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Formulation and acceptability of foam mat dried papaya (*Carica papaya* L.) powder

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Abstract
Technology for utilization of papaya fruit pulp for preparation of fruit powder was optimized by modifying the foam mat drying technique. The conversion of papaya fruit pulp into foam was standardized by whipping the pulp after addition of carboxy-methyl-cellulose (CMC) and glycerol-mono-stearate (GMS) @ 0-3% each and drying the resultant foam in a dehydrator (60 ± 5 °C) to a moisture content of about 8–12%. Further, fruit powder packed in aluminium and polyethylene pouches stored at ambient temperature (30–35 °C) exhibited slight increase in moisture content and pH with minimum changes in TSS, titratable acidity, reducing sugars and total sugars. The values of different attributes after packing powder either in polyethylene and aluminium pouches up-to 90 days of storage Further, ready-to-serve beverage prepared by reconstituting 12% papaya-mango powder in 50:50 proportions and raising TSS to 12°B by adding sugar syrup was found most acceptable with sensory on 9-point hedonic scale.

Keywords: *Carica papaya* L. foam mat drying, CMC, GMS, whipping

Introduction
Papaya (*Carica papaya* L.) belonging to family Caricaceae is a hollow stem, short lived perennial tree native of tropics of America and an important tropical and sub-tropical fruit crop in the world (Desai *et al.* 2017) [6]. 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.*, 1972; Widyastuti *et al.*, 2003) [8, 29]. 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) [28].
Owing to highly perishable nature due to nearly 88% of moisture, papaya fruits cannot be stored for longer periods under ambient conditions. In India, estimated losses in papaya fruit are 4.12% during farm operations (harvesting, collection, sorting/grading, packaging and transport) and 2.58% during storage channels (farm level, godown cold storage, wholesaler, retailer and processing unit) (Jha *et al.*, 2015) [12]. Therefore, processing of papaya fruits seems to be a viable proposition for production of different value added products rich in nutrients.
For the prevention of crop from deterioration and for extending shelf-life, various preservation techniques have been employed with main emphasis to convert perishable commodities into stable form so that these can be kept for longer periods thereby, reducing losses. It will also make the commodity available at time of scarcity and off-season use and for places which are away from production sites (Santos and Silva, 2008). [24] Among various methods of preservation, foam mat drying is a 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 a suitable foam with the help of foaming agents and the resultant foam is dried at low temperature (Meena *et al.*, 2014) [20]. 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 (Jayaraman *et al.* 1974; Rajkumar *et al.*, 2007) [10, 21], pineapple and tomato (Jayaraman, 1993; Hassan and Ahmed 1998) [11, 9]. Karim and Wai (1999) [16] and Akintoye and Oguntunde (1991) [1] obtained higher drying rates in the start of foam mat drying in star fruit and soymilk, respectively whereas Sankat and Castaigne (2004) [23]; Thuwapanichayanan *et al.* (2008) [27] have reported higher drying rate at the end of drying period in banana, Kadam *et al.* (2010) [15]

in mango and by Kadam and Balasubramanian (2011) [13] and Kadam *et al.* (2011) [14] in tomato juice. Limited work has been reported on foam mat drying of papaya. Thus, the present investigations were undertaken to optimize the process for conversion of papaya pulp into foam and drying the foam to prepare ready to serve beverage for increasing the consumption of this product among the consumers.

Material and Methods

The fruits of papaya cv. Madhu were used for pulp extraction. Aknownweight of thoroughly washed fruits was cut into two halves. Then seeds were removed and peeling of the halves was done manually. The pulp of fruits was prepared by adding 10% water (100ml/kg fruits), followed by heating for 10 minutesto soften (Morgan *et al.* 1959) 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. Fruit powder was prepared from the papaya pulp by making appropriate modifications to prepare foam from the pulp and drying the foam in a drier. Thepapaya powder was converted into stable foam by whipping the pulp after addition of carboxy methyl cellulose or glycerol mono stearate @ 0–3% each. Both natural as well as sweetened pulp (prepared after addition of sugar syrup to make 20°B TSS) was evaluated. The prepared foam was spread in-to the stainless steel trays in thin layer and placed in cabinet drier for drying at 60±5 °C to a 8% moisture content

