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Evaluation of physicochemical properties of pre-treated raw mango (*Mangifera indica*) powder during storage

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Abstract
Raw mango powder was prepared by subjecting raw mango slices to different pre-treatments like blanching in hot water at 90 °C for 1 minute, dipping in salt solution (1%) for 10 minutes and blending with glycerol monostearate (1%, 2% and 3%) to prepare foam. After pre-treatments of slices, they were dried at 50 °C, 60 °C and 70 °C, powdered, packed in LDPE bags and stored under ambient conditions followed by analysis at a regular interval of 30 days up to three months to assess the changes during storage. With storage, moisture, reducing sugar and total sugar content increased, whereas ash, fiber and ascorbic acid content of the powder decreased. On the basis of sensory evaluation treatment T_5 was adjusted the best, having the highest score for colour (8.77), texture (8.15) and overall acceptability (8.46). No microbial spoilage was detected up to 90 days of storage.

Keywords: Raw mango powder, pre-treatments, hot water blanching, glycerol monostearate, salt solution dip

Introduction

Mango (*Mangifera indica*) is a juicy stone fruit (drupe) crop of tropics and subtropics, particularly of Asia and more precisely of India. India is the leading producer of mango in the world. The annual production of mango in India is 21822 million tonnes over an area of 2258 thousand hectares (Anonymous, 2018) [1].

Mango can be utilized at all stages of maturity, from immature unripe stage to ripened stage. It has to face discouraging elements like strong winds, hail storms, lack of fertilization, pest and disease pressure etc., during its growth and development. This causes heavy fruit drop before reaching maturity, which causes serious loss to the growers. These losses can be minimized to a greater extent by utilizing the fallen fruits at green stage and can be used in the preparation of processed products like amchur, pickles, mango slices and beverages.

Mango powder (amchur) is prepared from raw mango pulp. It is a rich source of citric acid, malic acid along with other nutrients. It is also a good source of fibre and minerals. Several potential health benefits are reported for mango such as improved immunity, digestive health and eye health, lowering the blood pressure. In India green mangoes are dried historically to produce 'amchur, a dried brownish powder for use in seasoning and culinary preparations. It is widely used to give a sour taste to dishes. Raw mango powder can be used in the preparation of chutneys and traditional beverages like panna.

The quality of raw mango powder can be improved by using different pre-treatments. The pre-treatments like blanching, salt solution dipping, foaming agent helps in improving the colour, texture, shelf life and overall quality of the developed product.

Materials and Methods

Fresh, healthy and disease-free raw mango fruits used in this experiment was collected from local market of Jammu. The fruits were washed properly followed by separation of peel and seed manually from the fruit. Mango pulp was extracted and blended with glycerol monostearate (1%, 2% and 3%) to prepare foam. After treatment foam was dried at 50 °C, 60 °C and 70 °C. The dried product was scraped, powdered, sieved, packed in LDPE pouches and stored at ambient temperature for 90 days.

The values for moisture, ash, crude fiber, ascorbic acid of dried raw mango powder were determined according to Association of Official Analytical Chemists (AOAC, 2012) [2]. Ascorbic acid content was determined by the procedure of Sadasivam and Manicham (2008) [19] using 2, 6-dichlorophenol indophenols dye.

Titratable acidity was determined by titrating a known quantity of sample solution of Sodium hydroxide (NaOH) to a faint pink colour using Phenolphthalein as indicator. Total phenol was determined by the procedure of Icyer (2012) [7]. Reducing sugars was determined by the method of Rangana (1986) [17].

Results and Discussion

Moisture content

Highest mean moisture content of 5.82% was observed in T_1 (control) and lowest (5.34%) was observed in T_7. On the basis of mean values the moisture content increased from the initial values of 5.36 per cent to 5.84 per cent after 90 days of storage (Table 1). Moisture content decreased with an increase in drying temperature. Kaya *et al.* (2008) [11] informed that increasing of drying temperature can also increase the rate of heat transfer and consequently reduced the total drying time. During storage period moisture content significantly increased due to hygroscopic nature of dried product. Similar results of increase in moisture content during storage of fruit powder was also reported by Krishna *et al.* (2020) [12] in amchur powder respectively.

