ISSN: 0975-8585

Research Journal of Pharmaceutical, Biological and Chemical Sciences

Influence of Maltodextrin and Nutritive Anti-Caking Agents on Quality Characteristics and Storage Stability of Papaya Powder.

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ABSTRACT

Papaya powder was formulated using drying adjuncts such as maltodextrin (MD) and nutritive anti-caking agents such as tricalcium phosphate (TCP) and skimmed milk powder (SMP) in various combinations to determine their effect on product functionality. MD was added at the ratio of 25:75(25M), 35:65(35M) and 45:55(45M). TCP was added at 1.5%, without SMP (25MT and 35MT) or with SMP at 2.5% level (25MTS and 35MTS) to the 25M and 35M papaya powder. These formulated papaya powders (FPP) were stored in metalized polyester pouches (MP) for 30d at 28± 2^{0}C. Significantly better quality profile was observed in 25MTS papaya powder in terms of low moisture content, lower degree of caking and browning, excellent flowability, higher yield and bulk density, good rehydration and solubility compared to other combinations. Similar result was obtained after one month storage, suggesting 25MTS combination to be optimum for production of good quality papaya powder.

Keywords: maltodextrin, anti-caking, papaya

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INTRODUCTION

Papaya is one of the main tropical fruits produced in Asia. Apart from its luscious taste and attractive colour, papaya is a rich source of antioxidant nutrients such as carotenoids, vitamins C and E and flavanoids; the B vitamins, folate and pantothenic acid; and the minerals, potassium, magnesium; and fiber. The presence of these compounds has been reported to confer a myriad of health benefits [1].

Papaya is a highly perishable fruit with a shelf life of very few days (2-3) at room temperature and market conditions. Huge surplus of these fruits especially during seasons are largely unprocessed and are subjected to considerable post-harvest losses. Fruits could be processed into value added products which could help to minimize loss in both quality and quantity [2]. Quality and convenient papaya products with better shelf life would also help to increase its export potential and foreign exchange earnings.

Dehydration is an economic alternative processing technique for preservation of fruits and vegetables, helping to reduce the post-harvest losses. Commercial interest in the production of fruit and vegetable powders has also increased. These are in demand for use in various food products such as beverages, soups, pizza mixes, sauce powders, dairy products and bakery products.

The dehydrated powders owe their popularity to their ease of handling, transport and minimum storage requirements. However, there are many challenges in producing fruit powders. These include stickiness, thermoplasticity and hygroscopicity particularly at high temperature and humidity levels causing problems in handling, packaging and storage [3, 4]. These characteristics are particularly seen in fruits with high sugar content [5]. The fruit powders tend to be very hygroscopic in amorphous state leading to caking and reduction in flow characteristics.

Different methods have been explored to produce free flowing fruit powders. One of the approaches is use of drying adjuncts such as maltodextrins and skimmed milk powder [5, 6]. Maltodextrin is a high molecular weight compound and is a popular drying aid. It has been reported to reduce stickiness and agglomeration problems during storage of high sugar content fruit powders [7].

Various other adjuncts added in powders include anti-caking agents such as tricalcium phosphate (TCP). It contains highest calcium content (39 per cent) among the various calcium additives, providing highest Ca: P ratio, and thereby also used as a nutritional fortificant. As it is known to impart free flow properties it is used in beverage mix, spice mix and low moisture cheese powders. Tricalcium phosphates functionality has been also proved in fruit and vegetable juices, extruded cereals, cheeses and other processed foods [8].

Studies related to papaya powder have mainly focused on the effect of different drying methods [9] for preparation of powder. Effect of freeze drying on carotenoids in papaya powder has been studied [10]. Chung *et al.* [11] have reported the particle size and caking characteristics of commercially available papaya powder. There is a paucity of scientific reports on the functional characteristics of papaya powder or the effect of drying adjuncts/additives on powder quality and storage stability.

The objectives of the present study were to prepare papaya powder using varying levels of maltodextrin, TCP and skimmed milk powder as adjuncts and to evaluate the developed powders for various functional quality characteristics and changes on storage.

MATERIALS AND METHODS

Experimental materials

Papaya fruits (optimally ripened) were procured from the local market of Anantapur. The local seedless variety was identified as *Carica papaya* L.cv. Pusa Delicious. Drying adjunct maltodextrin (DE 18.5) was obtained from Riddhi Siddhi Gluco Boils Limited (Bangalore). Skimmed milk powder (SMP)-Sagar brand was procured from the local market and tricalcium phosphate (TCP) was procured from PdNavkar Bio Chem Pvt. Ltd., Bangalore.

Papaya pulp preparation and drying

Evenly ripened fruits were washed thoroughly in water. The cleaned fruits were peeled, sliced manually and blended to obtain the pulp. Prior to formulation of powders, the basic pulp obtained was characterized. The total soluble solids (TSS), titrable acidity (TA) and non enzymatic browning (NEB) and pectin content of the pulp, vitamin C, total and reducing sugars, total carotenoids; β-carotene and lycopene were estimated by chromatographic method as given by Ranganna [12]. The physico-chemical and nutritional characteristics of papaya pulp are given in table 1.

