

Original Research Article

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Effect of Foaming Agent on Quality and Yield of Foam Mat Dried Papaya Powder

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ABSTRACT

The study was carried out for utilization of papaya fruit cv. *Madhu* for preparation of foam mat dried fruit powder. The conversion of papaya pulp into foam was optimized by whipping the pulp after addition of glycerol-mono-stearate (GMS) and drying the resultant foam in dehydrator ($60\pm 5^{\circ}\text{C}$) to constant moisture content. Drying of papaya foam by using 3% GMS results in 11.93 per cent yield and was found the most appropriate with respect to desired foaming properties (foam density, foam expansion and foam stability), physico-chemical as well as sensory characteristics. With the increase in the foaming agent concentration, the foam density decrease significantly however; the percentage of foam expansion was increased. In comparison to foam density, the papaya pulp exhibited higher foam expansion of 21.72 per cent with 3% GMS in sweetened pulp. The dried powder by using 3% GMS contained 84.07-89.83%B TSS, 7.00-8.28% moisture content, 2.40-4.50% ash content, 52.47-62.63% reducing sugars, 81.39-87.73% total sugars, 928.76-1242.98 $\mu\text{g}/100\text{g}$ total carotenoids respectively in natural and sweetened papaya pulp. There was no significant change in other biochemical constituents such as pH and acidity. Thus, the papaya fruit can be utilized for preparation of self-stable powder using foam mat drying technique for further preparation of ready to drink beverages.

Keywords

Papaya pulp, Glycerol monostearate, CMC, whipping, Foam expansion, Foam thickness, Drying

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Introduction

Papaya (*Carica papaya* L.) is an important tropical and sub-tropical fruit crop in the world that is widely preferred for its nutritional values (Sidhu, 2006). Papaya fruits are rich in nutrients especially β -carotene, Vitamin A, Vitamin C, minerals like potassium and magnesium and are good source of energy (Gopalan *et al.*, 1989;

Widyastuti *et al.*, 2003). Besides, the papaya fruit juice also contains alkaloids, glycosides, flavonoids, carbohydrates, saponins, terpenoids, steroids and tannins. The extract of various parts of papaya has multifarious uses such as anti-hypertensive, anti-inflammatory, anti-tumour, anti-fungal, anti-microbial, anti-sickling and anti-ulcer activity (Vij and Prashar, 2015). Papaya fruit is mostly consumed fresh but can also be utilized for

making processed products like puree, jam, jelly, pickle, nectar, papaya cake, barfi, halwa, baby food, tuty-fruity, candied fruit, mixed beverages, canned slices/chunks, concentrate etc. to extend its shelf-life and period of availability in the market (Rajarathnam, 2010).

In India, the annual production of papaya is 6.216 million Metric tonnes from an area of 0.143 million hectare contributing 2.19% of total area under fruit crops (NHB, 2018). In Himachal Pradesh, papaya cultivation covered an area of 0.23 thousand hectare with an annual production of 1.11 thousands Metric tonnes during the year 2018 (NHB, 2018); and this crop is being extensively grown in mid and low hills of the state. Owing to highly perishable nature and nearly 88% of moisture, papaya fruits cannot be stored for longer periods under ambient conditions. In India, total estimated postharvest losses of 25.49% are recorded (Gajanana *et al.*, 2010).

Among various methods of preservation, foam mat drying is an alternate technique to mitigate the post-harvest losses and enhance keeping quality. It is one of the simple techniques of drying where liquid concentrate is transformed into suitable foam with the help of foaming agents and the resultant foam is dried at low temperature (Meena *et al.* 2014). Foam mat drying is an appropriate method for heat sensitive and thick materials as compared to drum and spray drying due to better reconstitution property of final dried material. According to Kudra and Ratti (2006) rehydration and retention of volatiles are important properties which are maintained by foam mat drying. Foam mat drying have been used in many fruits such as guava, mango, apple, banana (Rajkumar *et al.*, 2007a, b), pineapple and tomato (Jayaraman, 1993; Hassan and Ahmed 1998). Sankat and Castaigne (2004); Thuwapanichayanan *et al.*, (2008) have reported higher drying rate at the

end of drying period in banana, Kadam *et al.*, (2010) in mango and Kadam and Balasubramanian (2011) and Kadam *et al.*, (2011) in tomato juice.

Keeping in view the availability of papaya fruit in low-hills of Himachal Pradesh, papaya pulp was converted into powder by adopting a simple foam mat drying technique for further utilization of powder in preparation of instant value added products.