Table 1: Effect of the pre-treatments, drying temperatures and storage on moisture (%) of raw mango powder

Treatments	Drying temperature (°C)	Storage period (days)				Mean
		0	30	60	90	
T_1 (Control)	Sun drying	5.68	5.77	5.85	5.99	5.82
T_2 (HWB: 1 min at 90 °C)	50 °C	5.59	5.67	5.82	5.95	5.75
T_3 (HWB: 1 min at 90 °C)	60 °C	5.47	5.59	5.80	5.94	5.70
T_4 (HWB: 1 min at 90 °C)	70 °C	5.29	5.38	5.57	5.78	5.50
T_5 (1%GMS)	50 °C	5.18	5.28	5.47	5.72	5.41
T_6 (2%GMS)	60 °C	5.12	5.26	5.45	5.70	5.38
T_7 (3%GMS)	70 °C	5.06	5.22	5.41	5.68	5.34
T_8 (1%SSD)	50 °C	5.56	5.68	5.84	5.97	5.76
T_9 (1%SSD)	60 °C	5.43	5.61	5.79	5.91	5.68
T_{10} (1%SSD)	70 °C	5.27	5.51	5.72	5.80	5.57
Mean		5.36	5.49	5.67	5.84	

HWB: Hot water blanching, **GMS:** Glycerol monostearate, **SSD:** Salt solution dips

Factors	**C D (0. 05)**
Treatment	0. 03.
Storage	0.02
Treatment x Storage	0.06

Ash

From the Table 2, the highest mean ash content (3.54%) was observed T_8 and the lowest (3.22%) was observed in T_4. As the storage period progressed, mean ash content decreased from initial mean values of 3.52 to 3.27 per cent after 90 days of storage. Higher ash content was observed in salt solution treated raw mango powder and lowest in blanched raw mango powder which might be due to the loss of minerals during blanching resulted in decrease in the dry matter led to decrease in ash content. Similar results of decrease in ash content with blanching was also reported by Kakade and Hathan (2014) [10] in beetroot leaves powder. Ash content decreased with increase in drying temperature which might be due to loss of heat labile mineral components during drying at high temperature Teoh *et al.* (2016) [24]. Ash content decreased with an increase in foaming agent concentration. Similar results of decrease in ash content with increase in foaming agent concentration was also reported by Shivani *et al.* (2019) [23] in foam mat dried papaya powder. During storage, decrease in ash content was observed which might be due to binding of certain minerals with organic substances. Similar findings of decrease in ash content with storage was reported by Rawal and Masih (2014) [18] in apple pomace powder.

Table 2: Effect of the pre-treatments, drying temperatures and storage on ash (%) of raw mango powder

Treatments	Drying temperature (°C)	Storage period (days)				Mean
		0	30	60	90	
T_1 (Control)	Sun drying	3.61	3.56	3.51	3.45	3.53
T_2 (HWB: 1 min at 90 °C)	50 °C	3.39	3.33	3.29	3.20	3.30
T_3 (HWB: 1 min at 90 °C)	60 °C	3.37	3.28	3.22	3.18	3.26
T_4 (HWB: 1 min at 90 °C)	70 °C	3.35	3.24	3.19	3.12	3.22
T_5 (1% GMS)	50 °C	3.59	3.49	3.40	3.32	3.45
T_6 (2% GMS)	60 °C	3.57	3.39	3.30	3.23	3.37
T_7 (3% GMS)	70 °C	3.55	3.29	3.28	3.21	3.33
T_8 (1% SSD)	50 °C	3.63	3.57	3.52	3.46	3.54
T_9 (1% SSD)	60 °C	3.59	3.44	3.39	3.33	3.43
T_{10} (1% SSD)	70 °C	3.57	3.36	3.28	3.24	3.36
Mean		3.52	3.39	3.33	3.27	

HWB: Hot water blanching, **GMS:** Glycerol monostearate, **SSD:** Salt solution dips