Analysis

Physico-chemical analysis of papaya fruits and dried powder was conducted by using standard analytical procedures (Ranganna, 2014) [22]. Total Soluble Solid (TSS) contents of papaya fruit pulp and dried was determined by hand refractometer and sugars were estimated by Lane and Eyon method as given by Ranganna (2014) [22]. Acidity was determined by titrating the aliquots against a standardized 0.1 N NaOH solution to a pink end point using phenolphthalein as an indicator (Ranganna 2014) [22] Foam Expansionwas calculated according to the equation given by Akiokato *et al.,* (1983) [2]. Foam Stability was estimated as per method of Marinova *et al.,* (2009) [19]. The rate of dehydration per unit time was calculated by placing a weighed quantity of foamed pulp (600 g) on a stainless steel tray (30×20 cm^2) and drying in mechanical dehydrator (60 ± 25°C) to a moisture content of 12–14% (w/w). The loss in weight during drying (% dwb) was calculated by plotting the moisture on dry weight basis against time in hours (Rangana, 2014). The equilibrium relative humidity (ERH) of fruit Powder was determined according to Ranganna (2014) [22] by placing known weight of fruit powder in atmosphere of different relative humidities (0–100%) in closed dessicator at room temperature (18.5–31.5 °C) maintained by using different concentration of H_2SO_4. After equilibrium loss or gain in weight of sample was plotted against the respective relative humidities to determine ERH of a given sample.. Critical and danger points of fruit Powder were calculated according to the weight equilibrium method (Ranganna, 2014) [22]. For sensory scoring, the RTS was served for evaluation by a panel of 7–9 semi-trained judges for various quality attributes *viz.,* colour, taste, flavour, body and overall acceptability on 9 point hedonic scale. Data pertaining to sensory evaluation of fruit powder were analyzed according to Randomized Block Design (RBD) as described by Mahony (1985) [18] while, the data on chemical characteristics of fruit leather were analyzed statistically by following Completely Randomized Design (CRD) according to Cochran and Cox (1967) [5].

Results and Discussion

Physico chemical characteristics of fruits

The papaya fruits having mean weight 1100.00±57.008 g, length 15.00±0.10 cm and diameter 11.36±0.18 cm with a peel:pulp ratio 1:6 (Table 1). The yield of papaya pulp was recorded as 82.60±0.920 per cent. Though, the pulp contains 8.00±0.070 °B total soluble solids with 0.033±0.0009 per cent titratable acidity. Papaya fruit belongs to the low acid group of fruits, having 5.73±0.046 pH of the fruit pulp. The content of reducing sugars, non-reducing sugars and total sugars in fresh papaya fruits found to be 5.53±0.057, 1.76±0.049 and 7.39±0.042, respectively. The moisture content of fruit recorded 87.00±0.070 per cent.

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

S. No.	Parameters	Mean± SE*
	Physical characteristics	
1	Length (cm)	15.00±0.100
2	Diameter (cm)	11.36±0.180
3	Weight (g)	1100.00±57.008
4	Peel/Pulp ratio	1:6.0
5	Pulp yield (%)	82.60±0.920
	Chemical characteristics	
6	TSS (^{0}B)	8.00±0.070
7	Titratable acidity (%)	0.033 ±0.0009
8	pH	5.73±0.046
9	Reducing sugars (%)	5.53±0.057
10	Total sugars (%)	7.39±0.042
11	Moisture content (%)	87.00±0.700
12	Total carotenoids (µg/100ml)	799.68±3.431

*Means of 3 replicates

Conversion of pulp into foam for drying

The fruit pulp was converted into foam by using appropriate concentration of Glycerol mono stearate (0-3%) for the preparation of fruit powder. It was found that whipping of papaya pulp for 5 min at room temperature without addition of foaming agents did not yield any foam (Table 2). However, with the increase in the level of GMS (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% GMS. However, the foam obtained from papaya pulp along with 3% GMS was found completely stabilized during drying with was suitable for drying.

Further, conversion of pulp into foam by using GMS brought considerable reduction in drying time of foam for preparation of powder. The foam prepared by using 3% GMS dried within 8 hours to a constant moisture content (8.23 per cent) in mechanical dehydrator (60±5°C). While pulp dried without using foaming agent took about 9 hours to dry into powder with the yield of dried powder varying between 10.70-11.93 per cent (Table 2). Thus, the addition of GMS to the papaya pulp for foaming prior to drying to a powder of desired characteristics was optimized. The fruit powder contains 87.60 to 89.83 °B total soluble solids.

