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Preparation and evaluation of blended papaya-mango powder by foam mat drying

KK Sri Mohana Priya[1], Payel DasGupta[2*]
[1] Research Scholar, Department of Food Technology, Kongu Engineering College, Perundurai, Erode, Tamil Nadu, India
[2] Assistant Professor, Department of Food Technology, Kongu Engineering College, Perundurai, Erode, Tamil Nadu, India

Abstract
Fruits and vegetables are the part of healthy diet which are rich sources of phytochemicals as carotenoids, polyphenols, vitamins and minerals, besides presenting complex carbohydrates and fibers. Papaya (*Carica papaya* L.) fruit is usually consumed to prevent and manage constipation because it has laxative effect. To mask the typical flavour in papaya juice, blending of papaya-mango pulp is done and could be an economic requisite to utilize profitably. In order to reduce the postharvest losses in fruits and vegetables, fruit powders are made by dehydration technique. As papaya and mango are heat sensitive, sticky, viscous materials cannot be dried by spray drying, so foam mat drying is used. As a result of preliminary study, GMS (glycerol-mono stearate) had good foaming properties in these viscous pulps and the levels of foaming agent were optimized from the evaluation of foam density and expansion. GMS were used at 1, 2, 3 and 4% concentration, it was found that 4% level had higher foam expansion and lower foam density. Pulp concentration with 10˚ Brix with 4% GMS level were whipped for 10 min followed by drying at 50, 60 and 70˚C with 2 and 4mm foam thickness. The effect of drying rate of foamed blended pulp at 70˚C with 2mm foam thickness were high compared to 50 and 60˚C. Statistical analysis results showed that the logarithmic model has the best model with 4mm foam thickness provided the highest R^2 and the lowest RMSE at 60 and 70˚C temperatures and middle kuckuck model at 50˚C with 4mm foam thickness. Biochemical analysis of foam mat dried powder was studied. decrease in ascorbic acid, TSS, ß carotene whereas pH, acidity remains the same. Physicochemical analysis showed that bulk density in the range of 0.603 to 0.7533 g/cm^3, absolute density (1.26 to 1.49 g/cm^3), solubility (63.33 to 68.60%), rehydration ratio (6.4 to 6.6) and dehydration ratio (7.17 to 7.2) of foam mat dried blended powder.

Keywords: foam mat drying, blending of fruits, foaming agent, biochemical properties, physicochemical properties

1. Introduction
Papaya (*Carica papaya* L.) is one of the major fruits in tropical and subtropical regions in the world. This fruit is rich in β-carotene, vitamin-A and C, iron, calcium, protein, carbohydrates, phosphorous and good source of energy. Papaya has approximately 10% of carbohydrates in the form of fibers, sugars and starches. It is also rich in natural vitamins and minerals. Mango (*Mangifera indica* L.) is large, fleshy drupe with consumable mesocarp and has high bioactive compounds such as total phenolics, ascorbic acid, carotenoids, and dietary fiber. India is the largest producer of the mango, and it contributes 37% of all out 30.5 million tons of worldwide production. Yearly, India trades around 50 000 tons mangoes to different pieces of the world including Center East, Europe and US [1].

Some fruits which are rich in nutrients but are not accepted due to high acidity or poor taste and flavour. It can be blended with other fruits to improve their acceptability and make use of available nutrients. The perishable papaya is blended with mango. Blending of these two fruit pulp helps in improving nutrient elements, reducing cost of production by using less expensive fruits in the blends and also leads to new product developments [2]. Food dehydration is a procedure especially significant for fruits and vegetables, which contain a huge extent of water, and their preservation becomes complex. Dehydrated fruits are utilized either as nourishment items or industrial ingredients in the handling of different sustenances, for example, bakery items, instant fruit powders soups, colour and flavor extraction.

Foaming of fluid and semi-fluid materials has been perceived as one of the strategies for decreasing drying time. This drying innovation, known as foam mat drying, got reestablished consideration as a result of its additional capacity to process hard-to-dry materials, get results of desired properties (e.g., good rehydration, controlled density) and hold volatiles that generally would be lost during the drying of non-foamed materials. The foam mat drying is very appropriate for dehydration of high-sugar content, sticky, heat sensitive and viscous materials that are hard to dry utilizing other drying techniques [3]. The advantages associated with foam mat drying are nutrient retention, rapid drying, easy reconstitution and cost-effectiveness [3, 4].