Table 1: Physico-Chemical and Nutritional Characteristics Of Papaya Pulp

Parameter	Composition (Mean± S.D.)
Total soluble solids (^{0}Brix)	15.0 ± 0.54
Titrable acidity (%)	0.33 ± 0.05
Pulp Recovery	0.61 ± 0.02
NEB	0.04 ± 0.01
Pectin (%)	2.01 ± 0.03
Vitamin C (mg/100g)	46.1 ± 1.63
Reducing sugars (mg/100g)	9.91 ± 0.43
Total sugars (mg/100g)	24.7 ± 0.91
Non-reducing sugars (mg/100g)	14.8 ± 0.61
Total carotenoids (mg/100g)	3.73 ± 0.34
β – carotene (µg/100g)	213 ± 0.01
Lycopene (mg/100g)	2.13 ± 0.21

Homogenized papaya pulp was oven dried at 60±2^{o}C for approximately 6 – 7 hours. The dried samples obtained as flakes were powdered in a lab scale homogenizer and sieved using 20mm mesh sieve. The papaya powder obtained without addition of any other ingredient was treated as control (C). To another set of homogenized papaya pulp, the commonly used drying adjunct maltodextrin (MD) was added in the ratio25:75, 35:65 and

45:55 of the dry papaya solids. The pulp was spread on trays and oven dried. The powders obtained were designated as 25M, 35M and 45M. To one set of 25M and 35M powders, TCP was added at 1.5% level to obtain 25MT and 35MT powders. To another set, TCP (1.5%) and SMP (2.5%) were added and the resultant powders obtained were designated as 25MTS and 35MTS. All together, eight variations were developed i.e. C, 25M, 35M, 45M, 25MT, 35MT, 25MTS and 35MTS. Table 2 summarizes the details of the concentration of ingredients used in these eight formulations.

Table 2: Concentration of Ingredients Used In the Eight Formulations of Papaya Powder.

Formulations	Maltodextrin (ratio of dry papaya solids to pulp)	Tri calcium phosphate (%)	Skim milk powder (%)
PP	0:100	--	--
25M	25:75	--	--
35M	35:65	--	--
45M	45:65	--	--
25MT	25:75	1.5	--
35MT	35:65	1.5	--
25MTS	25:75	1.5	2.5
35MTS	35:75	1.5	2.5

Determination of functional quality characteristics

The developed powders were analyzed for moisture, total yield, degree of caking, bulk density (loose and tapped), compressibility, flowability, rehydration ratio, solubility, non enzymatic browning and colour index on the initial day and after 30 days of storage at 28 ± 3^{o}C.

The moisture content in the raw materials and prepared powders were determined [13]. The percentage yield of the powders was calculated as per the method given by Pachanon [14]. Degree of caking was estimated by the method given by Pisecky [15], with slight modifications. Powder was weighed and transferred onto a sieve. The sieve was then shacked for 5min in a shaking apparatus. The powder remaining in the sieve was weighed. The per cent degree of caking was calculated by using the following formula *DC = a/b x 100* where *b* in (g) is weight of the powder used for sieving and *a* in (g) is weight of the powder left on the sieve after sieving.

For determination of bulk density, weighed samples were taken in a measuring cylinder and the volume noted. The samples were then tapped using bulk density apparatus (SECOR, India) till constant final volumes were obtained. The loose and tapped bulk densities were calculated using formula given by Ranganna [12]. Compressibility was derived from loose and tapped bulk density as per the formula given by Babu and Gupta [16] and flowability as per the scale given by Carr *et al*. [17]. Solubility of the powders was determined by the method given by Liu *et al.* [18]. The rehydration ratio, non-enzymatic browning, titrable acidity (TA) and total soluble solids (TSS) of prepared powders were determined using standard methods [12].

For determination of colour index, the test sample was placed in a 3 inch diameter petri plate, which was completely filled with the sample. The color of the samples was measured using a color reader (Konica MINOLTA CR-10), using the Hunter L*, a* b* units, where L* indicates luminosity or brightness, a* corresponds to greenness (-)/ redness (+) and b* corresponds to blueness (-)/ yellowness (+). The L*, a* and b* data were transformed to colour index [CI= 1000 x a*/ L* x b*].

Sensory quality

The sensory quality of the powders was evaluated initially and after 1 month of storage. The sensory parameters were rated as follows:

Appearance		Mouthfeel		Colour; Flavour ; Overall acceptability	
5-	No lumpiness	5-	Very fine	5-	Like extremely
4-	Slightly Lumpy	4-	Fine	4-	Like very much
3-	Moderately lumpy	3-	Moderately coarse	3-	Neither like nor dislike
2-	Lumpy	2-	Slightly coarse	2-	Dislike slightly
1-	Very lumpy	1-	Very coarse	1-	Dislike extremely

Statistical Analysis

The experiments were repeated thrice with two replicates taken each time. The mean and standard deviation of the values were computed from the data obtained. Data was subjected to one way ANOVA using the least significant difference (LSD) method with a significance level of $P \leq 0.05$ using SPSS 16.0 software for windows.

