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Foam mat drying of papaya and guava pulp

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Abstract
The study was carried out for utilization of papaya and guava fruits pulp for preparation of foam mat dried fruit powder. The conversion of fruit pulp into foam was optimized by whipping the pulp after addition of carboxy-methyl-cellulose (CMC) and drying the resultant foam in dehydrator (60±5 °C) to constant moisture content. Drying of fruits pulp foam by using 3% CMC were found the most appropriate with respect to desired foaming properties (foam density, foam expansion and foam stability), drying time and powder yield. With the increase in the foaming agent concentration, the foam density decreases significantly however, the percentage of foam expansion was increased and foam stability were more stable. Thus, the papaya and guava fruit pulp can be utilized for preparation of self-stable powder using foam mat drying technique for further preparation of value-added products.

Keywords: Foam-mat drying, guava and papaya fruit, drying, CMC, foaming properties

Introduction
Papaya and guava are an important tropical and sub-tropical fruit crop in the world that is widely preferred for its nutritional values (Sidhu, 2006; Surendar *et al*., 2016) [22, 23]. Papaya is the fifth and guava is the fourth important fruit crops of india after mango, banana and citrus (NHB, 2019) [15].
Papaya fruits are rich in nutrients especially β-carotene, Vitamin A, Vitamin C, minerals like potassium and magnesium and are good source of energy (Widyastuti *et al*., 2003) [25]. 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) [24].
Also, Guava is a rich source of vitamin C (260 mg/100g) (Menzel, 1985) [13], pectin (1.8%) (Dhingra *et al*., 1983) [7] and vitamin A (250IU/100g) (Dhilion *et al*.,1987) [6]. It contains high amount of dietary fibre and also contains appreciable quantities of niacin, thiamine, riboflavin, carotene, calcium and phosphorus. However, pink guava fruit contains higher antioxidants than white guava (Yadava, 1996; Flores *et al*., 2015) [26, 9]. The high level of antioxidants pigments like carotenoids and polyphenols present in guava fruit increases its dietary value (Chen and Yen, 2006) [5].
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) [16].

Material and Methods
Sample preparation
Fresh papaya and guava fruits were purchased from the local market and brought to the department of food science and technology, college of horticulture and forestry, Neri. The fruits were then washed with running tap water, peeled and their seeds removed. The fruits were cut into pieces and processed into homogenous puree individually in a commercial blender (Robot 5.0 SS INALSA) for 5 minute. The liquidized fresh fruit puree were stained or sieved to remove fibers to obtain smooth puree. 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 fruit powder and for other analytical purposes.
The powder was prepared by converting the puree into a thick stable foam by whipping the pulp after adding (1-3%) carboxy methyl cellulose in different concentrations. The prepared foam was spread in-to the stainless steel trays in thin layer and placed in mechanical dehydrator (cabinet drier) for drying at 60±5 °C to a constant weight.

The dried foam was scrapped/removed from the trays and ground to a fine powder followed by packing in almunium and stored for further experimentation.

Physico-chemical analysis

Fruit size

Length and diameter of the fresh fruit were determined by using Vernier Calliper.

Weight

The weight of fruits in grams was determined gravimetrically and expressed as mean weight (g).

Pulp yield (%)

The pulp obtained from papaya fruits was weighed to find out the per cent pulp recovery as follows,

$$\text{Pulp yield (\%)} = \frac{\text{Weight of pulp}}{\text{Total fruit weight}} \times 100$$

Chemical characteristics

Total soluble solids (TSS)

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) [18]. The prism of refractrometer was washed with distilled water and whipped dry before every

Moisture Content

The moisture content was estimated by drying the weighed sample to a constant weight in hot air oven at 70 ± 5 0C followed by cooling at ambient temperature in desiccatorsprior to weighting (Ranganna, 2014) [18]. Moisture in term of percentage was calculated as given below:

$$\text{Moisture (\%)} = \frac{\text{Weight of fresh sample} - \text{weight of dried sample}}{\text{Weight of fresh sample}} \times 100$$

Titratable acidity

The titratable acidity of papaya pulp and its powder was determined by titrating the aliquots of known quantity of sample against 0.1 N NaOH to have pink end point by using 0.1 per cent phenolphthalein indicator. The values of titratable acidity were expressed as per cent citric acid (Ranganna, 2014) [18] and calculated by using the following formula:

$$\text{Titrable acidity (\%)} = \frac{\text{Titre value} \times \text{Normality of Alkali} \times \text{Volume made up} \times \text{Equivalent weight of acid}}{\text{Volume of sample taken} \times \text{Volume of aliquot taken} \times 1000} \times 100$$

pH

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, pH meter was calibrated with buffer solution of pH 4.0 and pH 7.0 (AOAC, 1995) [3].

