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Effect of drying temperature on Physio-chemical properties of protein enriched mango leather

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Abstract
This research paper highlights the significant impact of drying temperature on the physio-chemical properties of protein enriched mango leather. The study was carried out to optimized process parameters by using tray drying techniques. Protein enriched mango leather was prepared by varying process variables *viz.* whey protein (3-7%), sugar (10-20%), thickness of mango pulp (3-7 mm) and drying temperature (50-70 °C) and its responses like protein content, overall acceptability, Vitamin C and color values were analyzed by using Response Surface Methodology. The optimum value of process parameters like whey protein, sugar, thickness, temperature (4.00%, 17.50%, 6.00mm, 65 °C) for tray dried protein enriched mango leather having protein content=6.54 g/100gm, Vitamin-C = 67.25 mg/100gm, Overall acceptability= 7.33, color value L*=36.99, a*=9.67, b*=19.21, respectively.

Keywords: Physio-chemical, temperature, protein, mango leather

1. Introduction
Mango (*Mangifera Indica* L.) belonging to the *Anacardiaceae* family, the most important tropical and subtropical fruits of the world, is called as the king of fruits on account of its nutritive value, taste, attractive fragrance and health promoting qualities. The mango is the national fruit of India] Pakistan, and the Philippines. There are nearly 1,500 mango varieties in India, only about 20 are grown commercially. Most of the Indian mango varieties have specific eco-geographical requirements for optimal growth and fruiting.

The total global area under mango is 5.44 million ha and the global production is to the tune of 43.30 million tons. India ranks first among world's mango producing countries accounting for about 46% of the global area and 42% of the global production. Mangoes contain over 20 different vitamins and minerals. The fruit contains nearly 81moisture, 0.6% protein, 0.4% fat and 0.8% of fibers. It also contains nearly 17% of carbohydrate. The fruit is rich with important minerals like potassium, magnesium, sodium, phosphorus, and Sulphur (Sarojini *et al.*, 2009) [8]. Mango is a good source of dietary fiber, therefore, it is associated with a reduced risk of some types of cancer, protecting against heart disease and cholesterol build up (Abano *et al.*, 2013) [2]. The different products from ripe mango are mango pulp, mango jam, mango kulfi, mango leather/bar, mango toffee, mango candy etc. Mango pulp is perfectly suited for conversion to juices, nectars, soft drinks, jams, jelly and powder. Mango powder can also be used in puddings, bakery fillings, and fruit meals for children, flavors for food industry, and also to make the most delicious ice cream and yoghurt.

To avoid post-harvest losses and increase the shelf life, mango has to be processed into shelf stable product like mango leather. Mango leather is a healthy alternative to sugar confectionery. It is produced locally and can be a cheaper alternative ingredient. The quality of mango leather is affected by the drying method, type of dryer, tray design, and operating parameters. The pulp making process, mixing with other ingredients, drying temperature, thickness of pulp, total drying time, packaging, and storage conditions should be well established for high quality product. Biochemical, colour, texture, and moisture content are the most important parameters of mango leathers that are usually affected by drying. This study aims to standardize the production process of protein-enriched mango leather using the drying technique. The research objectives include optimizing different ingredients for protein-enriched mango leather (Aam papad) and evaluating the mango leather for its physico-chemical and sensory qualities.

2. Materials and Methods

The experimental procedures for determining various quality attributes and optimizing the process for producing kesar mango leather using the tray drying technique. The experiment was conducted in the Department of Processing and Food Engineering at the College of Agricultural Engineering and Technology, CAET AAU, Godhra, Gujart.

The raw materials and chemicals used for developing mango leather include fresh Kesar mango pulp, sugar, citric acid, pectin and whey protein concentrate. The apparatus and equipment utilized in the process consist of stainless steel knives, spoons, round plates, petri dish, bowls, beakers, an electronic weighing balance, digital tray dryer, digital photoelectric calorimeter, pH meter (Systronics), digital refractometer, BLS orbital shaker machine. The variables and their levels were WPC (3, 4, 5, 6, 7%), sugar concentration (10, 12.5, 15, 17.5, 20%), temperature (50, 55, 60, 65, 70 °C) and thickness (3, 4, 5, 6, 7 mm). The experimental design involved adopting Response Surface Methodology to optimize the response of interest influenced by several variables. RSM allows for statistically acceptable results with fewer experimental runs (Table 1).