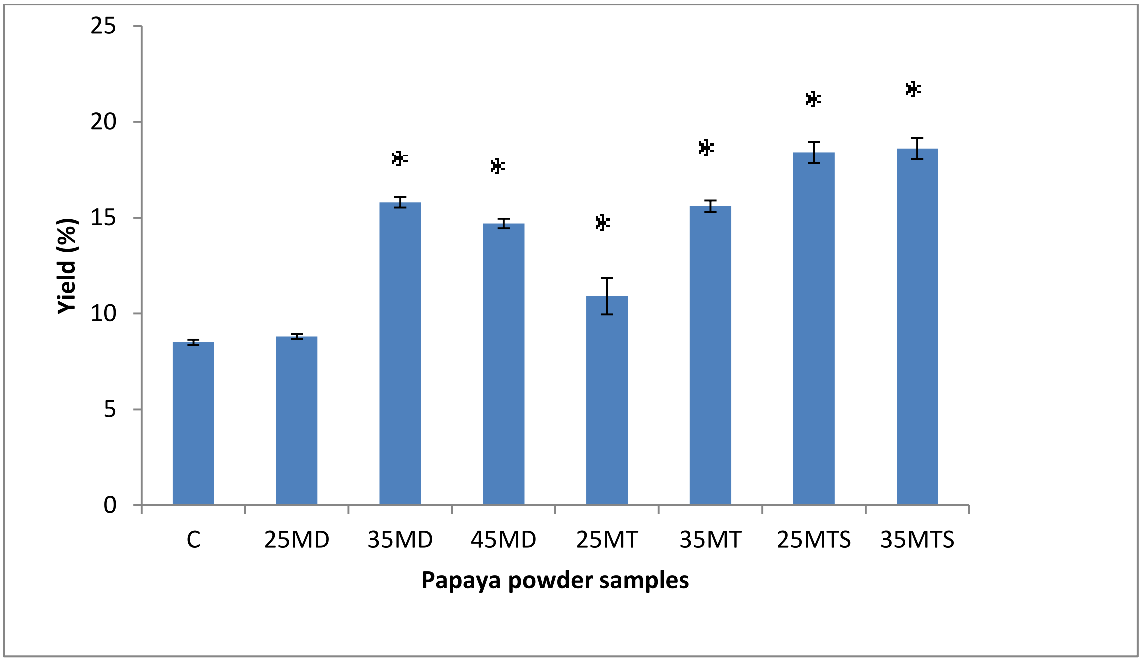
RESULTS AND DISCUSSION

Functional quality characteristics of formulated papaya powders

Papaya powders formulated using the different adjuncts were analyzed for various functional quality parameters and the results are given in figures 1, 2 and in tables 3, 4 and 5.

Total yield

The results for the total yield are reported in figure 1. Lowest yield of 8.5 % was observed in plain papaya powder /control sample (C). All the formulated powders, except 25M sample, showed significantly higher ($P<0.05$) yield compared to control. Highest yield of 18.4 and 18.6% was observed in 25MTS and 35MTS samples, respectively. Addition of drying adjuncts helped in obtaining a better yield which could be due to the ease of removal from trays, ease of powdering thereby preventing wastage and improving yield. High degree of caking in control sample further contributed to loss during powdering leading to reduced yield.



PP- Plain papaya powder; 25M, 35M and 45M- MD added in the ratio of 25:75, 35:65 and 45:55 of dry papaya solids, respectively; 25MT and 35MT- MD added in the ratio of 25:75 and 35:65 of dry papaya solids, respectively, and TCP added at 1.5% level of dry powder; 25MTS and 35MTS- MD added in the ratio of 25:75 and 35:65 of dry papaya solids, respectively, TCP added at 1.5% level of dry powder and SMP added at level of [illegible]% of pulp. 0D- 0th day and 30D- 30th day
Values are Mean ± S.D; * Indicates significant difference (P<0.05) with respect to control.

Moisture content

The moisture content of the formulated papaya powders is presented in table 2. The initial moisture content (6.95%) of plain papaya powder (C) was found to be the highest. Addition of various drying adjuncts helped in lowering the moisture content of papaya powder with 25MTS powder recording the lowest moisture content of 5.81%. Among the powders with maltodextrins, an increase in moisture content was observed with increase in the concentration of MD. Similar observations have also been reported in tomato powder [19].

An increase in moisture content was observed in all the stored samples with the control sample recording the highest moisture content of 8.5%. All the treated powders recorded significantly lower (P<0.05) moisture content compared to control. Lowest moisture was observed in 25MTS sample (7.15%), followed by 25MT (7.25%) and 25M (7.32%) samples. Samples with higher ratio of MD i.e. 35M, 45M and 35MTS recorded slightly higher moisture contents ranging from 7.4 to 7.65%.

The results obtained in the present study for moisture are similar to those reported for other fruit powders such as jackfruit (5.71 – 8.22%,) [20].The increase in moisture content upon storage has also been reported by other workers which has been attributed to the migration of water vapour from the storage environment into the packaging material [21].

As observed, the drying adjuncts demonstrated a beneficial effect by producing lower moisture content in the product and also minimal increase in moisture upon storage. Results akin to the present study have also been reported by Pua *et al.,* [20] on addition of gum arabic and soya lecithin to jackfruit powder. These additives prevent crystallization and keep the components evenly distributed.

Addition of MD at higher concentrations resulted in higher moisture content. However, the addition of tri calcium phosphate and skim milk powder mitigated this effect to a considerable extent as evidenced by the lower moisture levels in papaya powder containing all the three adjuncts.