Materials and Methods

Selection of fruits and foaming agent

Papaya fruits cultivar '*Madhu*' on the basis of their commercial importance and availability in the low hills zone of Himachal Pradesh (Hamirpur) were selected for preparation of Instant Papaya Fruit Powder using Foam-mat drying technique. The pulp of fruits was prepared by adding 10% water (100ml/kg fruits), followed by heating for 10 minutes to soften and finally pulp was prepared with the help of blender (Robot 5.0 SS INALSA). The pulp so obtained was preserved with potassium meta-bisulphite (2g/kg of pulp) and packed in plastic cans for its later utilization in Instant papaya powder and for other analytical purposes. The papaya natural (8°B) as well as sweetened pulp (20°B TSS after addition of sugar syrup) was evaluated.

The papaya pulp was converted into thick stable foam by whipping the pulp after adding carboxy methyl cellulose (CMC) or glycerol monostearate (GMS) in 1-3% concentrations alongwith control treatments. The prepared foam was spread into the stainless steel trays in thin layer and dried to a constant weight in mechanical dehydrator (cabinet drier) at 60±5°C. The dried foam was scrapped/removed from the trays and ground to a fine powder. The complete process for preparation of foam mat dried powder is given

in Figure-1.

Physico-chemical characteristics

The physical characteristics of fresh papaya fruits were determined by using Vernier Calliper, weight in grams was determined gravimetrically and expressed as mean weight (g). The peel/pulp ratio was calculated by using the following formula:

Peel :Pulp ratio =

$$\frac{\text{Weight of the fruits} - \text{Weight of the fruits after peeling}}{\text{Weight of the fruits} - \text{Weight of the fruits peel}}$$

The total soluble solids of papaya pulp and prepared powder were determined with the help of hand refractrometer and expressed as degree Brix (°B) at 20°C (Ranganna, 2014). The moisture content was estimated by drying the weighed sample to a constant weight in hot air oven at 70 ± 5 °C followed by cooling at ambient temperature in desiccators prior to weighting (Ranganna, 2014). The titratable acidity, carotenoids, ash contents, total and reducing sugars of pulp and fruit powder were determined by following method as detailed by Ranganna (2014). The drying rate/ratio and equilibrium relative humidity of the samples were estimated by plotting the data against relative humidity to determine ERH of given samples (Ranganna, 2014). The pH of the papaya pulp and prepared powder (after dilution) was determined with the help of automatic pH meter (Deluxe pH meter model 101). Before estimation, the pH meter was calibrated with buffer solution of pH 4.0 and pH 7.0 (AOAC, 1995).

Foam density

The density of the foamed papaya pulp was calculated as ratio of mass of foam to the

volume of foam and expressed as g/cm³ (Falade *et al.*, 2003). The density of papaya pulp was determined by weighing 100 ml of the pulp in a 100 ml measuring cylinder whereas for the foamed papaya pulp, 200 ml of foam was transferred into a 250 ml measuring cylinder and weighed. The foam density was calculated using the following formula:

$$\text{Foam Density (FD)} = \frac{\text{Mass of the foam(g)}}{\text{Volume of the foam(cm}^3\text{)}}$$

Foam expansion

It is the percentage increase of the volume of the pulp after foaming with required amount of the foaming agent and whipping time. The foam quality of foamed papaya pulp in terms of foam expansion was calculated according to the following equation (Akiokato *et al.*, 1983).

$$\text{Foam Expansion (FE)} = \frac{V_1 - V_0}{V_0} \times 100$$

Where,

V₀=initial volume of the papaya pulp before foaming (cm³),

V₁= final volume of the papaya pulp after foaming (cm³).

Foam stability

50 ml of foamed pulp was placed in a 50 ml glass tube and kept undisturbed in normal atmosphere for 2 hours (Marinova *et al.*, 2009). Then, the decrease of the foam volume was noted in every 30 minute time interval and was noted to be used as an index for the determination of the stability for every 30 minutes by using following relationship:

$$\text{Foam Stability (FS)} = \frac{V_0}{V_1} \times 100$$

Where, FS is expressed in percentage (%), V_0 is the final volume of the papaya pulp after 2 hours of foaming and V_1 is the initial volume of the papaya pulp after foaming.

Sensory and statistical analysis

Ninepoints hedonic scale method as suggested by Amerine *et al.*, (1965) was followed for conducting the sensory evaluation of foam mat dried papaya powder. Total plate count (TPC) was estimated by aseptically inoculating 0.1 gram of serially diluted sample (powder) in total plate count/standard plate count agar medium prepared according to Ranganna (2014). The data pertaining to sensory evaluation of papaya powder were analyzed according to Randomized Block Design (RBD) as described by Mahony (1985), while the data on physico-chemical characteristics of fruit, fruit pulp and instant powder were analyzed statistically by following Completely Randomized Design (CRD) of Cochran and Cox (1967).

