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Preparation and sensory evaluation of functional drink based on papaya (*Carica papaya* L.) pulp

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ABSTRACT

This research was aimed to develop functional drink based on foam-mat drying of papaya. Papaya pulp was foamed by the addition of 10, 15 and 20% egg white (w/w). Foamed papaya slurry was dried by using hot air at 60 ^{0}C for 5 hours. Drying yield and protein content of dried powder increased with the increase of egg white. Vitamin C decreased in powder due to heat degradation. Higher foam thickness resulted in longer drying time. Drying time of foamed pulp was much lower than the non-foamed pulp. Moisture content, reconstitution and water holding capacity of foam-mat dried powder were in the range of 3.27-3.93%, 82.43-83.53% and 5.23-5.93 g/g, respectively. Functional drinks were formulated by dry blending of foam-mat dried papaya powder and other ingredients at the ratio of 6:4, 5:5 and 4:6 (w/w) of foam-mat dried papaya powder and skim milk. Different ratio of foam-mat dried papaya and skim milk powder affected the physicochemical properties (moisture content, reconstitution rate, and water holding capacity) and sensory properties (color, viscosity, flavor and taste) of the product. The reconstituted drink at a ratio of 4:6 of foam-mat dried papaya powder and skim milk retained the best sensory properties.

Introduction

Papaya (*Carica papaya* L.) belongs to the family of *Caricaceae*. It is known as common man's fruit due to its reasonable price and high nutritive value and is rich in iron, calcium; a good source of vitamins A, B and an excellent source of vitamin C (ascorbic acid). Papaya is a highly perishable fruit with very poor keeping quality since it contains approximately 90% of moisture and its skin is thin. Post-harvest loss is high in this fruit. Post-harvest losses of papaya in the range of 40-100% have been reported in developing countries (Teixiera da Silva *et al*., 2007). Drying is a solution offered to overcome the post-harvest losses, increase the shelf life, simplify the storage and enlarge the application.

Foam-mat drying is a promising, new development in the field of drying aqueous foods. This method offers a wide scope for application in vegetable puree and fruit juice processing industry as it enables the dehydration of heat sensitive foods or which are difficult to dry, sticky, and viscous under relatively mild conditions without any quality change. This technology is finding an increasing application and importance on commercial scale mostly in the drying of liquids that tender a high quality concentrate such as milk, fruit, juices, soluble coffee etc. (Kadam *et al.,* 2010). Foam-mat drying is a drying method with the main advantages of lower temperature and shorter drying times, compared to the non-foamed material in the same type of the dryer. A shorter drying time can primarily result from the larger surface area exposed to drying air, but also from particularities of heat and mass transfer in foamed materials (Ratti and Kudra, 2006). Foam-mat drying techniques have been used to dry various fruits such as pineapple (Beristain *et al*., 1991), passion fruit (Jossy, 1999), apple (Raharitsifa *et al.*, 2006), apricot (Komes *et al.*, 2005) and mango (Rajkumar *et al*., 2007a; Rajkumar and Kailappan, 2006). The liquid or semi-solid of fruit slurry is made into foam with the addition of foaming agents. Egg white is generally used to foam the fruit pulp because of its good foaming

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properties (Ramaswamy and Marcotte, 2006), which are due to egg white proteins ability to encapsulate and retain air (Lomakina and Mikova, 2005). Increasing of egg white concentration resulted higher rates of drying as the surface area was higher. The optimum concentration of egg white depends on the type of fruit will be dried. Aroma and taste of papaya fruit is commonly disliked by consumer, which is still remained in the dried papaya (Widyastuti and Srianta, 2011). So, it is needed to develop a suitable formulation to improve the aroma and taste of functional drink based on foam-mat dried papaya. Preparation of drink from papaya by foam-mat drying will solve this problem. Considering these features this research was taken to optimize the foam-mat drying process of ripe papaya and to observe their effect on the sensory quality parameters of the functional drink prepared from the foam-mat dried papaya powder.

Materials and Methods

The experiment was conducted in the laboratory of the Department of Food Technology and Rural Industries (DFTRI), Bangladesh Agricultural University (BAU), Mymensingh, Bangladesh. Fully matured and ripe papaya fruits of uniform color were procured from local market. Other materials such as drying trays, chemical solvents, distilled water, polythene bags were provided by the DFTRI and egg, skim milk, and other ingredients were collected from the local market.