Degree of caking

The degree of caking exhibited by the various types of papaya powder is shown in table 2. On the initial day of storage, the control sample exhibited the highest degree of caking (32.7%). Addition of maltodextrin brought about a reduction in caking to some extent. Addition of TCP and SMP, which are proven anti-caking agents, resulted in further reduction in the degree of caking with 25MTS sample exhibiting the lowest percentage of caking of 5%. Even after one month storage, 25 MTS sample recorded caking of 9.1%, as against control sample which recorded significantly higher ($P<0.05$) caking of 86.9%.

Reduction in the degree of caking in mango powder with the addition of tri calcium phosphate, maltodextrin and glycerol monostearate (GMS) has been reported [22]. The levels of 43-57% MD and 1.5% each of TCP and GMS was reported to be optimum in producing mango powder of desirable quality. Similar results were reported by Dabhade and Khedkar [23] in mango powder when kept at room temperature.

Solubility

Solubility, expressed as the percentage of solids soluble in water, is considered to be an important specification in fruit powders as it gives an indication of the product reconstitution.

The solubility of the developed papaya powders and the changes during storage are presented in table 2. The control sample recorded solubility of 56.5% on the initial day, which was significantly ($P<0.05$) lower than formulated powders. Addition of MD resulted in a significant increase in solubility (68% to 72%), whereas, no further increase was noticed upon addition of TCP. With the addition of SMP, a significantly greater solubility was seen particularly in 25MTS sample (74.2%), which was highest compared to other samples.

A reduction in solubility of all the samples was observed on storage. The 25MTS sample was observed to maintain a higher degree of solubility even after 1 month storage (62.2%) followed by 35MTS and 35MT (56.5%). Least percentage of solubility was exhibited by control sample (50.5%) which was almost similar to 25M and 35M samples (50.5 and 51.1%).

The additives, MD and SMP, are easily dissolved in water. This could account for the enhanced dissolution ability of papaya powders containing these ingredients. Grabowski *et al*. [24] also reported higher water solubility index of sweet potato powder with an increase in MD concentration.

It was also observed that 25MTS sample with least moisture content (7.15%) exhibited the highest percentage of solubility (62.2%). A similar observation was recorded in a study on tomato powder [25], where an inverse co-relation was observed between moisture content and solubility of tomato powder.

Rehydration Ratio

Rehydration has been defined as a measure of injury to the material [26], with higher rehydration values indicating lower damage and vice versa. Rehydration has been defined as a complex process aimed at restoration of raw material properties, when dried material is contacted with water [27].

The rehydration ratios of the papaya powders are given in table 2. Highest rehydration ratio was recorded by 25MTS sample (5.11). In the samples wherein only MD was used i.e. 25M, 35M and 45M, an increase in rehydration ratio was observed with increasing MD concentration but it was less compared to the MTS combination samples. The least rehydration ratio was recorded by the control sample (3.83), significantly lower ($P<0.05$) than other samples.

A reduction in rehydration ratio was evidenced after one month storage in all samples with the control recording the lowest rehydration ratio (2.25). Even after 30 days storage, 25MTS sample maintained highest rehydration ratio (3.98) compared to the other samples.

Similar range of rehydration ratio of 3.6 to 4.98 as obtained in the present study has been reported for dried tomato slices [28]. The above study also reported better rehydration ratio in tunnel dried tomato samples compared to solar dried samples, which was attributed to the uniform exposure of slices to drying conditions. In the present study addition of drying adjuncts, especially MD and SMP to the pulp resulted in smoother pulp enabling better spreadability. This could have facilitated better heat transfer. Addition of these adjuncts also resulted in reduction in drying time, which could have minimized the textural changes during dehydration and resulted in higher rehydration ratio in the final product.

Bulk density

Bulk density (BD) is an important physicochemical parameter that has a direct impact on the packaging requirement of powders. It provides indication of physical properties like cohesion and porosity and may affect flowability and storage stability [29]. It has been reported to have significant co-relation with the powder moisture content, with the powders having higher moisture having larger bulk volume and lower bulk density. Product with lower moisture content would be less sticky and produce a free flowing powder of higher BD.

The loose and tapped bulk densities of the powders are shown in table 3. Lowest LBD and TBD of 0.51 and 0.49, respectively, were observed in the control sample on the initial day. This could be attributed to its high moisture content that resulted in more sticky powder granules occupying more space, thereby causing a low BD. Addition of drying adjuncts brought about an increase in bulk density, which could be due to their beneficial effect in lowering the moisture content of the powders. Among all the samples, highest LBD and TBD were recorded for 25MTS sample (0.7 and 0.72, respectively) on the initial day.

Storage for 30 days brought about a decrease in both LBD and TBD for all samples. The 25MTS sample continued to exhibit highest LBD and TBD values of 0.65 and 0.72, respectively, significantly higher ($P<0.05$) than all samples except 35MTS samples (0.61 and 0.69). On the other hand, the control sample recorded significantly ($P<0.05$) lower LBD and TBD of 0.42 and 0.58, respectively.

In a study [30], the addition of MD as food additive in the date powder resulted in higher bulk density which could be due to the dense powder mass.

Compressibility and flowability

Compressibility, calculated from loose and tapped bulk densities is another important parameter. A higher degree of compressibility indicates a lower flowable material and vice versa.