Table 2: Quality evaluation of foam-mat dried fruit powder from papaya (*Carica papaya* L.) pulp

Pulp + Stabilizer	Foam expansion (%)	Foam stability (%)	Drying time (hrs)	Dried yield of powder (%)	Total soluble solids (^{0}B)	Moisture (%)
Pulp + 0% CMC	0	0	9.25	10.70	87.60	10.73
Pulp + 1% CMC	7.33	99.40	9.10	10.90	89.00	10.00
Pulp + 2% CMC	9.78	99.43	9.00	10.99	89.40	9.28
Pulp + 3% CMC	13.26	99.44	8.45	11.00	89.80	8.45
Pulp + 0% GMS	0	0	9.20	10.71	87.60	10.70
Pulp + 1% GMS	19.39	99.59	8.54	11.50	89.20	9.67
Pulp + 2% GMS	20.14	99.66	8.40	11.70	89.43	8.42
Pulp + 3% GMS	21.72	100.00	8.35	11.93	89.83	8.28

Dehydration characteristics of fruit powder

The dehydration curve for foam mat dried papaya powder prepared from natural and sweetened pulp containing 3.0% GMS. In comparison to total period of drying, the rate of dehydration was very fast during the initial period as about 50–55% (fwb) of the moisture was lost within the first 2.0 h of drying of both Sweetened and unsweetened pulp, thereafter the rate of drying slowed down. The data on the ERH of papaya powder at particular relative humidity (0-100%) is presented in the Figure 1 and Figure 2. Results showed that equilibrium relative humidity of natural pulp powder was 60 per cent while fruit powder obtained from sweetened pulp exhibited an ERH of 50.0 per cent. These results indicate that the powder can be safely stored in the environment having relative humidity of 50 to 60 per cent.