Proximate analysis

Proximate composition represents the gross content of important chemical constituents such as moisture, protein, fat, carbohydrate, vitamin C, specific minerals and ash of the product. The study of the proximate composition serves as an important base to study the nutritive quality of papaya and papaya powder as well as papaya drinks. The standard methods have been used for the proximate analysis such as moisture content, protein, ash, fat, titratable acidity as described in AOAC (2005), Vitamin C content was measured according to Ranganna (2004) while carbohydrate content was calculated according to Pearson (1981). Total Soluble Solid (TSS) was determined by using an Abbe Refractometer (Model no. 8987 PujiKuki Ltd. Tokyo, Japan). Drying yield was calculated following the procedure described by Widyastuti and Srianta (2011).

Processing of foam mat dried papaya powder

Foam-mat drying of papaya consists of two main steps. Firstly, foaming of papaya slurry was made by the addition of egg white at different concentration and then drying of foamed papaya slurry was carried out in a cabinet dryer. The details of processing of foam-mat dried papaya powder have been shown in Figure 1.

Analysis of foaming properties of foamed papaya slurry

The foam density, foam expansion and foam stability of the foamed papaya slurry was determined using the method described by Kadam *et al.* (2010).

Analysis of foam mat dried papaya powder characteristics

Water holding capacity was determined using AACC (2000) and reconstitution was determined following the method of Widyastuti and Srianta (2011). Moisture Content and Drying Yield were determined as per the methods mentioned before.

Formulation of papaya powder drink

Powder drink was formulated by dry-blending of foam-mat dried papaya, skim milk and sugar. Three formulations of papaya powder drink were prepared by changing ratio of foam-mat dried papaya and skim milk. The ratio of foam-mat dried papaya and skim milk was 6:4, 5:5 and 4:6 (w/w). Dry-blending was carried out by using a dry blender blending for 1 minute at a speed scale of 1 followed by, at a speed scale of 2 for 2 minutes. The dry-blended product was wrapped within flexible packages. Dry-blended products were analyzed for moisture content, water holding capacity and reconstitution. Drinks were prepared by dissolving 25 g (5 g papaya powder and skim milk, 20 g sugar) of dry-blended powder in 250 ml water. The reconstituted drinks were analyzed for total soluble solid (TSS), acidity, pH and sensory properties.

Analysis of formulated product properties

Reconstitution rate of formulated product at different ratio of foam-mat dried papaya powder and skim milk was determined using the methods of Al-Kahtani and Hassan (1990) and Sommanas (1997). Water holding capacity and moisture content were determined as per the above-mentioned methods.

Sensory evaluation of reconstituted papaya powder drink

For statistical analysis of sensory data of reconstituted papaya powder drinks were evaluated for color, flavor, taste and overall acceptability by a panel of 10 members. The judges were selected randomly from the teachers and students of the DFTRI and were asked to assign scores on a 9 point hedonic scale (Ranganna, 2004) with the ratings of: 1=dislike extremely; 2=dislike very much; 3 dislike moderately; 4=dislike slightly; 5= neither like nor dislike; 6=like slightly; 7= like moderately; 8= like very much; 9=like extremely. The scores given by the panelists were analyzed by statistical software (MSTAT-C).