The results of compressibility and flowability of the samples are given in table 3. On the initial day of storage, the 25MTS powder sample recorded the lowest compressibility of 5.63, showing excellent flowability. The other samples which exhibited excellent flowability include 35MTS, 25MT and 25MD with the corresponding compressibility of 7.13, 9.35 and 9.37, respectively. The other powders fell in the 'good' category of flowability. Control sample recorded the highest compressibility value of 11.9. After storage for one month, the compressibility of control sample remained higher (17.6) than the other powders and hence it was categorized as being fair in flowability, whereas, all other powders were categorized as good. The stored 25MTS and 25MT papaya powders retained flowability to a greater extent with a value of 10.7, which is very close to the excellent category (< 10).

Non-enzymatic browning

Non-enzymatic browning (NEB) is an important parameter which indicates the visual and chemical quality of the product upon storage.

The effect of different additives on the NEB of papaya powders is given in table 3. The initial NEB recorded for the samples ranged from 0.08-0.17. Control recorded the highest NEB of 0.17 and the least value of 0.08 and 0.09 was observed in 45M and 25MTS samples, respectively. NEB of MD added samples were significantly (P<0.05) lower than that of control. Further lowering of browning was evidenced with the addition of TCP and SMP. Storage resulted in an increase in NEB. Rai and Chauhan [31] also observed NEB to gradually increase upon storage in papaya cereal flakes, which was attributed to long storage at high temperature. In the present study, the control sample recorded highest NEB of 0.28. Samples containing MD, especially 35M and 45M samples recorded significantly lower (P<0.05) NEB values of 0.19 and 0.17 respectively, closely followed by 25MT (0.20) papaya powder.

All the other samples recorded NEB of 0.21 upon storage, indicating that with the addition of drying adjuncts a marked reduction in NEB could be achieved. As discussed in the section on colour index, the L* value indicative of whiteness increased with increase in concentration of the additives. Increase in L* value was reported to correlate with decreased browning in banana powder [32].

Colour

The values of colour attributes L*, a* and b* are given in table 3.

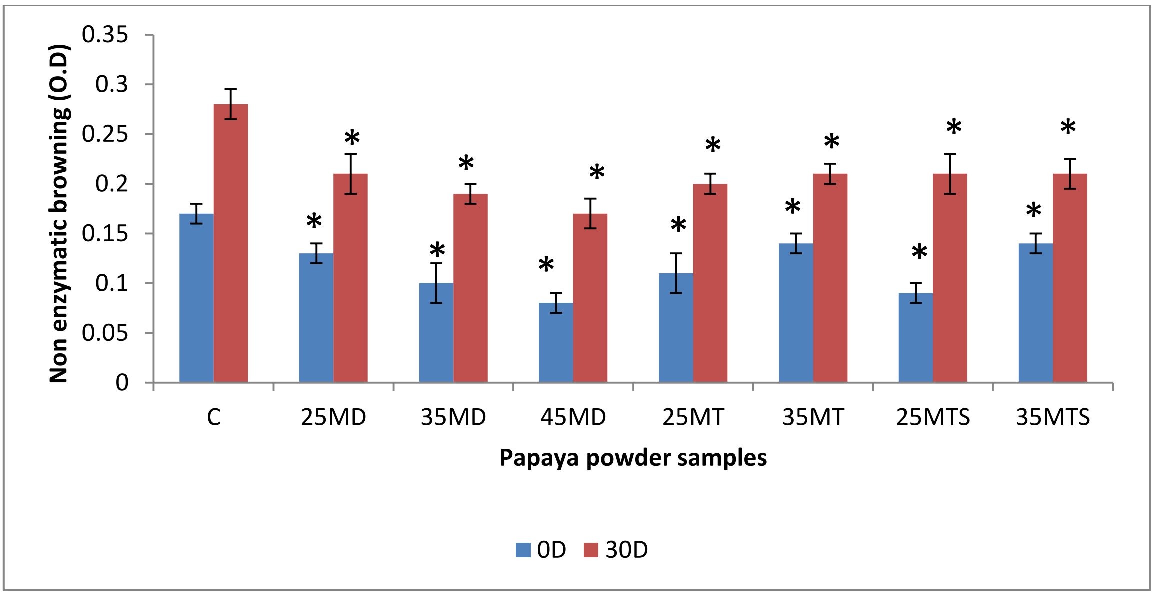
L* is indicative of brightness or lightness of the samples. A significant (P<0.05) increase in L* value was observed upon addition of the adjuncts, with the 35MTS sample recording the highest value, followed by 25MTS. Lowest L* was recorded by the control sample. Correspondingly, the positive a* values indicative of redness were found to be maximum in control. The other samples recorded lower a* values, though they were not significantly different from C, except for 35MTS sample. A reduction in L* value was seen on storage, with C sample exhibiting significantly lower value compared to other samples. Similar trend was followed even after 30d of storage.

The range of colour index (Fig. 2) observed on the initial day was from 7.66-11.45. Addition of various drying adjuncts brought about reduction in the colour index of papaya powder, with a corresponding increase in L* value. Control sample recorded colour index of 11.5, similar to 25M whereas addition of MD at higher levels resulted in colour index of 10.9 and 10.5 for 35M and 45M, respectively. However, no significant differences were observed between the control and the other samples on the initial day, except for 25MTS and 35MTS samples which recorded a colour index of 8.42 and 7.66, respectively.

Storage revealed a slight reduction in colour index in all the samples. The least colour index of 7.5 was observed for 35MTS followed by 25MTS (8.13) and highest for control (11.3). It was noted that no marked reduction or undesirable changes in colour was observed in the papaya powders upto one month storage. This could be due to the packaging material used which prevented the colour degradation by offering protection from oxygen and light.

