation and other human activities like agriculture and deforestation acceptor are loaded with diverse pollutants. Plastic is now regular material which is been used on daily basis in packaging industry, construction industry, disposable cutlery or storage. The increase used in production of plastic in developing emerging countries is a very much for concern as their waste management infrastructure may not be developed. Plastic pollution is defined as the accumulation of the different types of plastic material on land as well as on water bodies. As a community it used on a large scale it consists of a synthetic polymer that consists petrochemicals which degrade in around 500 to 1000 years all we may not know the actual degradation time. During manufacturing many hazardous chemical are emitted which can lead to disease to human and animal as well.

TN Malafi, MA Devine, LL Lesher in their Research paper (1994) "A user evaluation of biodegradable cutlery Journal of environmental polymer" Is a study on the evaluating the acceptance and performance of disposable cutlery made from starch based biodegradable polystyrene cutlery. 243 sailors on board three US Navy vessels at the launch using either biodegradable cutlery made with raisins or polystyrene cutlery the cutlery was rated on sensory and performance dimension as well overall acceptability and the resulted that the Sailor rated both the biodegradable and polyester and utensils are easy to hold.

References :

(1) Deepa M Madalageri, Pushpa Bharati & Udaykumar Kage (2017). Physicochemical properties, nutritional and antinutritional composition of pulp and peel of three mango varieties. International Journal of Educational Science and Research, 7(3) : 81-94.

(2) Fransisco Razza, maurizio fieschi, Francesco Degli Innocent (2009). Compostable cutlery and waste management: An LCA approach. Science Direct, 29(4) : 1424-1433.

(3) Hemraj Narhar Patil, Preeti Sinhal (2018). Atithya: A Journal of Hospitality. 4(1): 45-51.

(4) Horticultural statistics at a glance, 2018 : 180.

(5) Malafi, T.N., Devine, M.A. & Lesher, L.L. (1994). A user evaluation of biodegradable cutlery. Journal of Environ. Polymer Degradation, 2 : 219–223.

(6) NM dana Gopal, P Phebe, EVS Kumar (2014). Impact Of Plastic Leading Environmental Pollution. Journal of Chemical and Pharmaceutical Sciences. 3 : 96-99.

(7) Sangeeta sood, Deepshikha (2018), Development and Quality Evaluation of Edible Plate, ARC Journal of Nutrition and Growth. 4(2) : 1-4

7. Expertise available with the investigating group/Institute :

The PI &2 Co-PIs are associated with AICRP on PHET since many years and having enough experience of working in the field of Processing and Food Engineering. While another Co-PI is a mechanical engineer and having an experience of CAD-CAM design and will help to the PI in making of mold / dye. The facility and man power is available in the institute to conduct the process for product formation easily.

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

Patent will be obtained as per the rules of patent issuing authority.

9. (a) Expected output

i. The process technology for the development of biodegradable cutleries will be standardized.

ii. New product i.e. based on mango wastes will be developed.

iii. The proposed process technology for the biodegradable cutleries will be suggested to the entrepreneurs.

iv. Pollution removal through use of mango wastes as well as reduction in use of plastic cutleries.

v. To create new business opportunities as well as employment generation.

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

A recommendation will be useful for the mango farmers, entrepreneurs, processors and consumers.

10. Signatures

[Project Leader] [Co-PIs] ……

11. Comments and signature

Junagadh is a leading region in Gujarat on the cultivation and production of mango fruits. Many industries are engaged in mango pulp processing. Mango wastes create environmental pollution. Same problem is observed in plastic waste management. Biodegradable cutleries might be made out from mango peels and it might be replace the plastic cutleries. Such kind of project will be helpful for the pollution removal, new technology avail and new employment opportunities. Departmental research activities also get a new direction.

[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)

Project Title : Development of biodegradable cutlery from agro industrial waste.

2. Key Words : Biodegradable cutleries, mango peels & pollution removal

(a) Name of the Lead Institute : College of Agril. Engg. & Technology, Junagadh Agricultural University, Junagadh

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

3. (a) Name of the Collaborating Institute(s), if any : - -

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

4. 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 Food Microbiologist AICRP on PHET, College of Agril. Engg. & Tech., Junagadh Agril. University, Junagadh	P.I.	60%	• Review collection/literature survey • Preliminary trial for development of biodegradable cutleries. • Development of biodegradable cutleries using mango peel powder. • Laboratory trials as per the different process parameters. • Analysis of biodegradable parameters of the products. • Data collection and its analysis. • Report writing.
2.	Dr. P. R. Davara Assistant Research Engineer, AICRP on PHET, College of Agril. Engg. & Tech., Junagadh Agril. University, Junagadh	Co – P.I.	15%	• Work on RSM design. • To analyse the physical and rheological parameters of biodegradable parameters.