Table 1: Treatment combinations in term of coded and actual values for preparation of protein enriched mango leather

Sr. No.	Coded Value				Actual Value			
	Whey protein (%)	Sugar (%)	Thickness (mm)	Temp. (°C)	Whey protein (%)	Sugar (%)	Thickness (mm)	Temp. (°C)
1	-1	-1	-1	-1	4.0	12.5	4.0	55.0
2	1	-1	-1	-1	6.0	12.5	4.0	55.0
3	-1	1	-1	-1	4.0	17.5	4.0	55.0
4	1	1	-1	-1	6.0	17.5	4.0	55.0
5	-1	-1	1	-1	4.0	12.5	6.0	55.0
6	1	-1	1	-1	6.0	12.5	6.0	55.0
7	-1	1	1	-1	4.0	17.5	6.0	55.0
8	1	1	1	-1	6.0	17.5	6.0	55.0
9	-1	-1	-1	1	4.0	12.5	4.0	65.0
10	1	-1	-1	1	6.0	12.5	4.0	65.0
11	-1	1	-1	1	4.0	17.5	4.0	65.0
12	1	1	-1	1	6.0	17.5	4.0	65.0
13	-1	-1	1	1	4.0	12.5	6.0	65.0
14	1	-1	1	1	6.0	12.5	6.0	65.0
15	-1	1	1	1	4.0	17.5	6.0	65.0
16	1	1	1	1	6.0	17.5	6.0	65.0
17	-2	0	0	0	3.0	15.0	5.0	60.0
18	2	0	0	0	7.0	15.0	5.0	60.0
19	0	-2	0	0	5.0	10.0	5.0	60.0
20	0	2	0	0	5.0	20.0	5.0	60.0
21	0	0	-2	0	5.0	15.0	3.0	60.0
22	0	0	2	0	5.0	15.0	7.0	60.0
23	0	0	0	-2	5.0	15.0	5.0	50.0
24	0	0	0	2	5.0	15.0	5.0	70.0
25	0	0	0	0	5.0	15.0	5.0	60.0
26	0	0	0	0	5.0	15.0	5.0	60.0
27	0	0	0	0	5.0	15.0	5.0	60.0
28	0	0	0	0	5.0	15.0	5.0	60.0
29	0	0	0	0	5.0	15.0	5.0	60.0
30	0	0	0	0	5.0	15.0	5.0	60.0

Mango pulp (100 g) was weighed and its total soluble solids content was measured to be 21-22 °Brix. Sugar was added to adjust the total soluble solids to 30-43 °Brix. Citric acid (0.3%) was added and the mixture was shaken. The mixture was then heated to 90 °C and pectin was added. Stainless steel plates were smeared with vegetable oil or ghee to prevent sticking. The mango pulp was spread on the plates and dried to a moisture content of 15-20% (w.b). The dried mango leather was cooled, scraped, cut into rectangular pieces, and rolled. The pieces were packed in selected packaging materials and sealed. The mango leather was stored at ambient conditions (Fig. 1).

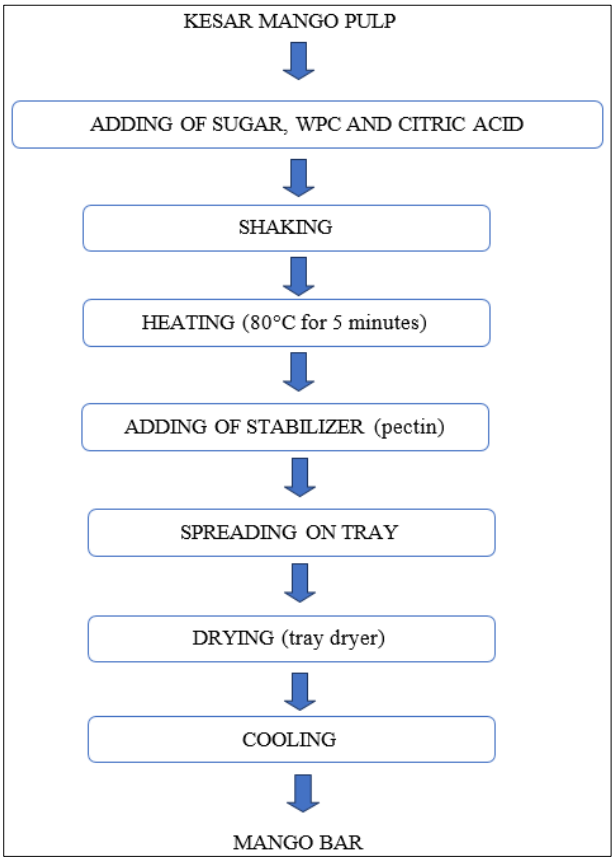

Fig 1: Process flow chart for preparation of protein enriched mango leather

Proximate composition represents the gross content of important chemical constituents such as Moisture, Protein, vitamin C, acidity, TSS, Colour value. The study of the proximate composition serves as an important base to study the nutritive quality of mango pulp and mango leather. The standard methods have been used for the proximate analysis.