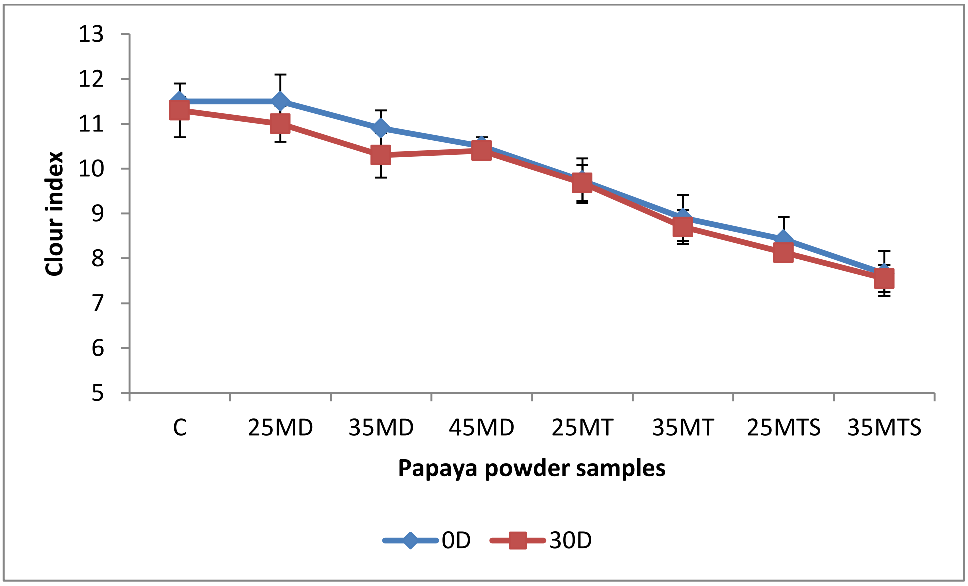
Sensory quality characteristics of formulated papaya powders

The results of the sensory evaluation of the samples are depicted in Fig 2 (A and B). On the initial day, no significant difference was recorded among the samples and all the samples recorded similar scores for all parameters evaluated i.e appearance, colour, flavor, mouthfeel and overall acceptability. However, the profile changed considerably after 30 days storage at room temperature, mainly in case of control sample.



PP- Plain papaya powder; 25M, 35M and 45M- MD added in the ratio of 25:75, 35:65 and 45:55 of dry papaya solids, respectively; 25MT and 35MT- MD added in the ratio of 25:75 and 35:65 of dry papaya solids, respectively, and TCP added at 1.5% level of dry powder; 25MTS and 35MTS- MD added in the ratio of 25:75 and 35:65 of dry papaya solids, respectively, TCP added at 1.5% level of dry powder and SMP added at level of 2.5% of pulp; 0D- 0th day and 30D- 30th day

Values are Mean ± S.D; * Indicates significant difference (P<0.05) with respect to control.



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Values are Mean ± S.D

Table 3: Effect of Addition of Maltodextrin and Anti-Caking Agents on the Functional Quality Characteristics of Formulated Papaya Powders (I)

Parameter	Samples / Storage Period	PP	25M	35M	45M	25MT	35MT	25MTS	35MTS
Moisture (g %)	0 D	6.95 ± 0.15cd	6.15 ± 0.35a	6.25 ± 0.45ab	6.71 ± 1.1bc	6.01 ± 0.28a	6.72 ± 0.31bc	5.81 ± 0.40a	6.15 ± 0.15a
	30 D	8.55 ± 0.35h	7.52 ± 0.49cde	7.41 ± 0.11efg	7.65 ± 0.15g	7.25 ± 0.35efg	7.61 ± 0.02fg	7.15 ± 0.1efg	7.41 ± 0.1efg
Degree of caking (g %)	0 D	32.7 ± 0.43g	16.6 ± 0.61f	24.1 ± 0.23e	28.3 ± 1.7f	8.91 ± 0.02bc	9.25 ± 0.25bc	5.01 ± 0.21a	7.15 ± 0.65ab
	30 D	86.9 ± 1.14j	27.5 ± 0.14f	38.2 ± 0.28h	44.5 ± 2.5i	16.3 ± 1.10d	16.7 ± 0.30d	9.10 ± 0.11bc	10.5 ± 1.45c
Rehydration ratio	0 D	3.83 ± 0.07b	4.48 ± 1.03cd	4.64 ± 0.15de	4.84 ± 0.22de	4.58 ± 0.03de	4.65 ± 0.07de	5.11 ± 0.20e	4.79 ± 0.07de
	30 D	2.25 ± 0.57a	3.43 ± 0.34b	3.67 ± 0.16bc	3.72 ± 0.26b	3.80 ± 0.02b	3.40 ± 0.07b	3.98 ± 0.07b	3.71 ± 0.08b
Solubility (g %)	0 D	56.5 ± 5.50abc	68.5 ± 0.5def	70.1 ± 5.2ef	72.1 ± 2.1ef	76.1 ± 4.2f	67.5 ± 2.5de	74.2 ± 6.3ef	67.5 ± 5.5de
	30 D	50.5 ± 4.51a	50.5 ± 2.1a	51.1 ± 1.1a	59.2 ± 2.1bc	53.2 ± 6.1ab	56.5 ± 3.5abc	62.2 ± 6.1cd	56.5 ± 4.5abc