Results and Discussion

Physico-chemical characteristics of fresh papaya fruits

The physico-chemical characteristics of papaya fruit cultivar 'Madhu' assessed during the present study are presented in Table 1. The mean length, diameter and weight of papaya fruit cv. 'Madhu' was found as 15.00 ± 0.10 cm, 11.36 ± 0.18 cm and 1100.00 ± 57.008 g, respectively with a peel:pulp ratio of 1:6. The pulp yield in papaya was recorded as 82.60 ± 0.920 per cent. The average total soluble solids (TSS) in fresh papaya fruit cv. 'Madhu' was $8.00 \pm 0.07^\circ\text{B}$, acidity 0.033 per cent with pH 5.73. The results were found to be slightly lower than the observations of Parker *et al.*, (2010), Santos and Realpe (2013) and Attri *et al.*, (2014). Bari *et al.*, (2006) reported very low (0.005 per cent)

titratable acidity in papaya fruit. The level of pH in papaya fruits was in-conformity with the findings of Sana *et al.*, (2009), Reni *et al.*, (2000) and Chauhan and Chatterjee, (2005). The moisture content of 87.00 ± 0.070 per cent was recorded which was in conformation with those of Chukwuka *et al.*, (2013), Sana *et al.*, (2009), Attri *et al.*, (2014), Ahuja *et al.*, (2008) and Othman (2009).

The content of reducing sugars and total sugars in fresh papaya fruits cv. 'Madhu' were found to be 5.53 and 7.39 per cent respectively, which were similar to the values recorded by Zamen *et al.*, (2006) and Reni *et al.*, (2000). The total carotenoids were $799.68 \mu\text{g}/100\text{g}$, however slightly lower values ($666 \mu\text{g}/100\text{g}$) have been recorded by Gopalan *et al.*, (2004) in papaya fruit. Devaki *et al.*, (2015) reported that total carotenoids content increased from mature stage to fully ripe stage and vary according to agronomic practices and planting time.

Effect of different foaming agents on foaming characteristics

The results presented in Table 2 represent the foaming properties of both natural (unsweetened) as well as sweetened papaya pulps while were converted into a foam by whipping for 5 minute after addition of CMC (1-3%) and GMS (1-3%) as foaming agents in different concentrations.

Foam density (g/cm^3)

It is evident from Table 2 that natural pulp exhibited significantly higher ($0.91 \text{ g}/\text{cm}^3$) foam density as compared to foam density of sweetened pulp ($0.81 \text{ g}/\text{cm}^3$). Among different foaming agent, foam density ranged between 0.76 to $0.99 \text{ g}/\text{cm}^3$ and foam prepared by using CMC (1-3%) exhibited higher density (0.99 - $0.83 \text{ g}/\text{cm}^3$) as compared to GMS (0.76 - $0.87 \text{ g}/\text{cm}^3$). Reduction in foam density with

increasing foaming agents has also been reported by Rajkumar and Kailappan (2006) in *Totapuri* cultivar of mango and in bael fruit pulp, foam density ranged between 0.58-0.917 g/cm³ by Bag *et al.*, (2011). According to Affandi *et al.*, (2017) the reduction in foam density with increasing concentration of foaming agents was probably due to the reduction in the interfacial tension and surface tension of the pulp which form an interfacial film as reported by.

Foam expansion

Data given in Table 2 reveal that the foam expansion was significantly higher (15.27 per cent) in sweetened pulp than that of unsweetened pulp (8.13 per cent). Among the different foaming agents, use of GMS exhibited higher (19.40 per cent) foam expansion as against 7.33-13.26 per cent expansion in the foam obtained by using CMC. Further, increase in concentration of foaming agent caused more expansion of foam in both the foaming agents, which was probably due to incorporation of more air in to the pulp during the foaming process. The maximum foam expansion was 21.72 per cent in sweetened pulp treated with 3% GMS. Similar results were reported by Affandi *et al.*, (2017) and Rajkumar and Kailappan (2006). Foam expansion is the inverse of foam density.

Foam stability

A perusal of data in Table 2 also reveals that the foam stability was significantly higher (99.59 per cent) in sweetened pulp as compared to natural pulp (97.69 per cent). Among the different concentration of foaming agents with the increase in the concentration of foaming agents (1-3%) the values of foam stability increased to 97.26-98.25 per cent by using CMC and 99.13-99.97 per cent by using GMS. Similar findings have been reported by Affandi *et al.*, (2017), Rajkumar and

Kailappan (2006). According to Kandasamy *et al.*, (2012b), the foam stability decrease with decreasing the pulp concentration and increase in drainage volume.