2.1 Determination of protein content (Micro Kjeldahl Method)

The protein content of mango pulp and leather were determined using Micro-Kjeldahl's apparatus (AOAC, 2005) [1]. The procedure involved taking approximately 0.2g of sample and transferring it to a digestion flask along with catalyst mixture and concentrated sulfuric acid. After digestion, water was added, and the contents were transferred to a 50 ml volumetric flask and diluted with distilled water. In the distillation unit, ammonia liberated from the digest was collected and titrated with hydrochloric acid. The protein content was calculated using appropriate formulas. Reagents used included N-free sulfuric acid, hydrogen peroxide, boric acid, sodium hydroxide with sodium thiosulfate, a catalyst mixture, mixed indicator, and standard hydrochloric acid.

$$\text{Nitrogen, \%} = \frac{Titre\ value \times Normality\ of\ HCL \times Volm\ made\ up\ of\ digest \times 100}{Aliquot\ of\ the\ sample \times weight\ of\ the\ sample\ taken \times 1000}$$

Protein (%) = Nitrogen (%) × 6.25

2.2 Acidity

Acidity of Kesar mango pulp and leather were determined by following the method described by Ranganna (2004) [7]. 10 ml mango pulp was taken in a 100 ml conical flask. A few drops of 1% phenolphthalein solution (indicator) was added to the flask and titrated with 0.1N NaOH solution from a burette until a light pink color appeared and persist for 15 seconds. The titration was repeated in triplicate for accuracy. Percent acidity was calculated using the following formula:

$$\text{Acidity (\%)} = \frac{\text{T x N x V1 x E}}{\text{V2 x W x 1000}} \text{X100}$$

Where,
T= Titre, ml
N= Normality of NaOH, N
V_1=Volume made up, ml
E= Equivalent weight of acid,
V_2= Volume of mango pulp taken for estimation, ml
W= Weight of mango pulp, gm

2.3 Total soluble solid (TSS)

Total soluble solid (TSS) of kesar mango pulp and leather were determined by using Hand Refractometer. Two drops of prepared mango pulp was taken and placed on the prism of a Refractometer. TSS was obtained from direct reading of the Refractometer.

2.4 Determination of Ascorbic acid (Vitamin-C)

The ascorbic acid content of Kesar mango pulp was determined using the Rangana (2004) [7] method. The required reagents included 3% meta-phosphoric acid, ascorbic acid standard solution, and dye solution. The dye solution was standardized by titrating it with the standard solution. For the procedure, five grams of Kesar mango pulp were blended with 3% meta-phosphoric acid solution, and the liquid was filtered. Then, 5 ml of the filtrate was titrated with 2-6 dichlorophenol-indophenol dye, and the ascorbic acid content was calculated using a formula.

$$\text{Ascorbic Acid (\%)} = \frac{\textit{Titre x Dye Factor x Volume made up x100}}{\textit{Aliquot of extract taken for estimation x Weight or volume of sample taken taken for estimation}}$$

2.5 Colour

The kesar mango pulp and prepared mango leather color were assessed using L*, a*, and b* values on the CIELAB color scale. The instrument was calibrated using a standard white tile as per the reference manual. L* ranges from 0 to 100, with higher values indicating whiteness and lower values indicating darkness. Positive a* values indicate redness, while negative values indicate greenness. Positive b* values represent yellowness and negative b* values indicate blueness.

3. Results and Discussions

3.1 Total Soluble Solids (TSS)

TSS is an essential parameter that influences the taste and consistency of the product. The TSS values ranged from 35 to 45°Brix. The highest TSS was observed at 6% whey protein and 12.50% sugar with a thickness of 4 mm and a temperature of 55 °C (45°Brix). The lowest TSS was found in formulations with 6% whey protein, 15.00% sugar, 5 mm thickness, and 60 °C temperature (35°Brix).

3.2 Acidity

Acidity is crucial for the preservation and flavor enhancement of the product. The acidity percentage ranged from 1.60 to 3.66%. The highest acidity was observed at 6% whey protein, 12.50% sugar, 6 mm thickness, and 55 °C temperature (3.66%). The lowest acidity was found in formulations with 4% whey protein, 17.50% sugar, 4 mm thickness, and 65 °C temperature (1.60%).

3.3 Protein Content

Protein content is an important nutritional factor, especially for a whey protein-based product. The protein content varied between 4.21 to 12.28 g/100g. The highest protein content of 12.28 g/100g was observed in formulations with 7% whey protein, 15.00% sugar, 5 mm thickness, and 60 °C temperature. The lowest protein content of 4.21 g/100g was found in formulations with 4% whey protein, 12.50% sugar, 4 mm thickness, and 65°C temperature.