3.	Prof. N. B. Parmar Asstt. Professor (Mechanical Engineer) Dept. of Farm Machinery & Power, College of Agril. Engg. & Tech., Junagadh Agril. University, Junagadh	Co-P.I.	15%	To assist the PI, in finalizing spoon design with the help of CAD software. And helping to make final mold of spoon.
4.	Dr. M. N. Dabhi Research Engineer, AICRP on PHET, College of Agril. Engg. & Tech., Junagadh Agril. University, Junagadh	Co – P.I.	10%	Overall guidance, supervision and assist the PI in taking administrative approvals as and when needed to carry out the different project related activities.

5. Priority Area to which the project belongs : Post harvest technology

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

6. Project Duration: Date of Start : **March-2021**

LikelyDate of Completion: **December-2022**

7. (a) Objectives :

i. To develop a process technology for preparation of biodegradable cutlery using mango peel.

ii. To study physical, rheological and biodegradable properties of developed product.

iii. To estimate the cost economics of developed biodegradable cutlery.

(b) Practical utility :

i. The process technology for the development of biodegradable cutleries will be standardized.

ii. New product i.e. based on mango wastes will be developed.

iii. The proposed process technology for the biodegradable cutleries will be suggested to the entrepreneurs.

iv. Pollution removal through use of mango wastes as well as reduction in use of plastic cutleries.

v. To create new business opportunities as well as employment generation.

8. 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	Feb – 2021	April-2021	1. To collect the data on processes of biodegradable items. 2. To study the work done in the past.	100 %	-	A.M. Joshi
2.	Prepare CAD-CAM design of spoon. Finalise it and Make final a mold of spoon.	May–2021	June-2021	Depth, Length, strength etc. parameters will be evaluated in CAD-CAM design of spoon. And finally a mold of spoon will be prepared.	100 %	-	1. A.M. Joshi 2. N. B. Parmar
3.	Collect mango peels. Grind precisely.	July–2021	Aug-2021	- Peels will be collected. - Washing, drying, grinding of the peels.	100 %	-	1. A.M. Joshi 2. Dr. P. R. Davara
4.	Preliminary laboratory trials.	Sept-2021	Oct-2021	Preliminary trial run for preparation of biodegradable cutleries will be carried out.	100 %	-	1. A.M. Joshi 2. Dr. P. R. Davara 3. N. B. Parmar
5.	Preparation of biodegradable cutleries as per the final treatments.	Nov-2021	Feb-2022	Final treatment trials will be carried out.	-	100 %	1. A.M. Joshi 2. Dr. P. R. Davara 3. N. B. Parmar
6.	Quality analysis of biodegradable cutleries	March -2022	May-2022	Developed biodegradable cutleries will be	-	100 %	1. A.M. Joshi

	prepared by different treatments.			analysed for its engineering as well as biodegradable aspects.			2. Dr. P. R. Davara
7.	Data analysis and report writing	June-2022	Aug-2022	Compilation of collected data and preparation of report.	-	100 %	1. A.M. Joshi 2. Dr. M. N. Dabhi

9. Technical Programme (brief)

Justification

Cutlery has been one of the most simple but very useful devices that has been created and used in a world over for consuming food. It is believed that spoons are one of the oldest eating equipment that have been utilised by human beings. A lot of varieties and sizes were introduced in plastic cutleries like cups, plates, spoons, forks, knives, etc which have low prices as well easy to dispose. The plastic industry is worth 3000-4000 crores in India itself and as per the Central pollution control board in 2016 India produced more than 15000 tons of plastic waste everyday of which around 9000 tons are recycled and the remaining is not collected or remains littered. This increased to around 25000 tons in 2017. The use of this plastics and the problem of disposing them is a way big problem that is being observed in our country today. (Patil *et al.* 2018)

The post plastic era induces several industries, such as, biomedical, building and packaging industries, to move towards the use of biodegradable items. Biodegradable items prepared from biopolymers and containing reinforcing lignocellulosic particles not only have a big potential to replace petroleum-based films, but also form an essential part of the bioeconomy.

