International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
www.chemijournal.com
IJCS 2020; 8(2): 1220-1225

Received: 08-01-2020
Accepted: 12-02-2020

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Storage stability and utilization of foam mat dried papaya powder cv. *Madhu*

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DOI: https://doi.org/10.22271/chemi.2020.v8.i2s.8932

Abstract
Stability of papaya (cv. *Madhu*) powder packed in aluminium and polyethylene pouches and stored at ambient temperature (30-35 ^{0}C) was determined. Both packaging materials exhibited slight increase in moisture content and pH with minimum changes in TSS, titratable acidity, reducing sugars, total sugars under ambient conditions. However, products packed in aluminium pouches exhibited better retention of nutrients compared to polyethylene pouches. 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 score of 7.30 on 9-point hedonic scale. Thus, papaya fruit can be utilized for preparation of self stable powder by foam mat drying technique.

Keywords: Foam-mat drying, equilibrium relative humidity, storage studies, packaging, sensory evaluation

Introduction
The papaya fruits are considered to be a good source of β-carotene, Vitamin A and minerals like potassium and magnesium besides the presence of alkaloids, glycosides, flavonoids, carbohydrates, saponins, terpenoids, steroids and tannins (Gopalan *et al.* 1972; Widyastuti *et al.* 2003) [5, 21]. According to Vij and Prashar (2015) [20] the extract of various parts of papaya are known to have multifarious uses such as anti-hypertensive, anti-inflammatory, anti tumour, anti-fungal, anti-microbial, anti-sickling and anti-ulcer activity.

But, papaya fruits are highly perishable and cannot be stored for longer periods under ambient conditions. In India, estimated losses in papaya fruit have been reported 4.12% during farm operations and 2.58% during storage channels by Jha *et al.* (2015) [6]. Processing of papaya fruits can reduce these loses as well as make them available at time of scarcity and off-season use and for places which are away from production sites (Santos and Silva, 2008) [17]. Foam mat drying 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) [11]. It 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) [8] rehydration and retention of volatiles are important properties which are maintained by foam mat drying. The systematic information on preparation; storage and utilization of papaya powder is scanty. The present investigation was therefore, planned to study the physico-chemical storage characteristics of foam mat dried papaya powder as well as its utilization for preparation of blended RTS (Ready-To-Serve) beverages.

Materials and Methods
Ripe fruit of Papaya (*Carica papaya* L.) of '*Madhu'* variety were procured from the local market of District Hamirpur, washed thoroughly with water, cut into two halves to remove the seeds followed by peeling with hand peeler. The peeled papaya were cut into small pieces. The fruit pulp was prepared by adding 10% water (100ml/kg cut fruits), followed by heating for 10 minutes to soften and finally pulp was prepared with the help of blender (Robot 5.0 SS INALSA). Flow diagram for preparation of papaya powder is presented in figure 1.