Table 2: Effect of process parameters on physic-chemical propertied of protein fortified mango leather

Sr. No.	Whey protein (%)	Sugar (%)	Thickness (mm)	Temperature (°C)	Protein (g/100 g)	Vitamin C (mg/100 g)	TSS (°Brix)	Acidity (%)
1	4	12.50	4	55	7.00	57.40	42	1.99
2	6	12.50	4	55	7.14	69.76	45	2.96
3	4	17.50	4	55	6.02	39.65	40	1.60
4	6	17.50	4	55	7.24	64.53	43	2.38
5	4	12.50	6	55	7.95	39.82	38	2.38
6	6	12.50	6	55	10.91	44.85	37	3.66
7	4	17.50	6	55	10.53	44.57	38	2.98
8	6	17.50	6	55	7.16	39.80	36	2.48
9	4	12.50	4	65	6.30	34.66	40	2.49
10	6	12.50	4	65	5.79	49.70	42	2.47
11	4	17.50	4	65	7.37	44.79	42	1.89
12	6	17.50	4	65	10.64	54.74	39	2.50
13	4	12.50	6	65	8.78	34.86	35	2.44
14	6	12.50	6	65	11.68	89.13	35	1.88
15	4	17.50	6	65	5.27	69.32	39	2.46
16	6	17.50	6	65	9.22	59.60	37	1.84
17	3	15.00	5	60	9.25	54.52	44	1.90
18	7	15.00	5	60	12.28	49.52	41	2.54
19	5	10.00	5	60	5.44	44.74	39	1.82
20	5	20.00	5	60	4.35	39.73	40	2.48
21	5	15.00	3	60	4.53	30.94	44	2.48
22	5	15.00	7	60	5.23	79.73	31	3.10
23	5	15.00	5	50	5.72	31.00	36	2.43
24	5	15.00	5	70	4.89	39.93	37	2.55
25	5	15.00	5	60	4.21	39.92	35	2.55
26	5	15.00	5	60	4.21	39.92	35	2.55
27	5	15.00	5	60	4.21	39.92	35	2.55
28	5	15.00	5	60	4.21	39.92	35	2.55
29	5	15.00	5	60	4.21	39.92	35	2.55
30	5	15.00	5	60	4.21	39.92	35	2.55

The Model F-value of 8.58 implies the model is significant. Hence, A (whey protein) is significant term and R^2 and adjusted R^2 value of the model are 0.8889 and 0.7853 respectively. The adequate precision value of 11.2520 indicates that the model can be used to predict the response within the design space as it is greater than 9.2176. Consideration of the criteria, following response model was selected for representing the variations of protein for the analysis (Table 3).

Protein content = 4.21 + 0.6925A - 0.1783B + 0.6417C - 0.0233D -0.0262AB + 0.1450AC + 0.5413AD - 0.7612BC + $1.49A^2$+ $2.52B^2$+ $0.0177C^2$ + $0.1240D^2$

Table 3: ANOVA for protein content of protein fortified mango leather

Source	Sum of Squares	df	Mean Square	F-value	p-value	
Model	257.61	14	18.40	8.58	< 0.0001	Significant
A-WHEY	11.51	1	11.51	5.36	0.0351	
B-SUGAR	0.7633	1	0.7633	0.3557	0.5598	
C-THICKNESS	9.88	1	9.88	4.61	0.0486	
D-TEMPERATURE	0.0131	1	0.0131	0.0061	0.9388	
AB	0.0110	1	0.0110	0.0051	0.9438	
AC	0.3364	1	0.3364	0.1568	0.6977	
AD	4.69	1	4.69	2.18	0.1601	
BC	9.27	1	9.27	4.32	0.0552	
BD	0.2500	1	0.2500	0.1165	0.7376	
CD	1.16	1	1.16	0.5385	0.4744	
A^2	60.81	1	60.81	28.34	< 0.0001	
B^2	174.38	1	174.38	81.27	< 0.0001	
C^2	0.0086	1	0.0086	0.0040	0.9504	
D^2	0.4215	1	0.4215	0.1964	0.6640	
Residual	32.19	15	2.15			
Lack of Fit	32.19	10	3.22			
Pure Error	0.0000	5	0.0000			
Cor Total	289.79	29				
Std. Dev.	1.46		R^2		0.8889	
Mean	7.53		Adjusted R^2		0.7853	
C.V. %	19.45		Predicted R^2		0.3602	
			Adeq. Precision		11.2520	