Factors	**C D (0.05)**
Treatment	0.02.
Storage	0.01
Treatment x Storage	0.03

Crude fibre

It was observed in Table 3 that the highest crude fibre content (2.59%) was observed in T_2 (hot water blanching: 1 min. at 90 °C and dried at 50 °C) and it was at par with T_3, the lowest crude fibre content of 2.18% was observed in T_{10} (1% salt solution dip and dried at 70 °C) and it was at par with T9. With the advancement of storage period, there was a decrease in crude fibre content from the initial value of 2.43 to 2.14 per cent after 90 days of storage. With the increase in drying temperature crude fiber content of the powder decreased which might be due to degradation of pectin or other fiber such as cellulose or hemicelluloses during the drying process. Similar results were also reported by Sengkhamparn *et al.* (2013) [21] in pitaya powder. The progressive reduction in crude fiber content was observed with the advancement of storage period which might be due to degradation of hemicelluloses and other polysaccharides during storage (Sharon and Usha 2006) [22]. Similar result of decrease in crude fiber content during storage was also reported by Gurumeenakshi and Varadharaju (2019) [5] in osmodried mango slices.

Table 3: Effect of the pre-treatments, drying temperatures and storage on crude fiber (%) of raw mango powder

Treatments	Drying temperature (°C)	Storage period (days)				Mean
		0	30	60	90	
T_1 (Control)	Sun drying	2.38	2.33	2.25	2.17	2.28
T_2 (HWB: 1 min at 90 °C)	50 °C	2.59	2.48	2.27	2.23	2.39
T_3 (HWB: 1 min at 90 °C)	60 °C	2.57	2.40	2.25	2.16	2.35
T_4 (HWB: 1 min at 90 °C)	70 °C	2.55	2.39	2.23	2.14	2.32
T_5 (1% GMS)	50 °C	2.56	2.46	2.29	2.24	2.38
T_6 (2% GMS)	60 °C	2.54	2.45	2.28	2.21	2.37
T_7 (3% GMS)	70 °C	2.52	2.42	2.26	2.19	2.34
T_8 (1% SSD)	50 °C	2.22	2.17	2.12	2.08	2.14
T_9 (1% SSD)	60 °C	2.20	2.15	2.09	2.04	2.12
T_{10} (1% SSD)	70 °C	2.18	2.13	2.06	2.02	2.09
Mean		2.43	2.33	2.21	2.14	

HWB: Hot water blanching, **GMS:** Glycerol monostearate, SSD: Salt solution dips

Factors	**C D $_{(0.05)}$**
Treatment	0.02.
Storage	0.01
Treatment x Storage	0.04

Ascorbic acid

It was observed in Table 4 that the highest mean ascorbic acid content (129.21 mg/100 g) was recorded in T_5 and the lowest (114.25 mg/100 g) was recorded in T_1. With the advancement of storage period, there was a decrease in ascorbic acid with initial value of 121.60 to 120.45 mg/100 g after 90 days of storage. The higher retention of ascorbic acid might be due to foaming conditions which reduced the drying time and hence minimizing the destruction of ascorbic acid. Similar findings of retention of ascorbic acid with the use of foaming agents was also reported by Rajkumar and Kailappan (2006) [16] in foam mat dried totapuri pulp. The higher ascorbic acid content was observed in powders dried at 50 °C than those dried at 60 °C and 70 °C which might be due to oxidation and heat sensitive nature of ascorbic acid. Similar decline in ascorbic acid content was reported by Mishra *et al.* (2021) [13] in green mango powder. The decrease in ascorbic acid during storage might be due to increase in the moisture content as well as atmospheric temperature, oxygen and presence of trace metals (Hymavathi and Khader, 2005) [6]. Similar results of decrease in ascorbic acid during storage was also reported by Patil *et al.* (2019) in amchur [14].