Drying time

The papaya pulp after turning in to foam by using different foaming agents was dried in a cabinet drier at 60±5°C. Data given in Table 3 reveal that the average drying time for pulp with different concentration varied between 7.40 to 9.25 hours. The effect of foaming agents on foam mat drying of pulp is also presented in Figure 2. As expected, the sweetened pulp dried as such without using foaming agents, took the longest (9.25 hours) time for drying while foaming of pulp brought about significant reduction in drying time of the pulp. Mean drying time for un-foamed control pulp was 8.77 hours which reduced to 7.95 to 8.67 hours in foamed pulp by using CMC (1-3%) and only 7.87 to 8.30 hours in papaya pulp foamed by using GMS (1-3%) foaming agent. Sharma *et al.*, (2002) reported higher (20.30 hours) time for non-foamed hill lemon juice powder as compared to foamed lemon juice (19.40-17.15 hours). Gupta and Alam (2014) also stated that drying time was reduced (490-180 minutes) with increasing the concentration of foaming agents.

Pulp Yield (%)

A perusal of data in Table 3 reveals that the average yield varied from 10.10 per cent to 11.93 per cent in natural and sweetened pulp powder among different concentrations of foaming agents. As expected, the natural pulp dried as such without using foaming agents gave lower yield (10.10 per cent) while foaming of sweetened pulp brought a significant increase in yield of the dried powder. Mean yield for un-foamed control pulp was as 10.40 per cent which increased to 10.60 to 10.90 per cent in foamed pulp by using CMC (1-3%) and 11.25 to 11.78 per

cent by using GMS (1-3%) foaming agent. Higher yield of powder from sweetened pulp was attributed to the presence of higher solids in sweetened pulp as compared to natural pulp. Similar increasing trend with increase in concentration of foaming agents have been reported by Sharma *et al.*, (2002) in foam mat dried hill lemon juice powder (8.03-11.18 per cent).

Quality characteristics of foam mat dried powder

The data pertaining to quality evaluation of foam mat dried papaya powder presented in Tables 4-5 are discussed as under:

Total soluble solids (TSS)

Data in Table 4 indicate that the papaya powder prepared from sweetened pulp exhibited significantly higher (89.4°B) TSS as compared to powder from unsweetened natural pulp (82.4°B). Among different foaming agents, the powder from un-foamed pulp had 83.5°B TSS which increased to 84.6 to 86.5°B in powder prepared by using CMC (1-3%) and 85.6 to 86.9°B in GMS (1-3%) treated foamed papaya pulp powder. The powder prepared by using 3% GMS resulted in a TSS of 86.9°B which was similar to the findings of Sharma *et al.*, (2002). Similar trend of increase in total soluble solids with increase in foaming agent concentration (0-20%) has been reported by Shaari *et al.*, (2017).

Moisture and ash content

Data presented in Table 4 indicate that among different foaming agents, the powder from non-foamed pulp had 9.6 per cent moisture which reduced to 9.1 to 7.9 per cent for CMC (1-3%) and 8.8 to 7.6 per cent for GMS (1-3%) treated foamed papaya pulp powder. Among different concentration of foaming

agents, the increase in concentration of the foaming agents, the moisture content of the powder exhibited decrease. The powder prepared by using 3% GMS resulted in moisture content of 7.64 per cent. Similar to these findings, Sharma *et al.*, (2004) in hill lemon juice powder, Shaari *et al.*, (2017) in pineapple powders, Auisakchaiyoung and Rojanakorn (2015) in dried Gac fruit aril and Ojo *et al.*, (2015) in dried pineapple and cashew apple juice powder also observed decrease in moisture content.

The ash content ranged between 4.9 to 3.9 per cent in powder prepared by using CMC (1-3%) and 4.3 to 3.5 per cent in GMS (1-3%) treated foamed papaya pulp powder. The powder prepared by using 1% CMC resultant in ash content of 4.9 per cent. Earlier, Patil *et al.*, (2014) has reported increase in ash content (1.5-3.3 per cent) with subsequent increase in malto-dextrin foaming agent concentration (7-12 per cent) in guava powder.

Reducing sugars

The papaya powder prepared from sweetened pulp showed significantly higher (62.3 per cent) reducing sugars as compared to powder from unsweetened natural pulp (51.2 per cent). Among different foaming agents, the reducing sugars of powder from un-foamed pulp had 55.0 per cent reducing sugars (Table 4). The reducing sugars in foam mat dried powder increased from 56.0 to 57.2 per cent with increased concentration of CMC (1-3%) and 56.1 to 57.6 per cent with 1-3% GMS. Earlier Akhtar *et al.*, (2010) has also observed increase in reducing sugars from juice to mango juice powder Reducing sugars increased with increasing the concentration of foaming agent because acidic hydrolysis of sugars resulting in breakdown of disaccharides into mono-saccharides and conversion of non-reducing sugars into reducing sugars (Kadam *et al.*, 2010).