For replacement of plastic cutleries, edible cutleries are now available in a market. Edible cutleries are made out of dried millets (jowar or sorgum), rice and wheat flours. The spoons and chopsticks do not get soggy if placed in water and food. They only soften after some time (10-15 minutes), and can be easily eaten at the end of the meals. Even if discarded, they decompose within 5 to 6 days since they are bio-degradable. (Natarajan N. *et al*, 2019)

Another research aspect also to be opened to make biodegradable cutleries from mango peels. Like a plastic waste management, processed mango wastes management is again a challenge for the processors. Almost 30-40% mango fruits of their production are processed every year (according to virat farm fresh products, makhiyala, Tal. & Dist. Junagadh). The peel constitutes about 15 to 20 percent of the whole mango fruit. So, tonnes of mango wastes are generated and it has a great problem of disposal and it creates environmental pollution. Mango peels are good source of nutrients i.e. Fat – 3.59 %, Minerals - 3.49 %, crude fiber - 10.61 %, carbohydrates – 26.50 %, protein – 3.9 %, Pectin – 12.9 % etc. possess various beneficial effects on human health (Deepa M. *et al*, 2017). The Mango peels, as food wastes are able to compete with commodity plastics that can be used to form biodegradable cutleries. By choosing the right additives, biopolymers can be dissolved, plasticized or kept undissolved in order to perform the required function as cutleries.

The method for production of edible cutleries is already been well known. But, very negligible information is available for utilization bio-wastes i.e. mango peels for biodegradable cutleries manufacturing. Hence, the experiment is adopted in this study to develop the process technology for the production of biodegradable cutleries and to generate the information about the interaction between process parameters to optimize their levels for production of good quality cutleries.

Objectives :

i. To develop a process technology for preparation of biodegradable cutlery using mango peel.
ii. To study physical, rheological and biodegradable properties of developed product.
iii. To estimate the cost economics of developed biodegradable cutlery.

Technical programme :

a. Design : Optimal design for mixture (Response Surface Methodology)
b. Replication : 3
c. Treatments : 17

Run	Mango Peel powder (%)	Maida flour (%)	Carboxy Methyl cellulose (%)
1	60.00	10.00	30.00
2	60.55	29.45	10.00
3	65.25	18.50	16.25
4	68.24	10.00	21.76
5	60.55	29.45	10.00
6	80.00	10.00	10.00
7	80.00	10.00	10.00
8	52.84	17.16	30.00
9	65.25	18.50	16.25
10	68.24	10.00	21.76
11	57.39	20.00	22.61
12	40.00	30.00	30.00
13	72.74	17.11	10.16
14	49.94	30.00	20.06
15	46.84	24.15	29.01
16	57.39	20.00	22.61
17 (Control)	100 %	-	-

<u>Methodology</u> :

Mango Peel as raw material

↓

Drying

↓

Grinding and making powder using 48 mesh size.

↓

Add Maida flour & Carboxymethyl cellulose

↓

Mixing

↓

Making dough with 1:1 ratio of powder and water

↓

Molding

↓

Heating the cutlery at 80°C for 50 minutes in oven.

↓

Allowed to cool and packed in bag.

↓

Store at dry and cool environment.

Observation to be recorded:

(A) Physical & Rheological Parameters

(1) Moisture content

(2) Hardness

(3) Compressive strength

(4) Tensile strength

(5) Water absorption index

(6) Water solubility index

(B) Biodegradablity parameters

- Soil burial test

(C) Sensory parameters (Visual observation)

- Colour
- Appearance
- Texture
- Overall acceptability

Possible Outputs :

i. The process technology for the development of biodegradable cutleries will be standardized.

ii. New product i.e. based on mango wastes will be developed.

iii. The proposed process technology for the biodegradable cutleries will be suggested to the entrepreneurs.

iv. Pollution removal through use of mango wastes as well as reduction in use of plastic cutleries.

v. To create new business opportunities as well as employment generation.

References :

(1) Deepa M Madalageri, Pushpa Bharati & Udaykumar Kage (2017). Physicochemical properties, nutritional and antinutritional composition of pulp and peel of three mango varieties. International Journal of Educational Science and Research, 7(3) : 81-94.

(2) Fransisco Razza, maurizio fieschi, Francesco Degli Innocent (2009). Compostable cutlery and waste management: An LCA approach. Science Direct, 29(4) : 1424-1433.

(3) Hemraj Narhar Patil, Preeti Sinhal (2018). Atithya: A Journal of Hospitality. 4(1): 45-51.

(4) Horticultural statistics at a glance, 2018 : 180.

(5) Malafi, T.N., Devine, M.A. & Lesher, L.L. (1994). A user evaluation of biodegradable cutlery. Journal of Environ. Polymer Degradation, 2 : 219–223.

(6) NM dana Gopal, P Phebe, EVS Kumar (2014). Impact Of Plastic Leading Environmental Pollution. Journal of Chemical and Pharmaceutical Sciences. 3 : 96-99.