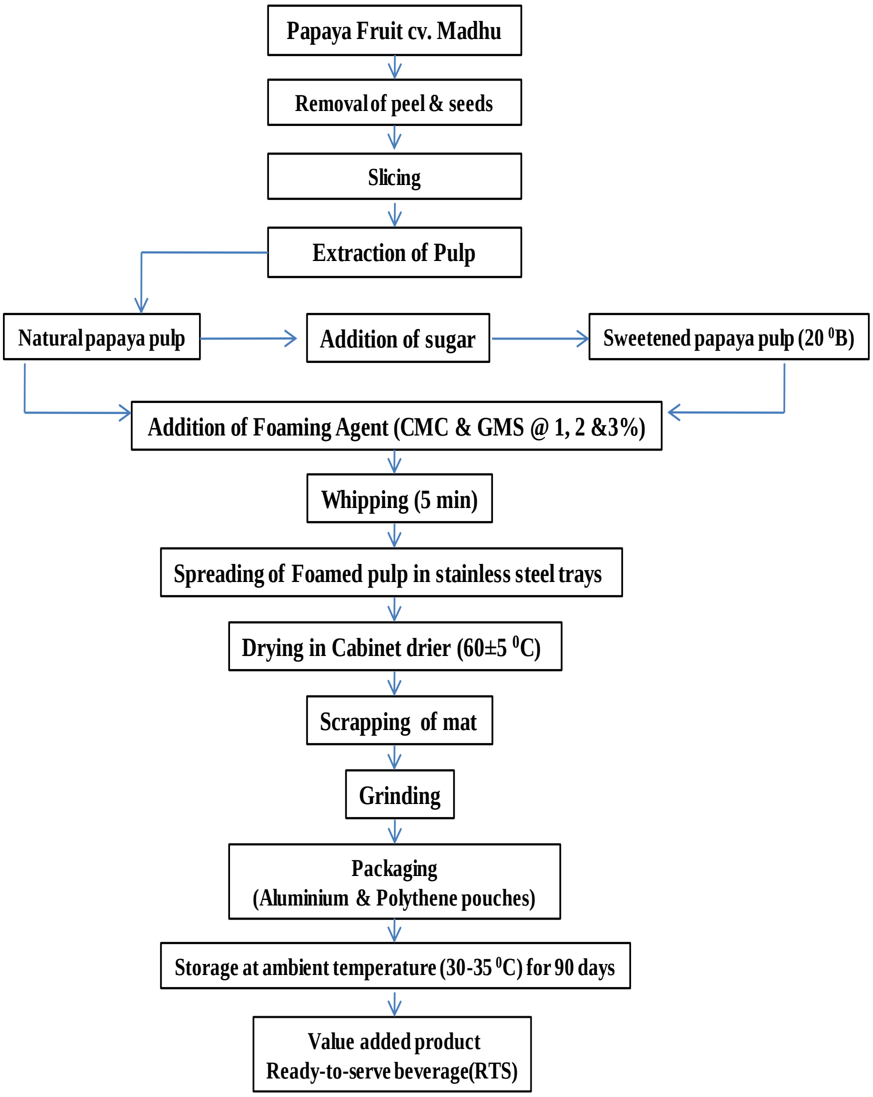

Fig 1: Flow chart for preparation of foam mat dried papaya powder

Physico-chemical analysis of fruit pulp and dried powder

TSS, Titratable acidity, pH and Moisture content were determined according to the procedure described by Ranganna, (2014) [13]. The moisture content was estimated by drying the weighed sample up to a constant weight in hot air oven at 70±2 ^{0}C and expressed in terms of percentage. Reducing sugars and total sugars in percent were estimated by Lane and Eynon method, (1923) [9].

The papaya powder was prepared by converting the papaya fruit pulp into a thick stable foam by whipping for 5 minutes after adding 1-3% concentration each of carboxy methyl cellulose or glycerol mono stearate. Thus, the prepared foam was spread in-to the stainless steel trays in thin layer and placed in tray drier at 60±5 °C temperature to a constant weight. The dried foam was scrapped/removed from the trays and ground to a fine powder followed by packing in almunium/polyethylene pouches and stored at ambient temperature (30-35 ^{0}C) for 90 days. Physico-chemical evaluation was carried out at one month interval.

Sensory evaluation

Sensory evaluation of RTS (ready-to-serve beverages) was carried out by semi-trained panellists and evaluated on the basis of color, taste, flavour and overall acceptability on 9-point hedonic scale where 9 is like extremely and 1 is dislike extremely (Mahony, 1985) [10],

Cost of production

Cost of production of foam mat dried papaya powder was calculated by taking into consideration various input costs such as raw material, labour, processing costs, packaging and other charges. For calculating the price of the product, 20 per cent profit margin was added to the cost of production of the product.

Statistically analysis

The data recorded from sensory evaluations and physico-chemical analysis of instant fruit powder were statistically analyzed by Randomly Block Design (RBD) and Completely Randomized Design (CRD) following the method of Mahony, (1985) [10] and Cochran and Cox (1967) [3], respectively to test the significance between the treatments.

Results and Discussion

The physico-chemical characteristics of papaya cultivars '*Madhu'* are presented in Table 1. The mean length, diameter and weight of papaya fruit 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 was 8.00±0.07^{0}B, titratable acidity 0.033 per cent with 5.73 pH which was found to be slightly lower than the observations of Parker *et al.* (2010) [12] who reported in *Rainbow* variety of papaya, Santos and Realpe

(2013) [16] in cv. *Maradol* papaya fruits and Attri *et al.* (2014) [1].

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) who reported 6.96-10.50 per cent total sugars with 3.42-6.92 per cent reducing sugars whereas, Reni *et al.* (2000) recorded slightly higher values as 6.40 per cent and 8.26 per cent of reducing and total sugars, respectively in papaya fruits. Earlier, Devaki *et al.* (2015) [4] observed that sugar is the major constituents of papaya fruits that may vary according to kind of varieties and agronomic condition.