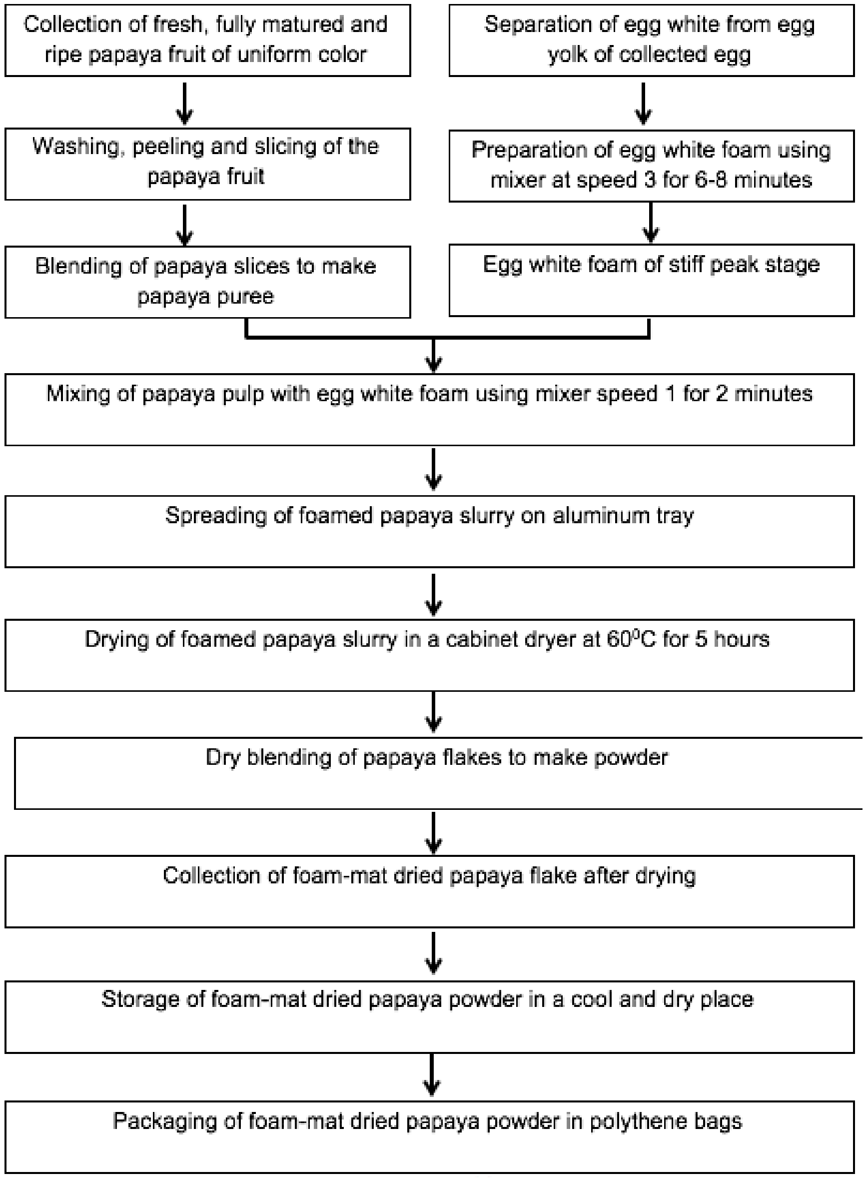

Fig. 1 Flow chart showing processing of foam-mat dried papaya powder

Results and Discussion

Proximate composition of papaya

Proximate compositions of fresh papaya pulp are shown in Table 1. The moisture content of ripe papaya was found 90.70%. The value was higher than the value found by Alam (2001) who reported 88.5% moisture and within the range of the value found by Nwofia *et al.* (2012) who reported 87.47-91.32% moisture. The protein content of ripe papaya was found 0.79%. The value was slightly higher than the value (0.61%) found by Milind and Gurditta (2011) and in the range of the value (0.4-1.17%) found by Nwofia *et al.* (2012). The fat content of ripe papaya was found 0.24%. The value was higher than the value found by Milind and Gurditta (2011) and lower to the range of Nwofia *et al.* (2012) who obtained 0.14 and 0.37-0.7 percent fat, respectively. The ash content of ripe papaya was found 0.29%. The value was very close to the result obtained (0.34 and 0.31-0.61 percent ash, respectively) by Alam (2001) and Nwofia *et al.* (2012). Total Carbohydrate content of ripe papaya was found 7.98%. The value was lower than the values described by Milind and Gurditta (2011) and Nwofia *et al.* (2012) who reported 9.81% and 6.5-9.51% total carbohydrate, respectively. Vitamin C content of ripe papaya was found 67.89 mg/100g of pulp. The value was higher than the value found by Milind and Gurditta (2011) and Nwofia *et al.* (2012) who reported 61.8 mg and 36.37-43.41 mg vitamin C, respectively. Total soluble solid of ripe papaya was found 7^0 Brix. The value was lower than the value found by Alam (2001) who reported total soluble solid as 10^0 Brix.