Sugars

Total and reducing sugars of pulp and fruit powder were determined by Lane and Eynon (1923) [11] volumetric method as detailed by Ranganna (2014) [18]. The samples were prepared after using standardized method followed by titration against 10 ml of standardized Fehling's solution using methylene blue as an indicator to a brick red precipitate for determining the reducing and total sugars, respectively.

Total and reducing sugars expressed as percent were calculated using the following formula:

$$\text{Reducing sugars (\%)} = \frac{\text{Factor} \times \text{Dilution}}{\text{Titre value} \times \text{Weight of sample}} \times 100$$

1.

2. Total sugars as invert sugars (%) = calculated as in (1) making use of titre value as obtained in the determination of total sugars after inversion

Total carotenoids

Carotenoids in papaya pulp and fruit powder were estimated according to the method prescribed by Ranganna, (2014) [18]. A known weight of sample diluted with petroleum ether and shakes for one hour then filtered. Extraction was continued till the residue became colourless. All extracts were combined and transferred into separating funnel then diluted with water. Petroleum ether was added to transfer all colour into it and then separated out. The colour intensity (optical density) was measured in a UV-Vis spectrophotometer with wavelength of 452 nm. The results were expressed in terms of total carotenoids as µg/100 g of the sample and estimated by using following formula:

$$\text{Total carotenoids as µg/100 g} = \frac{\text{µg of carotene per ml} \times \text{OD} \times \text{volume made}}{\text{Weight of sample}} \times 100$$

Foaming properties

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) [8]. 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 transferring was carried out carefully to avoid destroying the foam structure or trapping the air voids while filling the cylinder. The foam density was calculated using the following formula:

$$\text{Foam Density (FD)} = \frac{\text{Mass of the foam (g)}}{\text{Volume of the foam (cm3)}}$$

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) [2].

$$\text{Foam Expansion (FE)} = \frac{V1 - V0}{V0} \times 100$$

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) [12]. Then the decrease of the foam volume was noted in every 30 minute time interval. The reduction of the

foam volume was noted to be used as an index for the determination of the stability for every 30 minutes by using following relationship:

$$\text{Foam Stability (FS)} = \frac{V0}{V1} \times 100$$

Statistical analysis
All laboratory analysis were carried out in triplicates. The mean and standard deviation was calculated using MS Excel for all the chemical parameters analyzed by using analysis of variance (ANOVA) at 5% level of significance.

Results and Discussion
The fresh fruits pulp and developed powder were analyzed for their Physico-chemical (Length, Diameter, Weight, Pulp yield, TSS, Titrable acidity, pH, Reducing sugars, Total sugars, Carotenoids, Moisture, Non-reducing sugars) parameters.

Physico-chemical analysis of fresh fruits samples
The Physico-chemical analysis of fresh fruits of papaya and guava was carried out by different parameters such as length, diameter, weight, pulp yield, TSS, total acidity, pH, reducing sugars, non-reducing sugars, total sugars, carotenoids and moisture content are in Table 1.

Table 1: Physico-chemical analysis of fresh Papaya and Guava fruits

Parameters	Guava fruit	Papaya fruit
	Mean±S.E.	Mean±S.E.
Length (cm)	15.00±0.100	5.88±0.047
Diameter (cm)	11.36±0.181	6.06±0.049
Weight (g)	1,100.00±57.009	134.28±0.766
Pulp yield	82.60±0.927	85.33±0.180
TSS	8.00±0.071	11.66±0.117
Total Acidity	0.03±0.001	0.53±0.016
pH	5.74±0.046	5.14±0.158
Reducing sugars	5.53±0.058	5.52±0.168
Non-reducing sugars	1.77±0.082	2.95±0.133
Total Sugars	7.39±0.043	8.62±0.101
Carotenoids	799.68±3.431	1,987.98±5.315
Moisture content	87.00±0.707	85.72±0.084
C.D.	47.035	4.430

Analysis of foaming process
The different foaming properties (foam density, foam expansion and foam stability) at various concentrations of CMC in papaya and guava fruit pulp are depicted in Table 3.2.