Table.1 Physico-chemical characteristics of Fresh Papaya fruit (cv. *Madhu*)

S. No.	Parameters	Mean± SE*
Physical characteristics		
1	Length (cm)	15.00±0.10
2	Diameter (cm)	11.36±0.18
3	Weight (g)	1100.00±57
4	Peel/Pulp ratio	1: 6
5	Pulp yield (%)	82.60±0.92
Chemical characteristics		
6	TSS (⁰ B)	8.00±0.07
7	Titratable acidity (%)	0.033 ±0.01
8	pH	5.73±0.05
9	Reducing sugars (%)	5.53±0.06
10	Total sugars (%)	7.39±0.04
11	Total carotenoids (µg/100ml)	799.68±3.43
12	Moisture content (%)	87.00±0.70

* SE = Standard Error, n=5

Table.2 Effect of foaming agents on foaming characteristics of papaya pulp

Foaming agents	Concentration (%)	Foaming characteristics								
		Foam Density (g/cm ³)			Foam Expansion (%)			Foam Stability (%)		
		NP	SP	Mean	NP	SP	Mean	NP	SP	Mean
CMC	1.0	1.01	0.97	0.99	3.00	7.33	5.17	95.12	99.40	97.26
	2.0	0.94	0.82	0.88	4.38	9.78	7.08	96.66	99.43	98.05
	3.0	0.90	0.75	0.83	5.23	13.26	9.24	97.06	99.44	98.25
GMS	1.0	0.91	0.84	0.87	7.21	19.39	13.29	98.67	99.59	99.13
	2.0	0.85	0.77	0.81	11.90	20.14	16.02	98.74	99.66	99.20
	3.0	0.83	0.69	0.76	17.08	21.72	19.40	99.93	100.00	99.97
	Mean	0.91	0.81		8.13	15.27		97.69	99.59	
CD_{0.05}										
Pulp (P)		0.055			1.002			0.899		
Foaming agent(F)		0.095			1.736			1.480		
P x F		NS			2.455			NS		

Where, CMC= Carboxy methyl cellulose; GMS= Glycerol mono stearate; NP= Natural pulp; SP= Sweetened pulp

Table.3 Effect of foaming agents on drying time and yield of foamed papaya pulp

Foaming agents	Concentration (%)	Drying Time (hours)			Pulp Yield (%)		
		NP	SP	Mean	NP	SP	Mean
CMC	Control	8.30	9.25	8.77	10.10	10.70	10.40
	1.0	8.25	9.10	8.67	10.30	10.90	10.60
	2.0	8.05	9.00	8.52	10.36	10.99	10.67
	3.0	7.45	8.45	7.95	10.80	11.00	10.90
GMS	1.0	8.00	8.54	8.27	11.00	11.50	11.25
	2.0	7.91	8.40	8.15	11.20	11.70	11.45
	3.0	7.40	8.35	7.87	11.63	11.93	11.78
Mean		7.91	8.73		10.88	11.34	
CD_{0.05}							
Pulp (P)		0.096			0.049		
Foaming agent (F)		0.167			0.086		
P × F		0.236			0.085		

Where, CMC= Carboxy methyl cellulose; GMS= Glycerol mono stearate; NP= Natural pulp; SP= Sweetened pulp

Table.4 Effect of foaming agent on chemical characteristics of foam mat dried papaya powder

Foaming agents	Conc. (%)	TSS*(°B)			Moisture content (%)			Ash content (%)			Reducing sugars (%)		
		NP	SP	Mean	NP	SP	Mean	NP	SP	Mean	NP	SP	Mean
CMC	Control	79.3	87.6	83.5	8.5	10.7	9.6	4.7	3.8	4.3	49.7	60.3	55.0
	1.0	80.3	89.0	84.6	8.1	10.0	9.1	5.6	4.3	4.9	50.0	62.0	56.0
	2.0	82.0	89.4	85.7	7.7	9.3	8.5	5.2	4.2	4.7	50.9	62.3	56.6
	3.0	83.3	89.8	86.5	7.4	8.5	7.9	4.3	3.5	3.9	51.9	62.6	57.3
GMS	1.0	81.9	89.2	85.6	8.0	9.7	8.8	5.6	3.0	4.3	50.5	61.7	56.1
	2.0	83.1	89.4	86.3	7.4	8.4	7.9	4.7	2.7	3.7	51.6	62.4	57.0
	3.0	84.1	89.8	86.9	7.0	8.3	7.6	4.5	2.4	3.5	52.5	62.6	57.6
Mean		82.4	89.4		7.6	9.0		4.9	3.4		51.2	62.3	
CD_{0.05}													
Pulp (P)		0.729			0.298			0.265			0.470		
Foaming agent (F)		1.263			0.516			0.459			0.814		
P × F		NS			NS			0.649			NS		