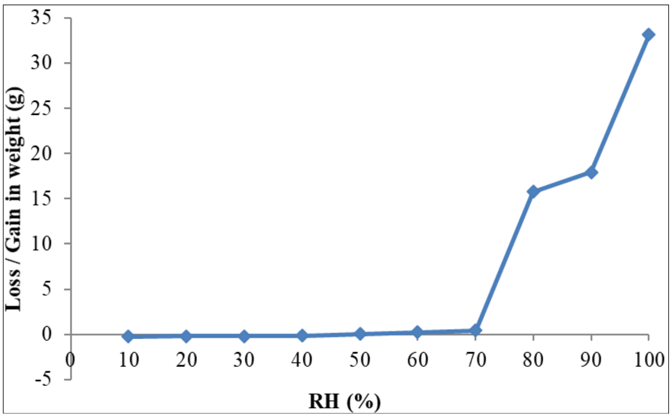

Fig 1: Equilibrium Relative Humidity (ERH) of Natural pulp powder

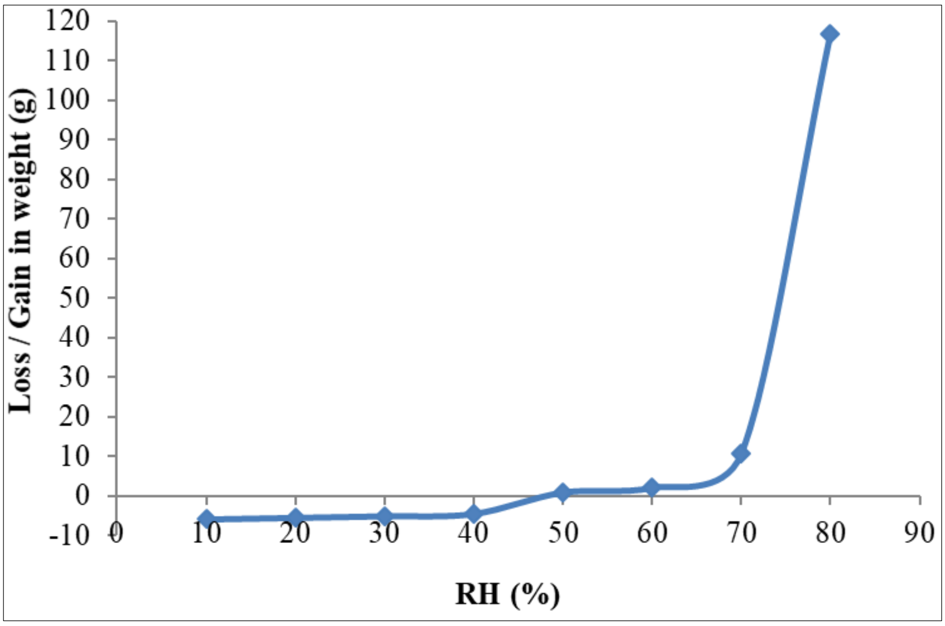

Fig 2: Equilibrium Relative Humidity (ERH) of Sweetened pulp powder

Physico-chemical characteristics of fruit powder

The data on physico-chemical characteristics of foam mat dried papaya fruit powder indicate that product prepared by using sweetened pulp exhibited better retention of nutrients than that of natural pulp. The fruit powder prepared from sweetened pulp (20°B) showed a higher proportion of TSS (87.60 °B vs. 79.30 °B), moisture content (10.73 per cent vs. 8.53), pH (5.34 vs. 5.04), reducing sugars (60.33 per cent vs. 49.67 per cent), non-reducing sugars (24.39 per cent vs. 23.75 per cent) and total sugars (86.00 per cent vs. 74.67 per cent) as compared to powder prepared by natural pulp (Table 3).

Table 3: Physico-chemical characteristics of foam-mat dried powder from papaya (*Carica papaya*) pulp

Parameters	Papaya pulp powder	
	Natural (mean ± SD)	Sweetened (mean ± SD)
Moisture (%)	8.53	10.73
Total soluble solids (^{0}B)	79.30	87.60
Titratable acidity (%)	0.276	0.148
Ash content (%)	4.73	3.83
pH	5.07	5.34
Reducing sugars (%)	49.67	60.33
Non-reducing sugars (%)	23.75	24.39
Total sugars (%)	74.67	86.00
Carotenoids (mg/100g)	1.34	1.04

Quantitative evaluation

With the advancement in period of storage, the TSS in papaya powder exhibited slight decline in different packaging materials. However, the effect of packaging on TSS in papaya powder was non-significant (Table 4). The mean moisture content of papaya powder increased to 10.64% from the initial value of 8.52% after 90 days storage in different packaging materials. However, the powder packed in aluminium pouches exhibited comparatively less changes in moisture content than that of powder packed in polythenene pouches. The effect of packaging on moisture content in papaya powder was significant. Data in Table 4 indicate that reducing sugars of papaya powder was not statistically significant. During storage of papaya powder the reducing sugars experienced or slight change 62.63 to 63.46 per cent after 90 days of storage at ambient temperature. Among different packaging materials, the powder in 0 day to 90 day increased from 62.63 to 63.51 per cent packed in polyethylene pouch and 62.63 to 63.46 per cent in aluminium pouch. The increase in reducing sugars during storage intervals is attributed due to polysaccharides hydrolysis. However, minimum effects on reducing sugars were observed in aluminium pouches as compare to polyethylene pouches. Scrutiny of data presented in Table 4 indicated that the total sugars of papaya powder significantly decreased from 87.73 to 85.70 per cent during 90 days of storage interval at ambient conditions (30-35°C). Among different packaging materials, the powder from 0 day had 87.73 per cent total sugars which were decline up-to 85.70 per cent in polyethylene pouches and 87.73 to 86.40 percent in aluminium pouch. The increase in total sugars during storage intervals is attributed due to polysaccharides hydrolysis and inversion of sugars into mono-saccharides. Whereas, minimum decreased of total sugars were found in aluminium pouches. Similar results have been observed by Sharma *et al.* (2002) [22] in hill lemon juice powder, Shaari *et al.* (2017) [25] in pineapple powders, Kadam *et al.* (2011) [13] in mandarin powder etc.