Table 1. Proximate composition of fresh papaya pulp

Parameter	Fresh papaya pulp	
	Wet basis	Dry basis
Moisture (%)	90.70	975.27
Protein (%)	0.79	8.5
Fat (%)	0.24	2.6
Ash (%)	0.29	3.1
Total Carbohydrate (%)	7.98	85.8
Vitamin C (mg/100g)	67.89	730
Total Soluble Solid (TSS) (^{0}Brix)	7.0	
Acidity (% Citric Acid)	0.77	
pH	5.0	

Titratable acidity of ripe papaya was found 0.77%. The value was higher than the value (0.31%) found by Alam (2001). pH value of ripe papaya fruit was found 5. The value was little higher than the value found by Alam (2001) who obtained pH value 4.5 for ripe papaya fruit. The variation in the mentioned proximate composition may be due to the differences in variety, maturity, postharvest environmental condition and climate as well.

Drying of foamed papaya

Effect of thickness on drying rate

The effects of thickness on drying rate of foamed papaya slurry were investigated at 60^0 C temperatures and at a constant air velocity (0.6 m/s) during mechanical drying. Different values of time (hr) versus moisture ratio (MR) were plotted on a semi-log graph (Figure 2a) and following equations were obtained.

MR = 0.9945 $e^{-1.415t}$ (For 3 mm, t = hr) ……………(1)
MR = 0.9725 $e^{-1.099t}$ (For 5 mm, t = hr) ……………(2)
MR = 1.0177 $e^{-0.923t}$ (For 7 mm, t = hr) ……………(3)

From equations 1 to 3 and Figure 2a, it is obvious that there is pronounced effect of thickness on drying time. Drying time increased with the increase in thickness. It is also observed that the drying rate constant decreased with the increase of the sample thickness. From equations, it is seen that the drying rate constant is 1.415 hr^{-1} for 3 mm thickness but that value decreased to 1.099 hr^{-1} and 0.923 hr^{-1}when thickness increased to 5 mm and 7 mm, respectively.

Different values of drying rate constant for 3 different thicknesses (3mm, 5mm and 7mm) when plotted on a log-log graph (Figure 2b) the following power law relationship has been developed:

m = 0.0411$L^{-0.503}$……………….……….. (4)

where, m = drying rate constant (min^{-1}), L = sample thickness (mm)

From the above equation it is seen that the value of 'n' is 0.503. This value is less than 2 as defined by power law equation. Several researchers have found different 'n' value for different products, for example, Alamgir (2000) indicated the n value of 0.333 for drying of coconut slices, Shafiqul (2003) calculated 'n' value of 1.57 and 1.59 for dehydration of Bangladeshi onion and Indian onion respectively. Iqbal and Islam (2005) found 'n' value 0.287 and 0.4105 for cauliflower and cucumber, respectively. Sarker (2009) found the n value of 0.261 and 0.4586 for drying of High Yielding Variety (HYV) and Local Variety (LV) of potato, Mizan (2002) found 'n' value of 0.97 for sweet potato and so on. There are various factors that can affect this variation of 'n' value such as product composition and structure; simultaneous heat and mass transfer effect; thickness and airflow rate that demonstrate the importance of internal and external mass transfer resistance.

Drying rate of foamed and non-foamed papaya pulp

The effects of foam on drying rate of papaya were investigated at 60^{0}C temperatures and at a constant air velocity (0.6 m/s) by mechanical drying. Figure 3a shows the comparison of drying rate of the foamed and the non-foamed papaya slurry of same thickness (3 mm). Different values of time (hr) versus moisture ratio (MR) when plotted on a semi-log graph (Figure 3b), the following equations have been obtained.

MR = 0.9945 $e^{-1.415t}$ (For foamed, t = hr) ……………….. (5)
MR = 0.9162 $e^{-0.624t}$ (For non-foamed, t = hr) ………….. (6)

The above equations and figures illustrate the effect of foam on drying time. Drying time increased considerably with decreased drying rate constant in non-foamed papaya and vice versa. From Figure 3b, it is seen that the drying rate constant was 1.415 hr^{-1} which is more than double than the non-foamed. For non-foamed papaya the value was decreased to 0.624 hr^{-1}. From Figure 3a it is seen that the moisture content (db) of foamed papaya pulp was reduced to 20.9% from 975.27% at 3 hours. For non-foamed pulp the time was 6 hours for moisture (db) to be removed from 975.27% to 26.06%. Rajkumar *et al.* (2007) reported the similar observation while drying 3 mm thick foamed mango pulp from 451 to 5.3% moisture content (db) in 80 minutes and the time taken for drying of non-foamed mango pulp of same thickness from 448 to 6.4% moisture content (db) in 190 minutes. Addition of foam decreases the drying time. The reason for that the foam structure provides a large surface at which water evaporates rapidly. The overall drying behavior of this study is very consistent to the behavior reported by Sharada (2013) for different fruits and vegetables.