Blended mango- papaya beverage were prepared and utilized both high value fruits in the beverage. Thus the prepared beverage had high level of nutrients such as ascorbic acid and ß carotene and also blended beverage had better sensory attributes compared to non blended beverage of papaya [2]. The effects of papaya pulp powder were studied using glycerol mono-stearate as foaming agent using foam mat drying. From the results, the stability of the foam was high at high concentration of foaming agent and at 3% GMS, whipping time-10minutes with 9˚Brix pulp concentration, the foam formation was more stable with foam expansion around 90% [5]. Similarly drying characteristics of foamed alphonso mango pulp were studied in a continuous type foam mat dryer was done using (10%) egg albumin, (0.5%) methyl cellulose. From this study, the observed results were the use of Glycerol-monostearate, egg albumen, the foam volume increased and the foam density

decreased with an increase in the concentration of foaming agents. Mango pulp with small foam thickness dried at faster rate compared to other foam thickness [6].

Functional drink of papaya were prepared by foam mat dried papaya by using egg white as a foaming agent (10%, 15%, 20%) at 60˚C. High level of foaming agent increased the drying yield and thus foam mat dried powder were formulated in a functional drink to manage constipation [7].

Foam mat drying of pineapple powder were studied with two foaming agents such as tricalcium phosphate (0, 0.25, 0.50, 0.75%), egg white (0, 0.5, 1, 1.5, 1.2%) and carboxyl methyl cellulose (0.25%) used as a foam stabilizer. The resultant foam were dried 65, 75, 85˚C and the statistical analysis showed that the optimized sample dried at 1% tricalcium phosphate in 65˚C had 4.60% total sugars, 2.4%reducing sugars, 4.05mg/100g ascorbic acid, 0.35% total acid, 0.29mg/100g iron, 2.24 mg/100g phosphorous with no bacterial, fungal growth [3]. Statistical analysis were carried out for biochemical properties and microbial load of foam mat dried mango powder to evaluate the food quality before and after drying. Data were analyzed in 2 way-ANNOVA and reported that pulp dried at 65˚C with foam agent(milk) level 10% gave better results compared to others [8]. The objective of this study to formulate blended papaya mango powder and to evaluate the foaming parameters, physicochemical, biochemical properties of foam mat dried powder.

2. Materials and methods

The papaya fruits and mango fruits used in this study were obtained from the local market at Perundurai in Tamil Nadu. The ripened fruits were peeled using knife and the fresh pulp were grinded using mixer and sieved. Biochemical analysis of fresh pulp were done namely pH, acidity, TSS, Total sugars, ascorbic acid and ß- carotene were analysed to evaluate the loss during the foam mat drying of pulp. Ratio of blending of pulp (1:1) were selected from the preliminary trails. Blended pulp were stored in the container and heated in the water bath to inhibit the microbial and enzyme activity.

During Foaming, suitable pulp concentration (˚Brix) was prepared by adding the known amount of distilled water. From the preliminary study, GMS were selected as the foaming agent as well as stabilizer. GMS levels were used in accordance with legislation of prevention of food adulteration act (1955) under the government of India. GMS was prepared by measuring the known amount of powder into a hot water(100˚C) to get 20%(w/w) GMS suspension. Then the suspension was blended in the mixer and kept in the room temperature [5]. The prepared GMS suspension was added at 1, 2, 3 and 4%(w/w). Then the suspensions were added to the blended pulp and foamed using the hand beater. Initially there was no foam formation in the blended pulp and this was due to the high viscous nature of both the fruits. When the pulp was adjusted to lower concentration, the foam development was observed. Hence the pulp concentration was adjusted to 10˚Brix from 13˚Brix. The Foaming parameters such as foam density, foam expansion, foam stability were studied and suitable level of foaming agent concentration were selected to produce foam mat dried powder.

2.1 Determination of foaming properties

The foaming properties of foamed pulp were analyzed in terms of maximum foam expansion, foam stability, foam density.

2.2 Foam expansion

Foam expansion was calculated by the method used by [4]. It was determined by the amount of air incorporated into the blended pulp at the time of whipping. It was estimated by difference in volume of blended pulp before and after foaming as follows:

$$\text{Foam expansion}(\%) = \frac{(V_1 - V_o)}{V_o} \quad (1)$$

Where,

V_1 – Volume of pulp after foaming(cm^3),

V_o – Volume of pulp before foaming(cm^3)

2.3 Foam Density

The foam pulp was transferred into the measuring cylinder without breaking the foam structure. The weight of the foam was measured using the weighing balance and volume of the foam was calculated from the radius of the cylinder [9].