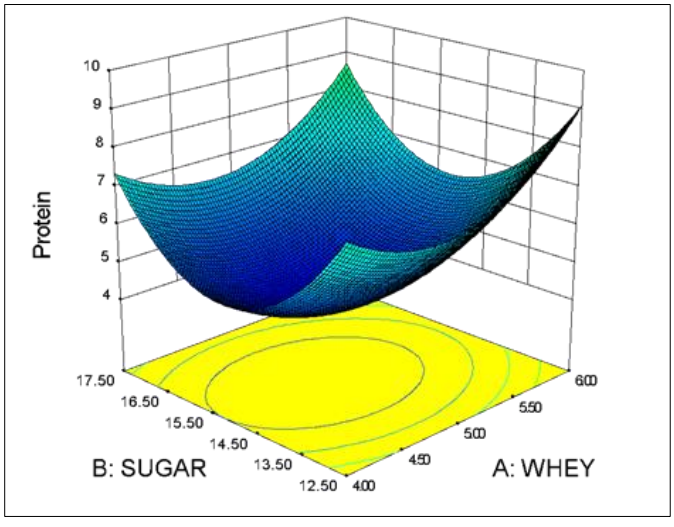

Fig 2: variation of protein with respect to sugar and WPC proportion in mango leather

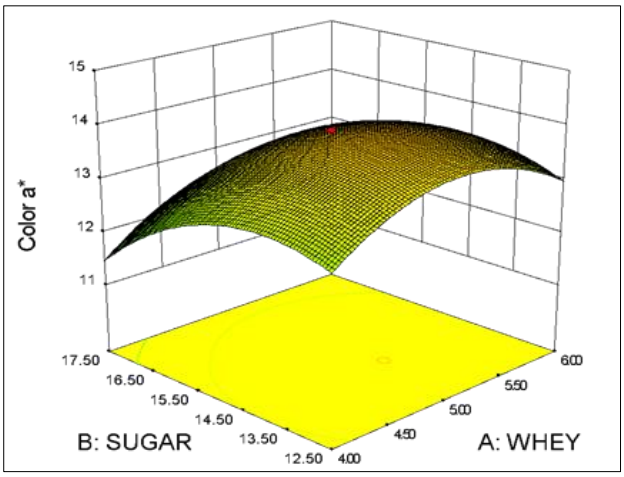

Fig 3: Variation of colour value (a*) with respect to sugar and WPC in protein enriched mango leather

P-values less than 0.0500 indicate model terms are significant. In this case A, C, A^2, B^2 are significant model terms. It can be observed from Fig. 2 that protein at centre was minimum and sides have high protein compare with centre. It can also observed from the figure that increase or decrease in whey protein may increase or decrease in the protein content in mango leather. Mir and Nath (2000) [6], Gayathri and Uthira (2008) [4], Chauhan N. (2013) [3] and Jethva *et al.* (2021) [5] have also observed similar behaviour with increase in other source of protein.

Table 4: Effect of process parameters on color values of protein enriched mango leather

Sr. No.	Whey protein (%)	Sugar (%)	Thickness (mm)	Temperature (°C)	Colour Values		
					L*	a*	B*
1	4	12.50	4	55	45.26	14.06	31.40
2	6	12.50	4	55	37.20	10.29	25.30
3	4	17.50	4	55	39.30	9.19	23.57
4	6	17.50	4	55	40.98	9.32	24.73
5	4	12.50	6	55	43.27	11.33	31.18
6	6	12.50	6	55	41.00	11.84	28.55
7	4	17.50	6	55	37.03	7.59	18.99
8	6	17.50	6	55	43.40	9.06	28.43
9	4	12.50	4	65	39.69	11.02	23.43
10	6	12.50	4	65	41.34	12.74	28.00
11	4	17.50	4	65	36.55	11.54	19.06
12	6	17.50	4	65	49.64	15.52	38.66
13	4	12.50	6	65	38.96	10.96	23.94
14	6	12.50	6	65	40.63	11.97	28.28
15	4	17.50	6	65	42.10	11.79	26.83
16	6	17.50	6	65	31.55	7.74	11.38
17	3	15.00	5	60	41.36	8.69	25.77
18	7	15.00	5	60	38.33	11.15	25.41
19	5	10.00	5	60	40.66	10.11	24.84
20	5	20.00	5	60	39.47	10.15	22.98
21	5	15.00	3	60	34.47	7.02	17.07
22	5	15.00	7	60	34.30	7.21	14.89
23	5	15.00	5	50	25.10	11.73	18.34
24	5	15.00	5	70	38.85	12.65	22.69
25	5	15.00	5	60	42.97	13.90	29.98
26	5	15.00	5	60	42.97	13.90	29.98
27	5	15.00	5	60	42.97	13.90	29.98
28	5	15.00	5	60	42.97	13.90	29.98
29	5	15.00	5	60	42.97	13.90	29.98
30	5	15.00	5	60	42.97	13.90	29.98

3.4 Ascorbic acid (Vitamin C)

Vitamin C is an essential nutrient that contributes to the product's overall nutritional value. The vitamin C content ranged from 30.94 to 89.13 mg/100g. The highest vitamin C content (89.13 mg/100g) was observed at 6% whey protein, 15.00% sugar, 7 mm thickness, and 60 °C temperature. The lowest vitamin C content (30.94 mg/100g) was found in formulations with 4% whey protein, 17.50% sugar, 4 mm thickness, and 55 °C temperature.