Table 4: Effect of the pre-treatments, drying temperatures and storage on ascorbic acid (mg/100g) of raw mango powder

Treatments	Drying temperature (°C)	Storage period (days)				Mean
		0	30	60	90	
T_1 (Control)	Sun drying	114.89	114.69	113.94	113.51	114.25
T_2 (HWB: 1 min at 90 °C)	50 °C	120.84	120.39	119.90	119.65	120.19
T_3 (HWB: 1 min at 90 °C)	60 °C	118.87	118.62	117.96	117.54	118.24
T_4 (HWB: 1 min at 90 °C)	70 °C	116.95	116.42	115.89	115.46	116.18
T_5 (1% GMS)	50 °C	129.95	129.45	128.93	128.52	129.21
T_6 (2% GMS)	60 °C	127.89	127.42	126.97	126.58	127.21
T_7 (3% GMS)	70 °C	125.94	125.48	124.94	124.61	125.24
T_8 (1% SSD)	50 °C	122.96	122.58	121.98	121.59	122.27
T_9 (1% SSD)	60 °C	119.82	119.38	118.86	118.54	119.16
T_{10} (1% SSD)	70 °C	117.93	117.47	116.97	116.56	118.23
Mean		121.60	121.19	120.83	120.45	

HWB: Hot water blanching, **GMS:** Glycerol monostearate, **SSD:** Salt solution dips

Factors	**C D $_{(0.05)}$**
Treatment	0.03.
Storage	0.02
Treatment x Storage	0.07

Titratable acidity

Highest mean titratable acidity (1.52%) was recorded in T_1 and the lowest (1.38%) in T_2. On the basis of mean values the titratable acidity decreased from the initial values of 1.55 per cent to 1.33 per cent after 90 days of storage (Table 5). The increment of titratable acidity in sun dried sample may be due to the conversion of carbohydrate to organic acids through extended time of drying Workneh *et al.* (2014) [25]. Titratable acidity increased with the increase in drying temperature which might be due to increased moisture loss from the sample with corresponding increase in temperature. Similar results of increase in titratable acidity with increase in temperature was also reported by Purkayastha *et al.* (2013) [15] in dried tomato slices. The decrease in titratable acidity with increase in storage period which might be due to the biochemical interaction in binding of acid with other components with passage of time Gulzar *et al.* (2018) [4]. Decrease in acidity during storage was also reported by Patil *et al.* (2019) [14] in amchur.

Table 5: Effect of the pre-treatments, drying temperatures and storage on titratable acidity (%) of raw mango powder

Treatments	Drying temperature (°C)	Storage period (days)				Mean
		0	30	60	90	
T_1 (Control)	Sun drying	1.69	1.51	1.44	1.39	1.52
T_2 (HWB: 1 min at 90 °C)	50 °C	1.44	1.48	1.36	1.25	1.38
T_3 (HWB: 1 min at 90 °C)	60 °C	1.46	1.49	1.38	1.28	1.40
T_4 (HWB: 1 min at 90 °C)	70 °C	1.48	1.53	1.43	1.34	1.44
T_5 (1% GMS)	50 °C	1.62	1.54	1.44	1.36	1.49
T_6 (2% GMS)	60 °C	1.64	1.55	1.46	1.38	1.50
T_7 (3% GMS)	70 °C	1.66	1.56	1.45	1.40	1.51
T_8 (1% SSD)	50 °C	1.49	1.54	1.47	1.27	1.43
T_9 (1% SSD)	60 °C	1.51	1.55	1.49	1.31	1.46
T_{10} (1% SSD)	70 °C	1.53	1.57	1.50	1.32	1.48
Mean		1.55	1.53	1.44	1.33	

HWB: Hot water blanching, **GMS:** Glycerol monostearate, **SSD:** Salt solution dips

Factors	**C D $_{(0.05)}$**
Treatment	0.03.
Storage	0.02
Treatment x Storage	0.04

Reducing sugars

From the Table 6, it is evident that the highest mean reducing sugars (7.09%) was in T_7 and the lowest (6.95%) was in T_2.With the increase in drying temperature, the reducing sugar content of the powder increased. With the advancement of storage period the mean reducing sugar content increased from the initial value of 6.27 to 7.76 per cent after 90 days of storage. Reducing sugars content increased with an increase in the foaming agent concentration and drying temperature. Increase in glycerol monostearate concentration results in acidic hydrolysis of sugars resulting in breakdown of disaccharides into monosaccharides and conversion of non-reducing sugars into reducing sugars. Similar results were also reported by Shivani *et al.* (2019) in foam mat dried papaya powder. Reducing sugars increased with the increase in storage period. This can be due to hydrolysis of sugars, which might be due to degradation of disaccharides to monosaccharides. Similar results of increase in reducing sugars during storage was also reported by Krishna *et al.* (2020) [12] in raw mango powder.