The fruit pulp from both papaya and guava fruits were converted into foam by using appropriate concentration of Carboxy methyl cellulose (0-3%) for the preparation of fruit powders. It was found that whipping of both fruits pulp for 3 min at room temperature without addition of foaming agents did not yield much foam (Table 3.2). However, with the increase in the level of CMC (1-3%), the pulp turned into foam and showed increase in its total volume after whipping. Maximum increase in foam volume was observed after whipping papaya pulp with 3% CMC in both the fruit pulp.

Table 2: Effect of foaming concentration on foamed pulp from papaya and guava fruits

Foaming properties	Foam Density		Mean	Foam Expansion		Mean	Foam Stability		Mean
	Papaya	Guava		Papaya	Guava		Papaya	Guava	
Control	0.81	0.96	0.88	7.00	3.14	5.07	98.67	0.00	49.33
1%	0.77	0.90	0.83	18.39	14.29	16.34	98.00	96.94	97.47
2%	0.76	0.87	0.82	19.38	16.35	17.86	99.50	99.07	99.28
3%	0.75	0.84	0.79	21.47	18.37	19.92	99.52	99.67	99.59
Mean	0.77	0.89		16.56	13.04		98.92	73.92	

Foam density
It is evident from Table 2 that guava pulp exhibited significantly higher (0.86 g/cm³) foam density as compared to foam density of papaya pulp (0.77 g/cm³). Among different concentration of foaming agent (CMC), foam density ranged between 0.75 to 0.96 g/cm³ and foam prepared by using guava pulp exhibited higher density (0.96 - 0.85 g/cm³) as compared to papaya pulp (0.81 - 0.75 g/cm³). Reduction in foam density with increasing foaming agents has also been reported by Rajkumar and Kailappan, (2006) [17] 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) [4].

Foam expansion
Data given in Table 2 reveal that the foam expansion was significantly higher (16.56 %) in papaya pulp than guava pulp (13.04 %). Among different concentration of foaming agent (CMC), foam expansion ranged between 3.00 to 21.47 % and foam prepared by using papaya pulp exhibited higher foam expansion (7.00 – 21.47 %) as compared to guava pulp (3.14 – 18.37 %). Increased in foam expansion with increasing foaming agents has also been reported by Affandi *et al.*, (2017) [1] and Rajkumar and Kailappan, (2006) [17]. 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 (98.92 %) in papaya pulp than guava pulp (73.92 %). Among different concentration of foaming agent (CMC), foam stability ranged between 0.00 to 99.67 % and foam prepared by using papaya pulp exhibited higher foam stability (98.67 – 99.52 %) as compared to guava pulp (0.00 – 99.67 %). Similar findings have been reported by Affandi *et al.*, (2017) [1].

Drying time
The papaya and guava pulp after turning in to foam by using

different foaming agent concentration was dried in a cabinet drier at 60±5°C. Data given in Table 3 reveal that the average drying time for pulp (average weight taken 1 kg for each pulp with each concentration) with different concentration varied between 9.21 to 7.38 hours. The effect of foaming agent concentration on foam mat drying of papaya and guava pulp is decreased with increased the concentration of foaming agent (CMC). Foaming without concentration took the longest (9.21 hours for papaya pulp and 8.30 hours for guava pulp) time for drying while foaming of pulp brought about significant reduction in drying time of the pulp. Foaming of guava pulp took longer time than papaya pulp, this may be because of guava pulp is mmore thick and contain high amount of tss than papaya. Gupta and Alam (2014) [10] also stated that drying time was reduced (490-180 minutes) with increasing the concentration of foaming agents.

Table 3: Drying time duration for one kg pulp of Guava

	Drying time durantion		
	Papaya	**Guava**	**Mean**
Control	8.30	9.21	8.76
1%	8.10	8.26	8.18
2%	7.45	8.09	7.77
3%	7.35	7.81	7.58
Mean	7.80	8.34	

Quality characteristics of foam mat dried powder

TSS

Data in Table 4 indicate that the foam mat dried powder prepared from guava pulp exhibited significantly higher (86.30°B) TSS as compared to powder from papaya pulp (80.43°B). Among different concentration of foaming agent, the powder from papaya pulp had 79.00°B TSS which increased to 80.66 to 81.21°B by using CMC (1-3%) and the powder from guava pulp had 85.39°B TSS which increased upto 86.95°B. The powder prepared by using 3% CMC resulted in a TSS of 86.95°B which was similar to the findings of Sharma *et al*., (2002) [20]. Similar trend of increase in total soluble solids with increase in foaming agent concentration (0- 20%) has been reported by Shaari *et al*., (2017) [19].