Where, NP = Natural Pulp; SP = Sweetened Pulp; Conc.= concentration; CMC = Carboxy-methyl-cellulose; GMS = Glycerol-mono-stearate; Control= Powder obtained from pulp without using foaming agents.

Table.5 Effect of foaming agents on quality characteristics of foam mat dried papaya powder

Foaming agents	Conc. (%)	Total Sugars (%)			Total Carotenoids (µg/100g)			Titratable acidity (%)			pH		
		NP	SP	Mean	NP	SP	Mean	NP	SP	Mean	NP	SP	Mean
CMC	Control	74.3	86.0	80.1	1341.2	1043.4	1192.3	0.28	0.15	0.21	5.1	5.3	5.2
	1.0	76.7	86.4	81.4	1289.3	1005.4	1147.3	0.27	0.15	0.21	5.1	5.4	5.2
	2.0	79.7	86.7	83.2	1271.3	992.0	1131.6	0.26	0.14	0.20	5.2	5.4	5.3
	3.0	81.6	86.8	84.2	1256.4	973.0	1114.7	0.26	0.14	0.20	5.2	5.4	5.3
GMS	1.0	76.8	86.6	81.7	1243.4	970.9	1107.1	0.27	0.14	0.21	5.1	5.5	5.3
	2.0	79.2	87.5	83.3	1283.1	960.1	1121.6	0.27	0.14	0.21	5.1	5.6	5.3
	3.0	81.4	87.7	84.6	1243.0	928.8	1085.9	0.27	0.14	0.20	5.2	5.6	5.4
Mean			79.2	86.9			971.7		0.27	0.14		5.1	5.5
CD _{0.05}											0.149		
Pulp (P)		0.429			8.790			0.002			NS		
Foaming agent (F)		0.743			15.225			0.004			NS		
P × F		1.051			21.532			NS			NS		

Where, NP = Natural Pulp; SP = Sweetened Pulp; Conc.= concentration; CMC = Carboxy-methyl-cellulose; GMS = Glycerol-mono-stearate; Control= Powder obtained from pulp without using foaming agents.