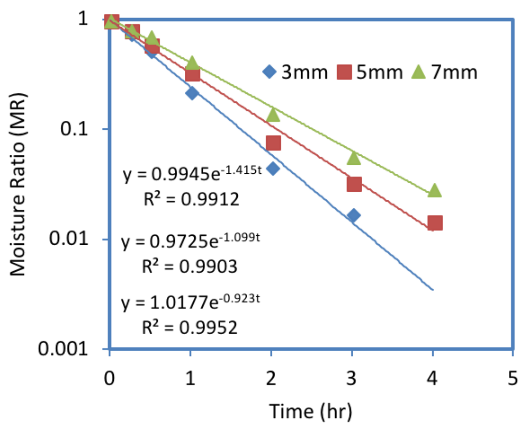

Fig. 2a Effect of thickness on drying rate of foamed papaya slurry at 60 ^{0}C

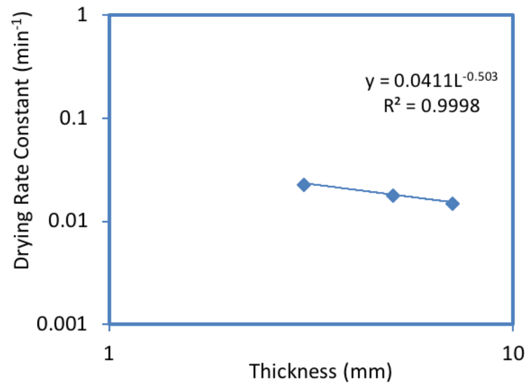

Fig. 2b Effect of thickness on drying rate of foamed papaya slurry at 60 ^{0}C

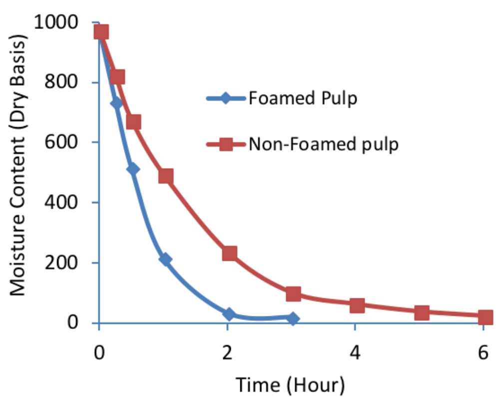

Fig. 3a Comparison of drying rate of foamed and non-foamed papaya at 60 ^{0}C

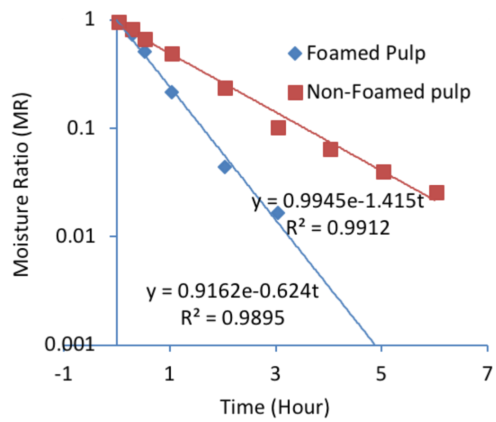

Fig. 3b Comparison of drying rate of foamed and non-foamed papaya at 60 ^{0}C

Optimization of foam-mat drying process

Foaming properties

Foam density, foam expansion and foam stability of foamed papaya slurry at different egg white concentration is shown in the Table 2. A one way analysis of variance (ANOVA) was performed to find out whether any significant difference exist or not. Duncan's Multiple Range Test (DMRT) was used to determine the difference. Foam density of foamed papaya slurry at 10, 15 and 20% egg white concentration was found 0.65, 0.58 and 0.52 g/cm^3, respectively which were significantly different from each other (Table 2). The density of foamed papaya slurry were varied and was closed to Hart *et al*. (1967) who reported the value of foam density suitable for foam mat drying between the range of 0.2 to 0.6 g/cm^3. The foam density was decreased with higher concentration of egg white. Widyastuti and Srianta (2011) reported the similar result which varied between 0.52-0.67 g/cm^3. The density of foamed mango pulp decreased as higher egg white concentration. These results indicate that higher concentration of egg white causes higher air volume entrapped in the slurry.