3.5 Colour Values (L*, a*, b*)

Table 4 shows the colour values of mango leather with different combinations of whey protein, sugar, thickness and temperature conditions.

In general, the colour of mango leather becomes lighter (higher L*) and redder (higher a*) with increasing whey protein content. This is because whey protein contains amino acids that can react with the mango juice to produce red pigments. The colour also becomes lighter with increasing sugar content. This is because sugar can absorb light, making the mango leather appear lighter. The thickness of the mango leather has a small effect on the colour. Thinner mango leather is slightly lighter and redder than thicker mango leather. This is because the thinner mango leather has less surface area, so it absorbs less light. The temperature at which the mango leather is processed had significant effect on the colour values. Mango leather processed at a higher temperature is darker (lower L*) and yellower (higher b*). This is because the higher temperature causes the mango juice to caramelize, producing brown pigments.

Colour value (a*) of the mango leather ranged from 7.02 to 14.06 with and avg. value of 10.54. The maximum colour value (a*) in combination (sugar:15%, WPC:5%, thickness:3, tempature:60 °C) was about 2 times more than the minimum combination (sugar:12.5%, WPC:4%, Thickness:4, Temperature: 55 °C) colour value (a*) at point of the statistical details are given in table. The Model F-value of 2.85 implies the model is significant. There is only a 2.64% chance that an F-value this large could occur due to noise (Table 5).

R^2 and adjusted R^2 values of the model are 0.7270 and 00.4723 respectively. The adequate precision value of 5.8868 indicates that the model can be used to predict the response within the design space as it is greater than 4.68. In consideration of the criteria, the following response model was selected for representing the variations of temperature for the analysis. P-values less than 0.0500 indicate model terms are significant. In this case A, D, BD A^2, B^2, C^2 are significant model terms.

Colour value (a*)= 13.9 + 0.246667 A + 0.515833 B + 0.459167 C + 0.518333 D + 0.12875 AB - 0.195 AC + 0.27 AD - 0.46125 BC + 0.76625 BD - 0.3325 CD - 0.801875 A^2 - 0.749375B^2 - 1.50312 C^2 - 0.234375 D^2

Table 5: ANOVA for colour value (a*) of protein fortified mango leather

Source	Sum of Squares	df	Mean Square	F-value	p-value	
Model	113.95	14	8.14	2.85	0.0264	Significant
A-WHEY	1.46	1	1.46	0.5120	0.4853	
B-SUGAR	6.39	1	6.39	2.24	0.1553	
C-Thickness	5.06	1	5.06	1.77	0.2028	
D-Temperature	6.45	1	6.45	2.26	0.1535	
AB	0.2652	1	0.2652	0.0930	0.7646	
AC	0.6084	1	0.6084	0.2133	0.6508	
AD	1.17	1	1.17	0.4089	0.5322	
BC	3.40	1	3.40	1.19	0.2919	
BD	9.39	1	9.39	3.29	0.0896	
CD	1.77	1	1.77	0.6202	0.4432	
A^2	17.64	1	17.64	6.18	0.0252	
B^2	15.40	1	15.40	5.40	0.0346	
C^2	61.97	1	61.97	21.73	0.0003	
D^2	1.51	1	1.51	0.5282	0.4785	
Residual	42.78	15	2.85			
Lack of Fit	42.78	10	4.28			
Pure Error	0.0000	5	0.0000			
Cor Total	156.74	29				
Std. Dev.	1.69		R^2		0.7270	
Mean	11.27		Adjusted R^2		0.4723	
C.V. %	14.99		Predicted R^2		-0.5723	
			Adeq. Precision		5.8868	

It can be observed from Fig. 3 that the sugar had significant effect on colour value (a*). This might be due to the better sugar-acid blend of the product. Jethva *et al.* (2021) [5] have also observed similar type of behaviour for increase in colour values of the mango leather.

3.6 Overall Acceptability

Sensory evaluation of the mango leather ranged from 5.86 to 7.46 with an average value of 6.74 (Table 6). The Model F-value of 9.83 implies the model is significant. R^2 and adjusted R^2 value of the model are 0.9017 and 0.8100 respectively. The adequate precision value of 11.3230 indicates that the model can be used to predict the response within the design space as it is greater than 4.68. Consideration of the criteria, following response model was selected for representing the variations of protein for the analysis. In this case A, C, AC, BD, CD, A^2, B^2, C^2, D^2 are significant model terms (Table 7).