Data are Mean ± S.D. Data in a row with different letters are statistically different ($P<0.05$)

Table 4: Effect of Addition of Maltodextrin and Anticaking Agents on the Functional Quality Characteristics of Formulated Papaya Powder (II)

Parameter	Sample / Storage Period	C	25M	35M	45M	25MT	35MT	25MTS	35MTS
Bulk density									
Loose (g/ml)	0D	0.51 ± 0.01c	0.58 ± 0.01d	0.53 ± 0.02c	0.52 ± 0.01c	0.63 ± 0.01e	0.62 ± 0.01e	0.70 ± 0.02g	0.71 ± 0.02g
	30D	0.42 ± 0.02a	0.48 ± 0.01b	0.43 ± 0.01a	0.42 ± 0.02a	0.60 ± 0.02e	0.59 ± 0.01d	0.65 ± 0.01f	0.61 ± 0.01e
Tapped (g/ml)	0D	0.58 ± 0.01a	0.64 ± 0.01b	0.60 ± 0.01a	0.61 ± 0.02a	0.69 ± 0.01fg	0.69 ± 0.01e	0.76 ± 0.02g	0.77 ± 0.02ef
	30D	0.49 ± 0.01c	0.54 ± 0.01d	0.58 ± 0.01c	0.50 ± 0.03c	0.60 ± 0.01ef	0.68 ± 0.01ef	0.72 ± 0.02 h	0.69 ± 0.01h
Compressibility (g %)	0 D	11.9 ± 2.27efg	9.37 ± 0.21c	11.6 ± 0.27ef	13.2 ± 1.22h	9.35 ± 0.78c	10.1 ± 0.08cd	5.63 ± 0.08a	7.13 ± 0.46b
	30D	17.6 ± 0.49i	11.9 ± 1.45efg	13.1 ± 1.61fgh	14.1 ± 0.72h	10.7 ± 0.71cde	11.8 ± 1.39ef	10.7 ± 0.02cde	11.5 ± 0.82de
Flowability	0 D	Good	Excellent	Good	Good	Excellent	Good	Excellent	Excellent
	30 D	Fair	Good	Good	Good	Good	Good	Good	Good
NEB	0 D	0.17 ± 0.01e	0.13 ± 0.01d	0.11 ± 0.01bc	0.08 ± 0.01a	0.11 ± 0.01cd	0.14 ± 0.01bc	0.09 ± 0.01ab	0.14 ± 0.01bc
	30 D	0.28 ± 0.01h	0.21 ± 0.01f	0.19 ± 0.01f	0.17 ± 0.01e	0.20 ± 0.02f	0.21 ± 0.02f	0.21 ± 0.01g	0.21 ± 0.01f

Data are Mean ± S.D. Data in a row with different letters are statistically different (P<0.05)

Table 5: Effect of Addition of Maltodextrin and Anticaking Agents On The L*, a* and b* Values of Formulated Papaya Powders

	0D			30D		
	L*	a*	b*	L*	a*	b*
PP	55.6 ± 0.89c	16.1 ± 1.23a	25.2 ± 1.51a	48.9 ± 1.06c	16.3 ± 0.34a	18.4 ± 0.91c
25M	59.6 ± 1.31b	15.6 ± 0.65a	24.2 ± 1.96a	57.2 ± 0.41b	15.4 ± 0.46b	27.4 ± 0.83b
35M	59.7 ± 0.66b	15.5 ± 0.41a	28.4 ± 0.37b	56.5 ± 0.65b	15.9 ± 0.54b	28.3 ± 0.29b
45M	60.8 ± 0.37b	15.4 ± 0.29a	28.8 ± 0.12b	59.1 ± 0.24a	15.6 ± 0.51b	28.3 ± 0.33b
25MT	60.4 ± 0.92b	15.1 ± 1.20a	29.4 ± 1.58b	57.4 ± 0.57a	15.8 ± 0.49b	26.8 ± 0.48b
35MT	60.1 ± 0.87b	14.9 ± 0.36a	27.8 ± 0.67b	59.2 ± 0.35a	15.6 ± 0.38b	29.1 ± 0.41b
25MTS	62.1 ± 0.89a	14.6 ± 0.41a	30.2 ± 0.74b	59.8 ± 0.92a	15.1 ± 0.41b	29.6 ± 0.72b
35MTS	66.4 ± 0.29a	14.1 ± 0.37b	29.2 ± 0.11b	61.9 ± 1.22a	15.7 ± 0.49b	30.1 ± 0.41c

Data are Mean ± S.D. Data in a column with different letters are statistically different ($P<0.05$)

The control sample (C) scored lowest for appearance (2.5) due to the presence of lumps on storage. Addition of the adjuncts helped in reducing the lumping to a good extent, which was proven by the higher scores (4) obtained by 25MTS and 35MTS samples. The significantly higher score obtained for flavor in case of 25MTS and 35MTS could be attributed to the addition of skim milk powder flavor (3). Significantly lower score (2.5) for mouthfeel was recorded by the control sample. This could be due to the presence of coarse and gritty particles caused by higher degree of caking observed in control sample. An improvement in the mouthfeel was recorded with significantly higher (P<0.05) scores of 4.5 (25MTS) and 4 (25MT, 35MT and 35MTS) in formulation containing the adjuncts. The overall acceptability scores revealed 25MTS sample to be most preferred, with a score of 4.5.