(7) Sangeeta sood, Deepshikha (2018), Development and Quality Evaluation of Edible Plate, ARC Journal of Nutrition and Growth. 4(2) : 1-4

11. Financial Implications (` in Lakhs)

(A) Financed by the institute

11.1 Manpower (Salaries / Wages)

Sr. No.	Staff Category	Man months	Cost
1.	Scientific	24	23,50,000
2.	Technical	--	--
3.	Supporting	12	90,000
4.	SRFs/RAs	--	--
5.	Contractual	--	--
	Total	36	24,40,000

11.2 Research / Recurring Contingency

S. No.	Item	Year(1)	Year (2)	Total
1.	Consumables	15,000	15,000	30,000
2.	Travel	2,000	2,000	4,000
3.	Field Preparation/ Planting/ Harvesting (Man-days/costs)	--	--	--
4.	Inter-cultivation & Dressing (Man-days/costs)	--	--	--
5.	Animal/Green house/Computer Systems/Machinery Maintenance	--	--	--
6.	Miscellaneous(Other costs)	2,000	2,000	4,000
	Total(Recurring)	19,000	19,000	38,000

Justification : ---

11.3 Non-recurring (Equipment)

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

Justification : --

11.4 Any Other Special Facility required (including cost) :

S. No.	Item	Year (1)	Year (2)	Total	Remarks
1.	--	--	--	--	--
2.	--	--	--	--	

11.5 Grand Total (11.1 to 11.4)

Item	Year (1)	Year (2)	Total
Grand Total	12,39,000	12,39,000	24,78,000

(B) Financed by an organization other than the Institute (if applicable) : - Nil -

(i) Name of Financing Organization

(ii) Total Budget of the Project

(iii) Budget details

Sr. No.	Item	Year(1)	Year(2)	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	--	--	--

12. Expected Output : Process will be standardised for preparation of biodegradable cutleries and will be provided to the society**.**

13. Expected Benefits and Economic Impact :

i. The process technology for the development of biodegradable cutleries will be standardized.
ii. New product i.e. based on mango wastes will be developed.
iii. The proposed process technology for the biodegradable cutleries will be suggested to the entrepreneurs.
iv. Pollution removal through use of mango wastes as well as reduction in use of plastic cutleries.
v. To create new business opportunities as well as employment generation.

14. Risk Analysis :

15. Signature :

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

16. Signature of HoD

17. 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 biodegradable cutlery from agro industrial waste.
2. Date of Start & Duration : February – 2021 to December - 2022
3. Institute Project [√] or Externally Funded [ ]
4. Estimated Cost of the Project : 24,78,000/- INR
5. Project Presented in the Divisional/Institutional Seminar? Y [√]
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 PMECELL OF RPP-I
(Refer for Guidelines ANNEXURE-XI (D)

1. Institute Name : AICRP on PHET, JAU, Junagadh
2. Project Title : Development of biodegradable cutlery from agro industrial waste.
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

Tentative Technical Programme for the year 2020-21

Sr.No.	Title
1.	Investigation No. 1 (Code No:PH/JU/85/1) Establishment of Agro Processing Centre training and demonstration of technologies (Operational research project on Agro Processing Centres)
2.	Investigation No. 2 (Code No.: PH/JU/2018/02) Design and development of grain treater for enzymatic pre-treatment to pigeon pea grains.
3.	Investigation No. 3 (Code No. : PH/JU/2020/01) Standardization of process technology for preparation of peanut sauce and peanut wadi (Chunks).
4.	Investigation No. 4 (Code No. :PH/JU/2020/02) Application of microwave technology for disinfestations of groundnut kernels.
5.	Development of biodegradable cutlery from agro industrial waste.

Publications, Training and Demonstrations

(1) RESEARCH / POPULAR ARTICLES PUBLISHED BY THE TEACHERS OF THE DEPARTMENT DURING YEAR, (2019-20)

A	**Publications**		
A1	**Books :**		
S N	**Title**	**Author**	**Name of Publisher**
1.	Pigeon pea milling	V. P. Sangani, Vaishali C. Chotaliya P. R. Davara	Scholar's Press, International Book Market Service Ltd. ISBN No. 978-613-8-93437-02020
2.	Effect of ozone and plastic material against the microbes of tomatoes	A. M. Joshi; BrijeshKhanpara; DharaVagh	Lambert Academic publishing; 2019