2.4 Drying experiments

The blended pulp was dried using the batch type tray drier. The tray dryer consisted of drying chamber, heating coils, blowers, air inlet and outlet, thermostat and control panel. For the foam mat drying of blended pulp, the foamed pulp were spread on the stainless steel plates with foam thickness of 4 and 6 mm. The foam thickness was determined by known volume of foam to the drying area. Three different temperature (50˚, 60˚, 70˚C) were selected from the previous literatures used to dry the foamed pulp with 4 and 6 mm thickness. At every 30 min interval, the plates were taken out and the change in weight was recorded until the constant weight attained.

$$\text{Moisture content (db\%)} = (W_1.W_2/W_1)*100 \quad (2)$$

Where,

W_1 - Initial weight of the sample(g);

W_2 – Final weight of the sample(g)

Drying rate (g H_2O/g solids/min) =

$$\frac{\text{Amount of water removed, g}}{\text{Dry solids} \times \text{Time interval}} \quad (3)$$

2.5 Thin layer mathematical modelling

Moisture content of blended pulp during the thin-layer drying was expressed in terms of moisture ratio (MR) using the following equation [10].

$$\text{Moisture ratio} = M_t / M_0, \quad (4)$$

Where M_t - moisture content at time ‘t’, %db; M_0 – Initial moisture content, %db.

Moisture content data at three different temperature 50, 60, 70˚C with 2 different foam thickness were fitted with 6 different models. These models were selected based on the previous research reported for foam mat drying of tomato, shrimp [10, 11]. The coefficient of determination (R2) was the essential criteria for selecting the best fit model to define the drying curves. Along with the coefficient of determination,

root mean square (RMSE) was used to determine the goodness of fit. For a best fit, R2 value should be higher and RMSE values should be lower. The experimental moisture ratio values were fit in the selected models using MATLAB (R2008a) software.

Table 1: Thin layer modelling

Name of the model	Model equation
Newton model	MR = exp – kt
Henderson and Pabis model	MR = aexp – kt
Two term model	MR = a exp – kt + c exp dt
Logarithmic model	MR = a exp – kt +c
Midilli kucuk model	MR = aexp – kt + bt

2.6 Physicochemical and biochemical properties

Bulk density

The bulk density of foam mat dried powder were calculated as per the method used by [12]. Foam mat dried powder was taken in the beaker and tapped by hand five times. Bulk density was determined by dividing weight of powder by volume in the beaker.

Absolute density

Absolute density of foam mat dried powder were calculated by the method adapted by [13]. Absolute density were measured by weighing 2.5 g of powder were placed in the measuring cylinder and total volume was filled with the toluene.

Solubility

Foam mat dried sample (1g) were taken and diluted by addition of 100 ml of distilled water with stirring for 5 min followed by centrifugation. Then the solutions were filtered with the pre weighed whatman no.1 filter man followed by drying at 105˚C.The remaining residue after in the filter paper were used for the calculating the solubility [13].

Dehydration and rehydration ratio

Dehydration ratio was determined as the ratio of weight of the sample before drying to the dried weight of sample. Whereas, rehydration ratio was determined as the ratio of the weight of the rehydrated sample to that of dehydrated sample [14].

Rehydration of sample powder

Reconstitution of foam mat dried powder were done in the ratio 1.2:10 (Blended powder: water) and used for the estimations of ascorbic acid, pH, total carotene content, titratable acidity and microbial load (fungi and bacteria) [8].

PH and Titratable acidity

Reconstituted sample were used for measuring pH and titratable acidity. pH was measured using digital pH meter. Titratable acidity was measured by titrating the sample against 0.1 NaOH using phenolphthalein as a indicator.

Total soluble solids

TSS of the rehydrated mango juice sample (1.2:10 i.e. foam mat mango powder ⁄ water) was measured with the help of hand refractometer.