Foam expansion of foamed papaya slurry at 10, 15 and 20% egg white concentration was found 54.25, 60.62 and 75.20%, respectively and are significantly different from each other. It is seen that an increase in foam expansion was occurred when the egg white addition was increased from 10% to 20%. Egg white of 20% produced foamed papaya slurry with highest foam expansion. Widyastuti and Srianta (2011) reported the similar result which varied between 53-75%. The higher concentration of egg white produce the higher protein content of the mixture, therefore higher protein molecules act to form cohesive viscoelastic film by the ability to rapidly adsorb on the air-liquid interface during whipping. Globulins are excellent foam formers, but foaminess is significantly affected by the protein interactions with ovomucin, lyzozyme, ovomucoid, ovotransferrin and ovalbumin (Lomakina and Mikova, 2005). Foam stability of foamed papaya slurry at 10, 15 and 20% egg white concentration was found 100% for the entire three samples. There was no significant difference among the samples. Widyastuti and Srianta (2011) found the similar result in which foam stability was 100% for all the samples at 10, 15 and 20% egg white concentration which reflects the good performance of proteins contained in egg white.

Table 2. Foaming properties of foamed papaya slurry at different egg white concentration

Sample	Foam density (g/cm^3)	Foam expansion (%)	Foam stability (%)
S_1	0.65^a	54.25^c	100^a
S_2	0.58^b	60.62^b	100^a
S_3	0.52^c	75.20^a	100^a

Means value with the different alphabets in the column are significantly different at p = 0.05; Here, S_1 = Foamed papaya slurry with 10% egg white concentration; S_2 = Foamed papaya slurry with 15% egg white concentration; S_3 = Foamed papaya slurry with 20% egg white concentration

Table 3. Foam mat dried papaya powder properties at different egg white concentration

Sample	Drying yield (%)	Moisture content (%)	Reconstitution (%)	Water Holding Capacity (g/g)
S_1	10.25^c	3.93^a	82.43^b	5.23^c
S_2	10.74^b	3.54^b	83.27^a	5.45^b
S_3	12.37^a	3.27^c	83.53^a	5.93^a

Means value with the different alphabets in the column are significantly different at p = 0.05; Here, S_1 = Foamed papaya slurry with 10% egg white concentration; S_2 = Foamed papaya slurry with 15% egg white concentration; S_3 = Foamed papaya slurry with 20% egg white concentration

Table 4. Properties of reconstituted drink

Drink sample	TSS (^{0}Brix)	Acidity (%)	pH
S_1	8	0.49	5.91
S_2	8	0.46	5.99
S_3	8	0.44	6.06

Here, S_1 = Foamed papaya slurry with 10% egg white concentration; S_2 = Foamed papaya slurry with 15% egg white concentration; S_3 = Foamed papaya slurry with 20% egg white concentration

Table 5. Mean scores for color, flavor, taste, viscosity and overall acceptability of reconstituted drink

Sample	Sensory Attribute				
	Color	Flavor	Taste	Viscosity	Overall Acceptability
S_1	6.6^a	5.6^b	4.4^c	4.9^c	5.5^c
S_2	6.3^a	6.2^a	5.2^b	5.7^b	6.3^b
S_3	5.7^b	6.7^a	5.9^a	6.5^a	7.1^a
LSD	0.5332	0.5972	0.5746	0.5365	0.6716

Means value with the different alphabets in the column are significantly different at p = 0.05; Here, S_1 = Foamed papaya slurry with 10% egg white concentration; S_2 = Foamed papaya slurry with 15% egg white concentration; S_3 = Foamed papaya slurry with 20% egg white concentration

According to Sikorski (2002), hydrophilic amino acids (the major amino acids of ovomucin) lowered the surface tension at interface of liquid and gas which layered on the foam.