Table 1: Physico-chemical characteristics of 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

Equilibrium relative humidity (ERH)

Data presented in Figure 2 and Figure 3 on moisture absorption behaviour revealed that the moisture absorbed by Natural pulp powder and Sweetened pulp powder held at different relative humidity (0 to 100%) caused the deterioration of powder, respectively. The pulp powder with initially attractive colour and good texture turned dark soft textured, hard textured and/or mouldy with increase in relative humidity. The critical points during storage of natural pulp powder and sweetened pulp powder were found 60 and 50%, respectively.

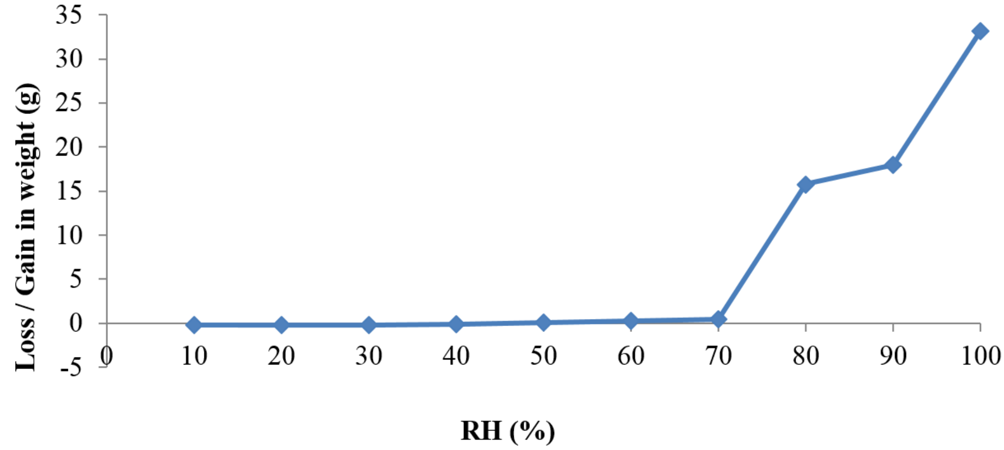

Fig 2 Equilibrium Relative Humidity (ERH) of Natural pulp powder

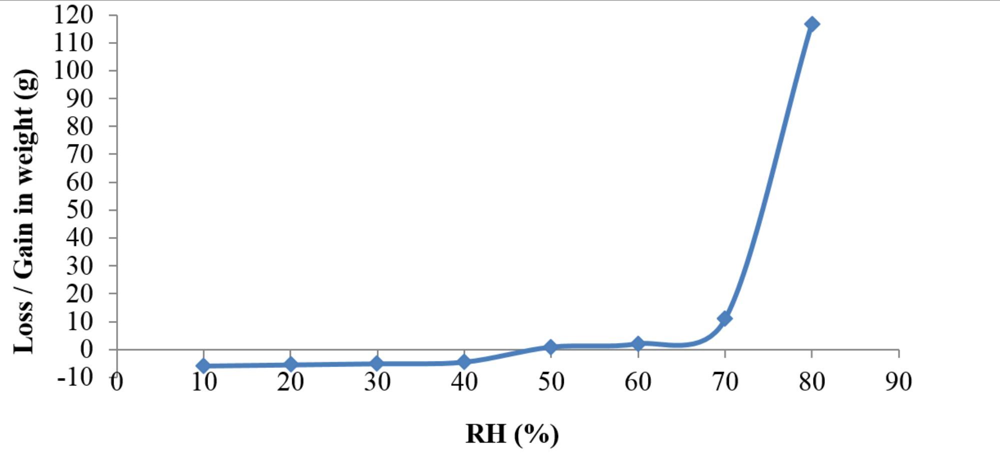

Fig 3 Equilibrium Relative Humidity (ERH) of Sweetened pulp powder

Storage studies

The conversion of papaya pulp into foam was optimized by whipping the pulp after addition of carboxy-methyl-cellulose (CMC) and glycerol-monostearate (GMS) @ 0-3% each and drying the resultant foam in dehydrator (60±5 °C) to a constant moisture content. Drying of papaya foam by using 3% GMS was found the most appropriate with respect to desired foaming properties (foam density, foam expansion and foam stability), physico-chemical and sensory characteristics. Dried powder contained 79.30-89.83°B TSS, 7.00-10.73% moisture content, 2.40-5.56% ash content, 49.67-62.63% reducing sugars, 74.27-87.73% total sugars, 928.76-1341.20 µg/100g total carotenoids, 0.135-0.276% titratable acidity and 5.07-5.57 pH.