Overall acceptability = 6.4375 + 0.174792 * A + 0.06125 * B + 0.07625 * C + 0.02375 * D + 0.0365625 * AB +

$0.125937 * AC + 0.090625 * AD + 0.0453125 * BC + 0.095625 * BD + 0.169375 * CD + 0.122135 * A^2 + 0.209948 * B^2 + 0.0780729 * C^2 + -0.0903646 * D^2$

It may be seen from Fig. 4(a) that the sugar had significant effect on overall acceptability of leather and increase or decrease in sugar content in mango leather may affect the overall acceptability of the product and there is no significant effect of whey protein on overall acceptability of mango leather. But, it may also be seen from Fig. 4(b) that whey protein had significant effect and thickness had non-significant effect on overall acceptability of the mango leather.

Table 6: Effect of process parameters on sensory score in terms of overall acceptability of protein enriched mango leather

Sr. No.	Whey protein (%)	Sugar (%)	Thickness (mm)	Temperature (°C)	Overall Acceptability
1	4	12.50	4	55	7.24
2	6	12.50	4	55	7.23
3	4	17.50	4	55	6.64
4	6	17.50	4	55	6.61
5	4	12.50	6	55	6.78
6	6	12.50	6	55	6.50
7	4	17.50	6	55	6.71
8	6	17.50	6	55	6.23
9	4	12.50	4	65	6.75
10	6	12.50	4	65	6.48
11	4	17.50	4	65	6.75
12	6	17.50	4	65	6.53
13	4	12.50	6	65	7.29
14	6	12.50	6	65	6.61
15	4	17.50	6	65	7.46
16	6	17.50	6	65	6.36
17	3	15.00	5	60	7.21
18	7	15.00	5	60	6.64
19	5	10.00	5	60	7.25
20	5	20.00	5	60	7.30
21	5	15.00	3	60	7.13
22	5	15.00	7	60	6.36
23	5	15.00	5	50	6.29
24	5	15.00	5	70	5.86
25	5	15.00	5	60	6.44
26	5	15.00	5	60	6.44
27	5	15.00	5	60	6.44
28	5	15.00	5	60	6.44
29	5	15.00	5	60	6.44
30	5	15.00	5	60	6.44

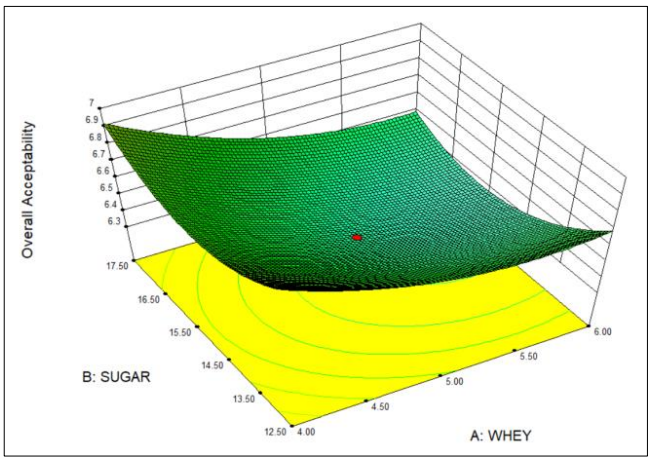

Fig 4 (a): variation of overall acceptability with respect to sugar and WPC in protein enriched mango leather

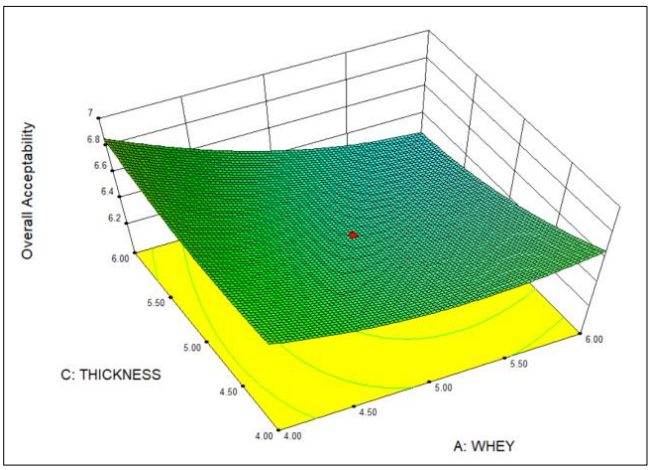

Fig 4 (b): variation of overall acceptability with respect to thickness and WPC in protein enriched mango leather