CONCLUSION

The study revealed the formulation containing maltodextrin, tricalcium phosphate and skim milk powder to be optimum in terms of both functional and sensory attributes. This demonstrates the effective use of drying adjuncts to significantly improve the quality profile of papaya powder. Such formulated papaya powders could function as convenient nutraceutical ingredients for addition and development of various attractive healthy food products.

Practical Applications

Papaya is one of the chief fruit crops of India. However it is prone to a high level of post- harvest loss due to its very short shelf life. Use of dehydration technologies is one of the best alternatives to reduce these losses and to extend its utility. Various carrier agents and drying adjuncts have been employed to overcome the problems of stickiness, caking and poor rehydration commonly observed in fruit powders. Papaya powder formulated in the present study with improved functional and nutritional quality could be used in the preparation of papaya juice, juice blends, papaya jelly, as a nutritional colorant in baby foods, milk shakes, extruded products and masala powders, and as a health ingredient in confectionary and bakery products. The developed technology for papaya powder using simple convective drier and nutritive standard additives could be easily adopted by small scale entrepreneurs and cottage industries.

ACKNOWLEDGEMENTS

The first author acknowledges the financial support provided by the University Grants Commission, New Delhi through Research Fellowship (letter no.F.17-4/2009 (SA-I). The authors thank the founder Chancellor and the management of Sri Sathya Sai Institute of Higher Learning, Andhra Pradesh, India for the research facilities provided for conducting the present study.

REFERENCES

[1] Krishna KL, Paridhavi M and Patel JA. Natural Products Radiance. 2008; 7: 364-373.
[2] Rao KPG In Souvenir - 16th Indian convention of Food Scientists and Technologists, Mysore, India.

[3] Cano-Chauca M, Stringheta PC, Ramos AM & Calvidhal J. Innov. Food Sci. Emerg. Technol 2005; 6: 420–428.
[4] Jaya S, Das H and Sudhagar M. Int J Food Prop 2006; 9: 13-24.
[5] Bhandari BR, Dutta N and Momes T. Drying Technol 1997; 5: 671 – 684.
[6] Adhikari B, Howes T, Bhandari BR & Troung V. J Food Eng 2004; 62: 53-68.
[7] Silva MA, Sorbal PJA, Kieckbusch TG. J Food Eng 2006; 82: 276-283.
[8] www.prayon.com/media/cms/prayon_leaflet.com. Accessed on 29/3/2012
[9] Hawlader M N A, Perera CO, Tian M. and Yeo KL. Drying Technol 2006; 24: 77-87.
[10] Arya SS, Natesan V and Vijayaraghavan PK. Int. J Food Sci Technol 1983; 18: 177-181.
[11] Chung MS, Ruan RR, Chen P, Chung SH, Ahn TH and Lee KH. J Food Sci 2000;65: 134-138.
[12] Ranganna S. Handbook of analysis of quality control for fruit and vegetable products, 2nd Ed, Tata Mc Graw-Hill publishing co. Ltd., New Delhi, India, 1986.
[13] AOAC. Official Methods of Analysis, 15th ed. Association of official analytical chemists, Washington D.C, 1990.
[14] Pachanon C. A study of the elements in Aloe vera powder by neutron activation analysis. A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science (radiological science) faculty of graduate studies-Mahidol University, 2005.
[15] Pisecky J. MC Diarnwid (ed.) Concentration and drying of foods (pp 203-220). New york: Elsevier science publishing co.
[16] Babu RD & Gupta DDK. J Food Sci Technol 2005; 42: 241-245.
[17] Carr RL. Chem Eng 1970; 72:163-168.
[18] Liu F, Cao X, Wang H & Liao X. Powder Technol 2010; 204: 159-166.
[19] Goula AM and Adamopoulos KG. LWT Food Sci Technol. 2007; 38: 479-487.
[20] Pua CK, Sheikh Abd.Hamid N, Rusul G and Abd. Rahman RJ. Food Eng 2007; 78: 630-636.
[21] Hymavathi TV and Khader V. J Food Comp Anal 2005; 18, 181-192.
[22] Jaya S and Das HJ. Food Proc Preserv 2005; 29: 45-62.
[23] Dabhade RS & Khadkar DM. Indian Food Packer 1980; 34: 43-47.
[24] Grabowski JA, Truong VD and Daubert CR. J Food Sci 2006; 71: E209-E217.
[25] Goula AM and Adamopoulos KG. LWT Food Sci Technol 2005; 38: 479-487.
[26] Okos MR, Narasimha G, Singh RK and Weitnaeur AC. Handbook of food engineering. New York, Marcel Dekker. 1992, Pp.437-562.
[27] Lewicki PP. Int J Food Prop 1998; 1: 1-22.
[28] Davoodi MG, Vijayanand, Kulkarni SG and Ramana KVR. 2007. LWT Food Sci Technol 40; 1832-1840.
[29] Moreyra R. and Peleg M. J Food Sci 1980; 45: 864-868.
[30] Sablani SS, Shrestha AK and Bhandari. J Food Eng 2008; 87: 41.
[31] Rai S. and Chuhan AS. EJEAFCHE 2008; 75: 2914-2931.
[32] Evelin MA, Jacob JP and Vijayanand P. J Food Sci Technol 2007; 44: 16-20.