Table 4: Changes in Physico-chemical properties of foam-mat dried papaya powder packed in different packaging materials during storage at ambient temperature (28-35 ^{0}C)

Parameters	Packaging material	0 day	30 days	60 days	90 days	Mean	CD
TSS (^{0}B)	Polythene Pouch	88.03	87.17	80.50	80.07	83.94	PM= 0.558
	Aluminium Pouch	88.02	87.77	81.70	80.90	84.59	P= 0.395
	Mean	88.03	87.47	81.10	80.48		PM×P= N/A
Moisture (%)	Polythene Pouch	8.42	10.59	10.74	10.78	10.13	PM= 0.120
	Aluminium Pouch	8.63	10.43	10.47	10.49	10.00	P= 0.085
	Mean	8.52	10.51	10.60	10.64		PM×P= 0.170
Titratable acidity (%)	Polythene Pouch	0.040	0.036	0.034	0.029	0.035	PM= 0.05
	Aluminium Pouch	0.039	0.038	0.032	0.030	0.035	P= NS
	Mean	0.039	0.037	0.033	0.029		PM×P= NS
Reducing sugars (%)	Polythene Pouch	32.39	33.57	33.82	34.43	33.55	PM= 0.642
	Aluminium Pouch	32.38	32.95	33.47	33.65	33.12	P= NS
		32.39	33.26	33.64	34.04		PM×P= NS
Non-reducing sugars (%)	Polythene Pouch	44.46	42.73	40.69	39.39	41.82	PM= 0.531
	Aluminium Pouch	44.45	43.62	41.62	40.99	42.67	P= 0.375
		44.46	43.18	41.16	40.19		PM×P= 0.750
Total sugars (%)	Polythene Pouch	79.19	78.55	76.66	75.89	77.57	PM= 0.775
	Aluminium Pouch	79.18	78.87	77.27	76.81	78.03	P= NS
		79.18	78.71	76.97	76.35		PM×P= NS
pH	Polythene Pouch	5.56	5.55	5.61	5.66	5.59	PM= 0.012
	Aluminium Pouch	5.56	5.52	5.54	5.61	5.56	P= 0.018
		5.56	5.53	5.58	5.63		PM×P= NS

Where, PM= packaging material, P= parameters NS= non-significant

Sensory evaluation of papaya -mango powder Ready- to-serve beverages

The data pertaining to the effect of addition of varying proportions of papaya powder and *mango powder* on the sensory quality of the prepared papaya-mango RTS beverage are presented in Table 5. The data recorded for colour mean score remained highly significant within all combinations. With the increase in proportion of *mango powder* and corresponding decrease in papaya powder, the colour acceptability of the prepared drink exhibited increase on a 9 point hedonic scale. The colour score was recorded as statistically highest for drinks having 50 per cent papaya powder (8.30) and lowest for 100 per cent *papaya powder* (6.20). As expected, the highest mean score for taste acceptability were recorded for a drink having 50 per cent papaya powder. The aroma score of the papaya mango RTS beverage ranged from 5.80 to 7.33. The lowest aroma score was awarded to combinations having 100% papaya powder (5.80), thus, indicating the unacceptability 100 percent papaya powder in the beverages.

Table 5: Effect of addition of mango powder on the Sensory characteristics (9point hedonic scale) of papaya -mango Ready-to-serve beverage

Proportion of papaya and Mango powder	Color	Taste	Aroma	Overall acceptability
T_1 (100:0)	6.20 ± 0.15	6.00 ± 0.029	5.80 ± 0.058	5.95 ± 0.026
T_2 (80:20)	7.05 ± 0.02	6.45 ± 0.029	6.08 ± 0.060	6.10 ± 0.058
T_3 (70:30)	7.58 ± 0.04	6.90 ± 0.058	6.70 ± 0.115	6.58 ± 0.044
T_4 (60:40)	7.98 ± 0.04	7.55 ± 0.029	7.00 ± 0.058	6.98 ± 0.044
T_5 (50:50)	8.30 ± 0.05	7.80 ± 0.058	7.33 ± 0.088	7.36 ± 0.120
$CD_{0.05}$	0.253	0.137	0.253	0.213

Conclusion

Out of two foaming agents evaluated, the GMS foaming agent with 3% concentration proved best for foaming of papaya pulp. Foe low cost production of papaya powder, surplus and damaged papaya, available during gluts could be used. Increased production of papaya powder has a lot of scope for the industry with respect to value added powder based products.

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