Table 6: Effect of the pre-treatments, drying temperatures and storage on reducing sugars (%) of raw mango powder

Treatments	Drying temperature (°C)	Storage period (days)				Mean
		0	30	60	90	
T_1 (Control)	Sun drying	6.30	6.48	7.59	7.68	7.01
T_2 (HWB: 1 min at 90 °C)	50 °C	6.21	6.33	7.57	7.70	6.95
T_3 (HWB: 1 min at 90 °C)	60 °C	6.23	6.35	7.64	7.79	7.00
T_4 (HWB: 1 min at 90 °C)	70 °C	6.26	6.47	7.67	7.82	7.05
T_5 (1% GMS)	50 °C	6.31	6.46	7.59	7.72	7.02
T_6 (2% GMS)	60 °C	6.32	6.48	7.58	7.79	7.05
T_7 (3% GMS)	70 °C	6.34	6.50	7.69	7.84	7.09
T_8 (1% SSD)	50 °C	6.25	6.38	7.59	7.71	6.98
T_9 (1% SSD)	60 °C	6.27	6.44	7.65	7.80	7.04
T_{10} (1% SSD)	70 °C	6.29	6.49	7.68	7.82	7.07
Mean		6.27	6.43	7.62	7.76	

HWB: Hot water blanching, **GMS:** Glycerol monostearate, **SSD:** Salt solution dips

Factors	**CD $_{(0.05)}$**
Treatment	0.03.
Storage	0.02
Treatment x Storage	0.06

Total sugars

It was observed in Table 7 that the highest mean total sugars (14.37%) was in T_7 and the lowest (14.21%) was in T_2. With the increase in drying temperature, the total sugar content of the powder increased. With the advancement of storage period the mean total sugar content increased from the initial value of 13.65 to 14.86 per cent after 90 days of storage. Increase in total sugars content with increase in foaming agent Concentration may be due to inherent content of foaming agent used (Kadam *et al*., 2012) [9]. Total sugars increased with the increase in storage period which might be due to accelerated hydrolysis of insoluble polysaccharides and other carbohydrates polymer and increased degree of inversion of sugar. Similar results of increase in total sugars during storage was also reported by Sarada *et al*. (2018) [20] and Patil *et al*. (2019) [14] in amchur powder.

Table 7: Effect of the pre-treatments, drying temperatures and storage on total sugars (%) of raw mango powder

Treatments	Drying temperature (°C)	Storage period (days)				Mean
		0	30	60	90	
T_1 (Control)	Sun drying	13.70	13.89	14.83	14.89	14.32
T_2 (HWB: 1 min at 90 °C)	50 °C	13.57	13.79	14.71	14.80	14.21
T_3 (HWB: 1 min at 90 °C)	60 °C	13.59	13.91	14.74	14.81	14.26
T_4 (HWB: 1 min at 90 °C)	70 °C	13.61	13.98	14.76	14.83	14.29
T_5 (1% GMS)	50 °C	13.68	13.82	14.85	14.92	14.31
T_6 (2% GMS)	60 °C	13.72	13.90	14.86	14.93	14.35
T_7 (3% GMS)	70 °C	13.74	13.91	14.88	14.96	14.37
T_8 (1% SSD)	50 °C	13.62	13.81	14.75	14.83	14.25
T_9 (1% SSD)	60 °C	13.64	13.83	14.78	14.84	14.27
T_{10} (1% SSD)	70 °C	13.66	13.85	14.80	14.88	14.30
Mean		13.65	13.86	14.79	14.86	

HWB: Hot water blanching, **GMS:** Glycerol monostearate, **SSD:** Salt solution dips

Factors	**C D** **(0.05)**
Treatment	0.02.
Storage	0.01
Treatment x Storage	0.04

Conclusion

The pre-treatment of raw mango helps in maintaining the quality attributes of the mango powder. With the advancement of storage up to 90 days, moisture, reducing sugar and total sugar content increased, whereas ash, crude fiber and ascorbic acid content of the powder decreased.

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