Figure.1 Process for preparation of papaya fruit powder

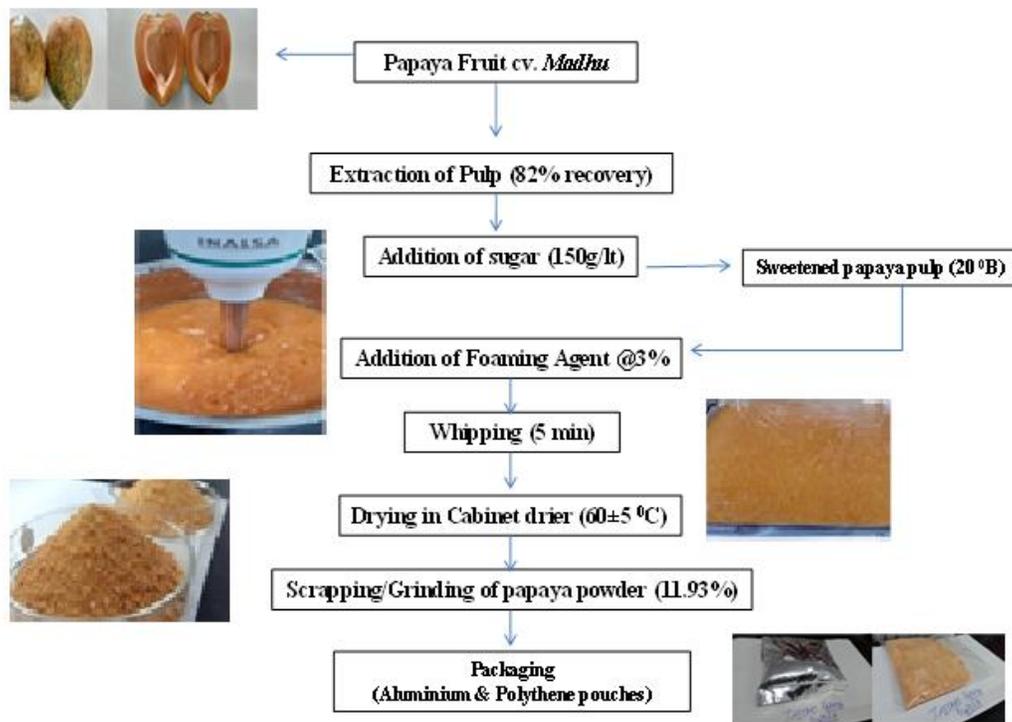


Figure.2 Effect of foaming agents on foam mat drying of papaya pulp cv. Madhu

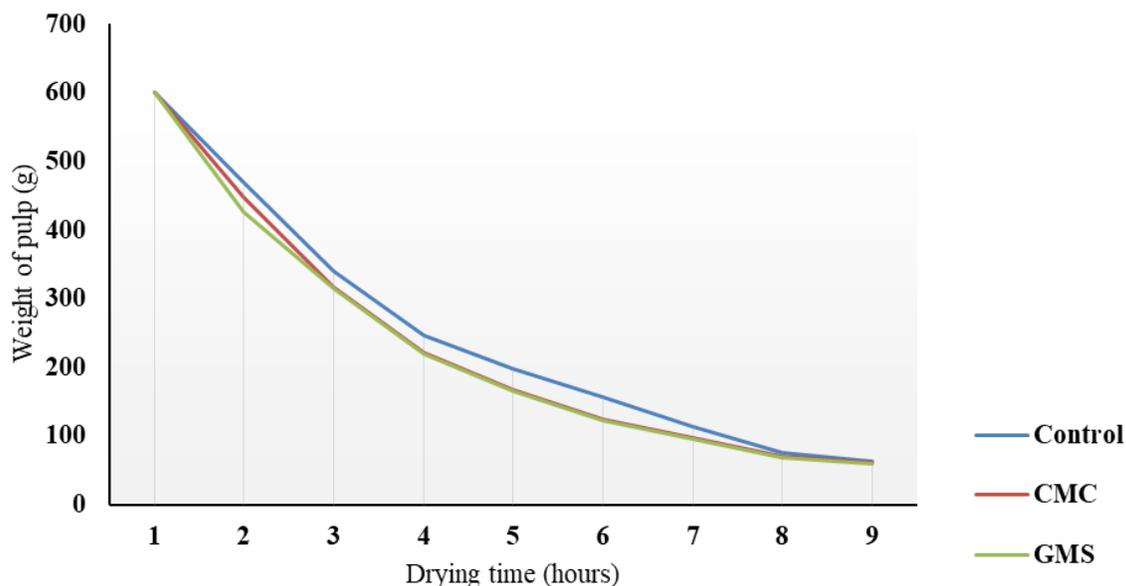
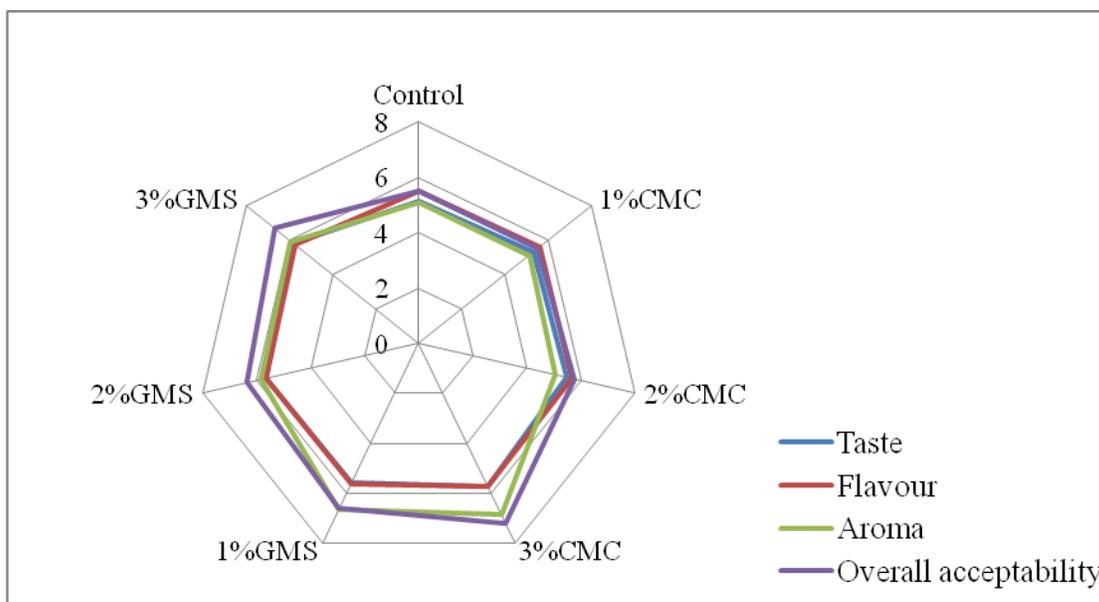


Figure.3 Sensory evaluation of papaya fruit powder (cv. Madhu) prepared by using different concentrations of foaming agents



Total sugars

Table 5 indicated that the papaya powder prepared from sweetened pulp exhibited significantly higher 86.9 per cent total sugars as compared to natural pulp (79.2 per cent).