Reducing sugars

Data presented in Table 4 indicate that the foam mat dried powder prepared from guava pulp had higher (52.31 %) reducing sugars as compared to powder from papaya pulp (44.73 %). Among different concentration of foaming agent, the powder prepared from papaya pulp had 79.00°B TSS which increased to 80.66 to 81.21°B by using CMC (1-3%) and the powder from guava pulp had 85.39°B TSS which increased upto 86.95°B. The powder prepared by using 3% CMC resulted in a TSS of 86.95°B which was similar to the findings of Sharma *et al*., (2002) [20]. Similar trend of increase in total soluble solids with increase in foaming agent concentration (0- 20%) has been reported by Shaari *et al*., (2017) [19].

Total sugars

Data in Table 4 indicate that the foam mat dried powder prepared from guava pulp exhibited significantly higher (78.56 %) Total sugars as compared to powder prepared from papaya pulp (75.88 %). Among different concentration of foaming agent, the powder from papaya pulp had 74.27 % Total sugars which increased to 77.03 to 74.73 % by using CMC (1-3%) and the powder from guava pulp had 77.66 Total suagrs which increased upto 79.16 %. The results similar to the findings of Sharma *et al*., (2002) [20]. Similar trend of increase in total sugars with increase in foaming agent concentration (0- 20%) has been reported by Shaari *et al*., (2017) [19].

Table 4: Effect of foaming agent concentration on TSS, Reducing sugars and Total sugars of foam mat dried papaya and guava powder

	TSS (°B)			Reducing sugars (%)			Total sugars (%)		
	Papaya	**Guava**	**Mean**	**Papaya**	**Guava**	**Mean**	**Papaya**	**Guava**	**Mean**
Control	79.00	85.39	82.19	41.13	51.45	46.29	74.27	77.66	75.97
1%	80.66	86.30	83.48	45.74	52.33	49.03	77.03	78.56	77.79
2%	80.85	86.58	83.72	46.26	52.56	49.41	77.49	78.86	78.17
3%	81.21	86.95	84.08	45.79	52.92	49.35	74.73	79.16	76.95
Mean	80.43	86.30		44.73	52.31		75.88	78.56	

Titratable acidity

The foam mat dried powder prepared from guava pulp had higher titratable acidity (2.17 per cent) as compared to papaya pulp (0.17 per cent). Among different concentrations of foaming agent, the powder had titratable acidity 2.21 to 0.13 per cent (Table 5). With increase in the concentration of foaming agents non significant effect was observed. Similar trends in titratable acidity has been reported by Sharma *et al.*, (2002) [20] in hill lemon juice powder and Shivani *et al.*, (2020) in foam mat dried papaya powder.

Carotenoids

The data presented in Table 5 shows that the foam mat dried powder prepared from guava pulp had higher (2279.87 µg/100g) total carotenoids as compared to foam mat dried powder from papaya pulp (1917.35 µg/100g). Among different concentrations of foaming agent, the foam mat dried powder prepared by using CMC had 1179.03 to 2210.91 µg/100g total carotenoids as which decreased with increasing the concentration of foaming agents. Similar trend of decline in total carotenoids was observed by Shivani *et al*., (2019) [21] in papaya powder. The loss of total carotene could be attributed to its photosensitive nature, isomerisation and epoxide forming nature of carotenoids (Mir and Nath, 1993) [14].

Table 5: Effect of foaming agent concentration on Titratable acidity and Carotenoids of foam mat dried papaya and guava powder

	Titratable acidity (%)			Carotenoids (µg/100g)		
	Papaya	**Guava**	**Mean**	**Papaya**	**Guava**	**Mean**
Control	0.17	2.47	1.32	1341.56	2403.88	1872.72
1%	0.13	2.13	1.13	1179.03	2260.57	1769.80

2%	0.16	2.05	1.11	1144.68	2244.10	1694.39
3%	0.20	2.04	1.12	1104.14	2210.91	1657.53
Mean	0.17	2.17		1917.35	2279.87	

Conclusion
It is concluded, on the basis of all Physico-chemical characteristics, effect of foaming agents on foaming characteristics of papaya pulp and guava pulp and their foam mat dried powder, the use of 3% CMC followed by foam mat drying of the resultant foam in dehydrator (60±5 °C) to a constant moisture content has been found the most appropriate and suitable for drying of fruit pulp. Thus, the technique can be used for commercial production of papaya and guava powder for further utilization in development of other products by reconstituting the powder.

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