Fruit powder packed in laminated and polyethylene pouches and stored under ambient storage conditions (Table 2). The total soluble solids experienced a slight change from 89.8 to 88.0°B after 90 days of storage at ambient temperature. The powder packed in aluminium pouches exhibited its superiority in checking the changes in TSS during storage. Similar to these findings Sivakumar and Nallakurumban (2016) [19] also observed decrease in TSS (38.85-38.50°B) of foam mat dried mango powder based ice cream. Titratable acidity of papaya powder exhibited decrease from 0.135 to 0.120 per cent up-to 90 days of storage interval at ambient temperature (30-35 °C). However, the difference was statically non-significant. Among different packaging materials, titratable acidity decreased from 0.135 to 0.120 per cent in papaya powder packed in polyethylene pouch while powder packed in aluminium pouches showed only marginal change in titratable acidity from 0.135 to 0.130 percent in aluminium pouch. Similar trends of reduction in titratable acidity has been reported by Sharma *et al.* (2004) [18] in hill lemon juice powder (43.54-42.79 per cent) and Barooah *et al.* (2018) [2] in banana powder (3.66-2.30 per cent). pH of papaya powder exhibited increase from 5.57 to 5.65 up-to 90 days of periodic intervals at ambient temperature. However, the difference was statically non-significant. Among different packaging materials pH, increased from 5.57-5.65 packed in polyethylene pouch which showed marginal change in pH 5.57 to 5.61 in aluminium pouch. The increase in pH of papaya powder during storage intervals attributed due to decline of titratable acidity. Whereas, minimum increased of pH was found in aluminium pouches. Gradual increase in pH during storage interval has been reported by Kadam *et al.* (2011) [7] in mandarin powder during storage.

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. Similar trend was recorded by Sharma *et al.* (2004) [18] in hill lemon juice powder (17.10-17.42 per cent) and Barooah *et al.* (2018) [2] in banana powder (24.98-28.40g). 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 trend of decline in total sugars was observed by Sharma *et al.* (2004) [18] in foam mat dried hill lemon juice powder (45.82-45.53 per cent). The moisture content of papaya fruit powder ranged from 8.28 to 9.90 per cent. Among different packaging materials, the powder from zero days had 8.28 per cent which was increased to 8.90 to 9.90 per cent of papaya powder packed in polyethylene pouch and 8.40 to 9.60 per cent in aluminium pouch. Whereas, minimum increased of moisture content was found in aluminium pouches. These changes can be attributed to the environmental changes, which will bring changes in the relative humidity outside the packaging system. Similar of these findings reported by Sharma *et al.* (2004) [18] in hill lemon juice powder (4.86-11.37 per cent), Rodge and Yadlod, (2009) [15] in ber powder and Barooah *et al.*, (2018) [2] in banana powder.

Table 2: Effect of different packaging material on the physico-chemical attributes of papaya powder during storage at ambient temperature (30-35 ^{0}C)

Parameters	Storage intervals							t-test	Probability
	0 day	30 days		60 days		90 days			
		PP	AP	PP	AP	PP	AP		
TSS (°B)	89.83	89.00	89.50	88.30	89.00	88.00	88.80	4.9	0.008
Titratable acidity (%)	0.135	0.130	0.134	0.125	0.130	0.120	0.130	2.45	0.07
pH	5.57	5.60	5.57	5.62	5.59	5.65	5.61	1.16	0.24
Reducing sugars (%)	62.63	63.46	63.40	63.48	63.43	63.51	63.46	1.73	0.15
Total sugars (%)	87.73	86.50	87.00	86.00	86.80	85.70	86.40	2.71	0.05
Moisture content (%)	8.28	8.90	8.60	9.40	9.00	9.90	9.40	2.1	0.104

Effect of addition of mango powder on the sensory characteristics (9-point hedonic scale) of papaya-mango blended RTS Beverages

Blending of papaya powder is required to prepare a palatable product. The papaya powder obtained from *Madhu'* cultivar was blended with mango powder in different proportion viz, 100:00, 80:20, 70:30, 60:40 and 50:50. Blending of papaya powder with mango powder in 50:50 proportions was found the most acceptable with higher sensory score (Figure 4). The overall acceptability of the ready-to-serve beverages made from papaya powder ratio with mango powder has increase in mean score from 5.95 to 7.36. With the increase in the quantity of mango powder and decrease in papaya powder quantity.