Among different foaming agents, the non foamed pulp had 80.1 per cent total sugars which increased to 81.4 to 84.2 per cent in powder prepared by using CMC (1-3%) and 81.7 to 84.6 per cent in GMS (1-3%) treated foamed papaya pulp powder. Increase in sugar

content of foam-mat dried tomato with increasing the concentration of foam agents has been reported by Kadam *et al.*, (2012a) which may be due to the inherent content of foaming agents used.

Total carotenoid

The data presented in Table 5 shows that the papaya powder prepared from unsweetened natural pulp exhibited significantly higher (1264.3 µg/100g) total carotenoids as compared to powder from sweetened pulp (971.7 µg/100g). Among different foaming agents, the powder from un-foamed pulp had total carotenoids as 1192.3 µg/100g which decreased from 1147.3 to 1114.7 µg/100g in powder prepared by using CMC (1-3%) and 1107.1 to 1085.9 µg/100g in GMS (1-3%) treated foamed papaya pulp powder. Similar trend of decline in total carotenoids was observed by Khamjae and Rojanakorn (2018) in passion fruit (83.87-72.51 mg/100g) and Wilson *et al.*, (2012) in mango powder. The loss of total carotene could be attributed to its photosensitive nature, isomerisation and epoxide forming nature of carotenoids (Mir and Nath, 1993).

Titratable acidity

The papaya powder prepared from natural pulp exhibited significantly higher titratable acidity (0.27 per cent) as compared to sweetened pulp (0.14 per cent). Among different foaming agents, the powder from un-foamed pulp had 0.21 per cent titratable acidity (Table 5). With increase in the concentration of foaming agents non significant effect was observed. The powder prepared by using 1% GMS resulted in a titratable acidity of 0.27 per cent. Similar trends in titratable acidity has been reported by Sharma *et al.*, (2002) in hill lemon juice powder, Shaari *et al.*, (2017) in pineapple powders, Gupta and Alam (2014) in foam mat

dried grape bar and Kadam *et al.*, (2011) in mandarin powder.

pH

Among different foaming agents, the powder from un-foamed pulp had pH value of 5.2. With increase in the concentration of foaming agents (1-3%), the values of pH in dried papaya powder increased to 5.2-5.3 in powder prepared by using CMC and 5.3-5.4 in GMS (Table 5). Among different concentration of foaming agents, it was found that with the increase in concentration of the foaming agents, the pH of the resultant powder exhibited increase. Gradual increase in pH (3.7-4.8) with increase in concentration of foaming agent has also been reported by Kadam *et al.*, (2011) in mandarin powder and by Shaari *et al.*, (2017) in foam mat dried pineapple fruit.

Sensory evaluation

Sensory evaluation of papaya fruit powder of natural and sweetened pulp prepared by using 1-3% concentrations of CMC and GMS is shown in Figure 3. The mean hedonic score for the powder prepared from sweetened pulp was significantly higher (6.32) in comparison to natural pulp. Further, among foaming agents, the powder obtained from papaya pulp foam by using GMS was superior in taste with a mean score (5.57-5.78) as compared to CMS. The powder prepared by using 3% GMS in sweetened pulp was liked the most. The mean Hedonic score (9-point scale) for overall acceptability from the papaya powder prepared from sweetened pulp was significantly higher (7.33) in comparison to natural pulp. Among the foaming agents, the powder obtained from papaya pulp by using GMS was rated higher (6.35-6.65) as compared to CMC. Therefore the papaya powder prepared from 3% GMS obtained the highest sensory score on the basis of taste,

flavour, aroma and overall acceptability indicating better acceptability (Figure 3).

It is concluded, on the basis of all physico-chemical characteristics, effect of foaming agents on foaming characteristics of papaya pulp and sensory evaluation of papaya powder, the use of 3% glycerol-mono-stearate (GMS) followed by foam mat drying of the resultant foam in dehydrator ($60\pm 5^{\circ}\text{C}$) to a constant moisture content has been found the most appropriate and suitable for drying of papaya pulp. Thus, the technique can be used for commercial production of papaya powder for further utilization in development of ready-to-serve beverage by reconstituting the powder.

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