A2	**Research paper in referred Journals**			
SN	**Title of Paper**	**Author**	**Name of Journal**	**NAAS Rating**
1.	Effect of enzyme pretreatment on dehulling, cooking time and protein content of pigeon pea (variety BDN2).	M. N. Dabhi, V. P. Sangani, P. J. Rathod,	Journal of Food Science and Technology, 56(10):4552-4564 ISSN 0022-1155 CFTRI Mysore	7.85
2.	Response surface modeling of process parameters for banana juice clarification.	M. J. Nayaka,, E. R. Paghadal,, U. V. Patel, P. R. Davara,	Green Farming, 10(2):160-166 ISSN 0974-0775	4.79
3.	Physico-chemical analysis of honey based herbal gooseberry candies. 2020.	S. P., Cholera, M. B Kapopara. P. J. Rathod, S. D. Jadav, D. L. Pranami,	International Journal of Chemical Studies, 8(2):2501-2509 P-ISSN Number :2349-8528 (2020) DOI :https://doi.org/10.22271/chemi.2020. v8.i2al.9126	5.31
4.	Effect of Evaporative Water Cooled Grinding on Milling Quality of Wheat	P. R. Davara, V. P. Sangani, P. P. Vora, N. C. Thumar, H. V. Agravat J. Limbasiya.	*Int.J.Curr.Microbiol.App.Sci.* 9(06):1183-1190. doi:https://doi.org/10.20546/ijcmas.2020.906.147 2020	5.38
5.	Optimization of foaming and stabilizing	B. D. Chougale, V. P. Sangani,	*International Journal of Chemical Studies*, 8(5):2458-2462.	5.31

	process parameters for foam mat drying of prickly pear (Opuntiaelatior Mill.) pulp	P. R. Davara P. J. Rathod	**DOI:** chemi. 2020.v8.i5ah. 10685.2020	
6.	Influence of Gamma Irradiation on Micorbial Load of Peanut Kernels.	D. K. Gojiya,; S. P. Cholera, A. M. Joshi,	International Journal of Current Microbiology and Applied Sciences,9(8):589-602 ISSN:2319-7706 (2020)	5.38

A3	**Chapter in Book :**		
Sr. No.	**Title**	**Author**	**Name of Publisher**
1.	The effect of peanut (Arachishypogaea L.) flour on the quality and sensory analysis of cookies.	T. L. Dharsenda, M. N. Dabhi, M. H. Jethava, M. B. Kapopara,	Chapter in book Modern technology of agriculture, forestry, biotechnology and food science, Edited by Ratnesh Kumar Rao. Mahima Research Foundation and Social Welfare, Varanasi, UP, India. 2020. ISBN:978-81-943375-2-2.

A4	**Articles in vernacular language magazine**			
1.	Ragima Mulyavardhanni Tako	B M Devani B L Jani Dr. S H Akbari Dr. M N Dabhi Sh. D M Vyas	Krushi Jagran	April-2019
2.	Tametana Paakma Mulyavardhanni Tako	B M Devani B L Jani Dr. S H Akbari Dr. M N Dabhi	Krushi Jagran	May-2019
3.	Khadhya Padarthona Prasanskaranni Aadhunik Takniko	B M Devani B L Jani Dr. S H Akbari Dr. M N Dabhi	Krushi Jivan	February-2020
4.	Nutraceuticals: Nutritionally Functional Foods	B M Devani B L Jani Dr. M N Dabhi	Food Marketing & Technology	March-2020
5.	Hathala Thorna Jindavani Agatyata ane Pulp	Dr. P R Davara Viraj Naliyapara	Krushi Jivan	2019

	Melavvani Rit			
6.	Hathala Thorna Jindavanu Processing ane Mulyavardhan	Viraj Naliyapara Dr. P R Davara	Krushi Jivan	2020

Organized technology and demonstration mela at CAET on 19-02-2020


20-02-2020

કૃષિ યુનિવર્સિટી ખાતે ધરતીપુત્રો માટે કૃષિ ટેક્નોલોજી મશીનરી નિદર્શન મેળો યોજાયો

Organized training under SCSP

1 Agricultural product processing and value addition as well as use of plastic in agriculture at Tukda, Ta. Porbandar on 31/01/2020.

Prof. A.M. Joshi, Performed a duty as aAgril. Scientist in Krishi mahotsav-2019 at Jasdan (Tal. Rajkot)

A 2 **Demonstrations organized**

- Demonstrated processing machinery in technology and demonstration mela at CAET on 19-02-2020

- Processing machinery were demonstrated in “Food &Agri Tech” an Exhibition of Technology, Products & Services organized by The Southern Gujarat Chamber of Commerce & Industry during 06-08 March, 2020 at Surat.