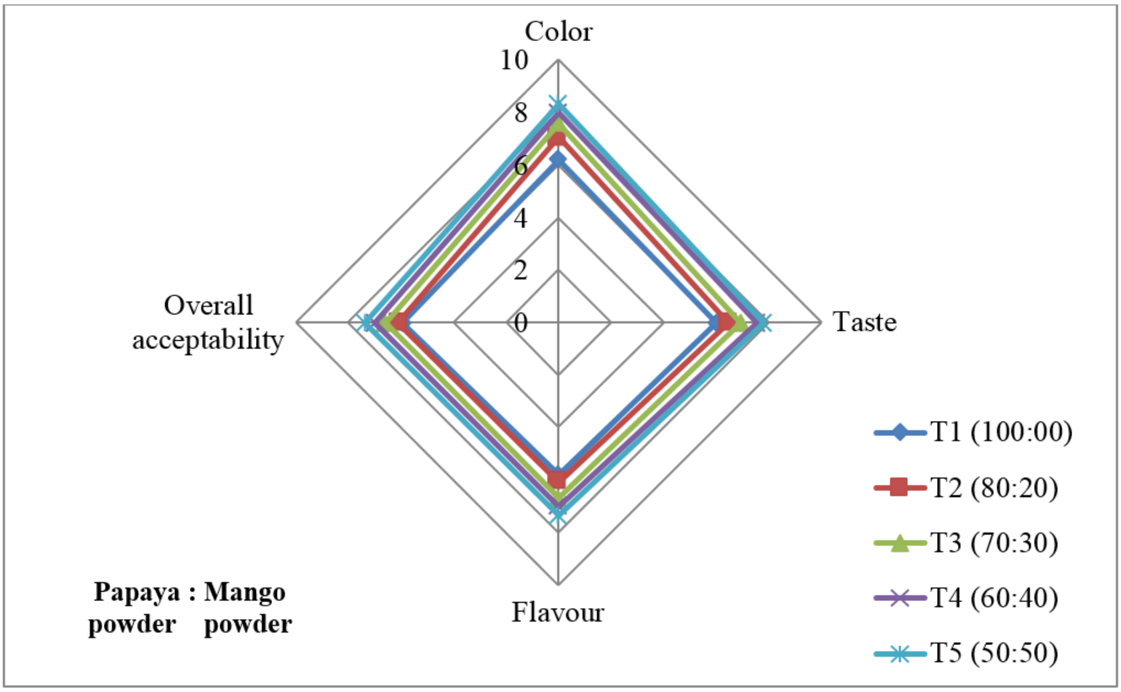

Fig 4: Effect of addition of mango powder on the sensory characteristics (9-point hedonic scale) of papaya-mango blended RTS beverages

Cost of production

The data pertaining to cost of production of papaya fruit powder is presented in Table 3. It is evident from the data that the cost of production of 100 g papaya fruit powder packed in aluminium pouches is Rs. 87.33. The unit cost per kg of papaya fruit powder has been determined by considering into cost of raw materials and other inputs, for example sugar, GMS, packaging materials, including electricity, labour, processing charges and so on. Work and handling charges comprised 20% of cost of raw materials.

Table 3: Cost of production of papaya fruit powder from sweetened papaya pulp

Items	Quantity	Rate (Rs)/kg	Amount (Rs)
Papaya fruit	100 kg	35.00	3500.00
Pulp extraction charges	@20%	7.00	700.00
Pulp recovery @82%	82 kg	-	4200.00
Pulp cost/kg	-	51.22	51.22
Sugar	12 kg	40.00	480.00
GMS @3%	2.460 kg	873/kg	2147.58
Packing material (AP)-Nos.	30 (No.)	2.00/each	60
Total	-	-	6887.58
Processing cost @20 % of total cost		-	1377.52
Profit @20 %		-	275.50
Total	-	-	8540.60
Total yield @11.93%	9.78 kg	-	-
Sale price per kg of dried fruit powder	-	-	873.27
Sale price/ pack (100 g)	-	-	87.33

Conclusion

Conclusively, keeping in view the changes in physico-chemical, microbiological and sensory evaluation in powder during storage, the preparation of papaya powder using foam mat drying technique followed by packing in aluminium pouches has been found the most appropriate and hence recommended.

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