Table 7: ANOVA for overall acceptafbility for protein enriched mango leather

Source	Sum of Squares	df	Mean Square	F-value	p-value	
Model	4.04	14	0.2884	9.83	< 0.0001	Significant
A-WHEY	0.7333	1	0.7333	25.00	0.0002	
B-SUGAR	0.0900	1	0.0900	3.07	0.1002	
C-THICKNESS	0.1395	1	0.1395	4.76	0.0455	
D-TEMPERATURE	0.0135	1	0.0135	0.4615	0.5073	
AB	0.0214	1	0.0214	0.7292	0.4066	
AC	0.2538	1	0.2538	8.65	0.0101	
AD	0.1314	1	0.1314	4.48	0.0514	
BC	0.0329	1	0.0329	1.12	0.3067	
BD	0.1463	1	0.1463	4.99	0.0412	
CD	0.4590	1	0.4590	15.65	0.0013	
A^2	0.4092	1	0.4092	13.95	0.0020	
B^2	1.21	1	1.21	41.22	< 0.0001	
C^2	0.1672	1	0.1672	5.70	0.0306	
D^2	0.2240	1	0.2240	7.64	0.0145	
Residual	0.4400	15	0.0293			
Lack of Fit	0.4400	10	0.0440			
Pure Error	0.0000	5	0.0000			
Cor Total	4.48	29				
Std. Dev.	0.1713		R^2		0.9017	
Mean	6.69		Adjusted R^2		0.8100	
C.V. %	2.56		Predicted R^2		0.4341	
			Adeq. Precision		11.3230	

3.7 Optimization of process parameters for preparation of protein enriched mango leather

Optimization of process parameters was done using Design Expert 8.0.7.1 software. Numerical optimization was carried out by putting the values of process parameters within the experimental range and by setting desirable goals for the responses. Optimization of process parameters for preparation of protein enriched mango leather was performed on the basis of its dominant quality attributes such as overall acceptability and protein content.

The best optimized sample found at combination of whey protein, sugar, thickness, temperature: (4.00%, 17.50%, 6.00mm, 65.00 °C) having overall acceptability, protein content, vitamin-C and colour value (L*, a* and b*) 7.33, 6.54 g/100g, 67.25 mg/100 g and (36.99, 9.67, 19.21) respectively.

4. Conclusion

Protein enriched mango leather was prepared by varying process variables *viz.* WPC (3, 4, 5, 6, 7%), sugar concentration (10, 12.5, 15, 17.5, 20%), temperature (50, 55, 60, 65, 70 °C) and thickness (3, 4, 5, 6, 7 mm) and its responses like protein content, overall acceptability, vitamin C, colour values (L*, a*, b*) of protein enriched mango leather were analyzed by using Response Surface Methodology for model fitting and determination of statistical significance of the model terms. Optimum combination of protein enriched mango leather was found as: whey protein (4%), sugar (17.5%), thickness of pulp (6mm), temperature (65 °C) and responses of process parameters were found as overall acceptability (7.33), protein content (6.54 g/100g) and vitamin-C (67.25 mg/100g), respectively. On the basis of the result it may be concluded that the prepared mango leather is extremely useful for satisfying consumer tastes and preference.

5. References

1. AOAC. Official Methods of Analysis. 18", Ed. Association of Official Analytical Chemists, Virginia, USA; c2005.
2. Abano EE, Sam-Amoah LK, Owusu J, Engmann FN. Effects of ascorbic acid, salt, lemon juice, and honey on drying kinetics and sensory characteristic of dried mango. Croatian Journal of Food Science and Technology. 2013;5(1):1-10.
3. Chauhan N. Development of fortified mixed fruit bar using whey protein concentrate. Master Thesis, University of Anand Agricultural, Anand; c2013. Retrieved from http://www.phytojournal.com krishikosh.egranth.ac.in/bitstream/1/5810002111/1/NIRALI%20PDFFINAL.pdf
4. Gayathri S, Uthira L. Preparation and evaluation of protein enriched mango- papaya blended fruit bar. Beverage and Food World. 2008;35:56-57.
5. Jethva KR, Sutar RF, Kumar N, Vyas DK. Effect of whey protein on sun dried protein enriched kesar mango leather. Journal of Pharmacognosy and Phytochemistry. 2021;10(2):824-830.
6. Mir MA, Nath N. Storage changes in fortified mango bars. J Food Sci. Technol. 1993;30:279-282.
7. Rangana S. Hand book of analysis and quality control for fruits and vegetable products. (2nd Ed.), Tata McGrawHill publication Co. Ltd., New Delhi; c2004.
8. Sarojini MG, Rao R. Veena V. Studies on fortification of solar dried fruit bars. Paper presented at International Solar Food Processing Conference, Indore (India); c2009. p. 14-16.