Foam mat dried papaya powder properties

Drying yield, moisture content, reconstitution and water holding capacity of foam mat dried papaya powder at different egg white concentration is shown in the Table 3. A one way analysis of variance (ANOVA) was performed to find out whether any significant difference exist or not. Duncan's Multiple Range Test (DMRT) was used to determine the difference.

Drying yield of foam-mat dried papaya powder at 10, 15 and 20% egg white concentration was found 10.25, 10.74 and 12.37%, respectively which are significantly different from each other (Table 3). Higher concentration of egg white produced higher drying yield. Widyastuti and Srianta (2011) found the similar result. This result is very much similar to the value reported by Sulaksono *et al.* (2013) and Krasaekoopt and Bhatia (2012) who obtained the moisture content of powder yoghurt within the range from 8.5 to 10.3% at similar temperature. Addition of 20% of egg white resulted highest drying yield. This might be related to the highest foam expansion of papaya slurry, hence the porosity of foamed papaya slurry are higher, which caused lower surface area of the mat which adhered to the surface of the trays. Moisture content of foam-mat dried papaya powder at 10, 15 and 20% egg white concentration was found 3.93, 3.54 and 3.27%, respectively which are significantly different (Table 3).

Widyastuti and Srianta (2011) found moisture content of foam mat dried papaya powder between the ranges of 2.91-3.09%. Similar result has been found by Kandasamy *et al.* (2012) for foam-mat drying of papaya using methyl cellulose as foaming agent who reported 4.5% moisture (dry basis) while drying was accomplished at the similar temperature used in this study. Reconstitution of foam-mat dried papaya powder at 10, 15 and 20% egg white concentration was found 82.43, 83.27 and 83.53%, respectively which were significantly different from each other. The result is very close to Widyastuti and Srianta (2011) who found the values between 81.34 and 83.42%.

Water holding capacity of foam-mat dried papaya powder at 10, 15 and 20% egg white concentration was found 5.23, 5.45 and 5.93 g/g, respectively and are significantly different (Table 3). Widyastuti and Srianta (2011) found the similar result which varied between 6.13-6.34 g/g. Above data reflects the potentiality of this product as an ingredient of beverage and food product. Based on the product properties it is seen that 20% of egg white produced best foam-mat dried papaya powder.

Reconstituted drink properties

Drink was prepared by the addition of different ratio of foam-mat dried papaya powder and skim milk, sugar and water. In 250 ml water 25 g of formulated product (5 g of foam-mat dried papaya powder and skim milk and 20 g sugar) was added and dissolved. The properties of reconstituted drink are shown in the Table 4. Total soluble solid was 8^0Brix for all three samples. Acidity decreased a little with the increase of skim milk powder while pH increased with the increase of skim milk powder.

Sensory evaluation of reconstituted drink

Three reconstituted drink were prepared with three different ratios of foam-mat dried papaya powder and skim milk were served to a taste panel of 10 members for organoleptic taste testing. The mean scores for color, flavor, taste, viscosity and overall acceptability of three different samples are presented in Table 5. A one way analysis of variance (ANOVA) was performed to find out whether any significant difference exist or not. Duncan's Multiple Range Test (DMRT) was used to determine the difference. Result obtained by statistical analysis shows that there was significant difference among the samples from view point of all the sensory attributes. Preference of aroma and taste scores as well as overall acceptability was higher at higher proportion of skim milk with highest score (7.3, ranking 'like moderately') at ratio of foam mat dried papaya and skim milk of 4:6.

Conclusion

Studies on foam mat drying of papaya revealed that with the increase in surface area exposed for drying, faster drying rate is observed. Foam mat drying has been resulted fruit powders which otherwise would not have been possible by conventional drying techniques and the mat dried powders are of good quality and have high reconstitution ability in water. Hence, the foam mat drying method is highly feasible in producing fruit and vegetable powders as well as ultimate functional drink production of acceptable quality at reasonable cost. The regular intake of the formulated drink could be a good source of recommended daily intake of dietary fiber as well as prevention of constipation. The developed product has a great potential as a functional drink to prevent and manage the constipation. Further research on assessment of laxative effect of the developed product in human is recommended.

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