Ascorbic acid

Reconstituted sample was diluted with 3% HPO_3 and titrated with 2, 6 dichlorophenolindophenol. Standard ascorbic acid solution of 5 mL was added to 5 mL of HPO3 and titrated with dye solution to a pink colour, which persisted for 15 s. The dye factor was determined, i.e. mg of ascorbic acid per mL of the dye, using the formula: Dye factor= 0.5 per titre. Ascorbic acid (mg per 100 ml) of reconstituted juice was calculated using the formula:

$$\text{Ascorbic acid} = \frac{\text{Dye factor} * \text{titre value} * \text{volume made up} * 100}{\text{Sample taken for estimation} * \text{aliquot of sample used up (ml)} * 1000} \quad (5)$$

ß-carotene

Foam mat dried (500 mg) was homogenized and agitated with 5 mL of acetone ⁄ hexane (4:6), allowed to settle down and then supernatant was decanted. The procedure was repeated until no colour was obtained, and supernatants were pooled and final volume was made up to 10 mL. The absorption of supernatant was recorded at 490 nm on UV visible spectrophotometer.

Microbial load

Microbial load were checked for the foam mat dried powder by pour plate method. Nutrient agar were used the medium to enumerate the bacterial count.

3. Results and Discussion

3.1 Evaluation of foaming parameters

Foaming agent namely glycerol mono stearate were used at 1, 2, 3, 4% in the blended pulp and their foam density, foam expansion, foam stability were evaluated and their results are shown below:

Table 2: Effect of GMS on foaming parameters at different concentration in blended pulp

GMS%	Weight of fresh pulp(1:1)g	Volume of fresh pulp(cm^3)	Density of fresh pulp(g/cm^3)	Foam Volume(cm^3)	Foam expansion (%)	Foam density (g/cm^3)
1%	300	281	1.064	423	38.45	0.86
2%	300	282	1.065	480	67.32	0.75
3%	300	281	1.056	512	97.56	0.62
4%	300	283	1.059	589	120.2	0.51

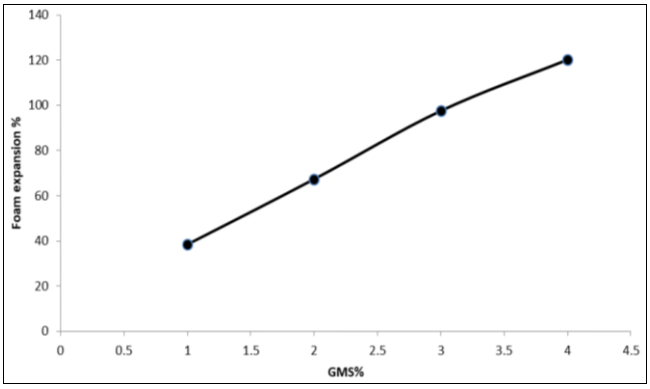

Fig 1: Effect of foam density with GMS concentration

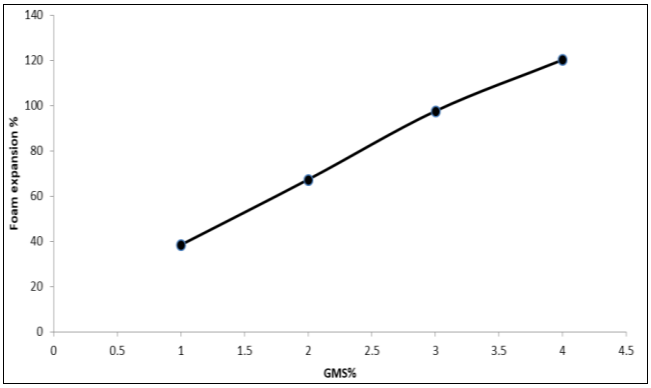

Fig 2: Effect of foam expansion with GMS concentration

In this study of evaluating foaming parameters of foamed blended pulp, it has been observed that the decreasing trend for foam density and increasing trend for foam volume, expansion. Foam expansion at 3% and 4% GMS concentration were in the range of 97.56%, 120.2% which is higher than 1% and 2% level. It was found that foam expansion increased with increase in GMS concentration due to the reduction in surface tension and interfacial tension to form interfacial film that increases the foam expansion [5]. Foam density for foam mat drying of blended pulp at 3% and 4% GMS concentration level were in the range of 0.62, 0.51 g/cm^3 which is lower than 1% and 2% level. Generally, foam density for foam mat drying should be around 0.2-0.6 g/cm^3 [15]. Foam density get decreased with higher concentration of foaming agent due to foam expansion in foam volume as it causes large surface area exposed to drying air [16]. In this study, the foaming agent was used upto 4% GMS concentration. when exceeding the GMS concentration beyond 4% level, there was no change in foam expansion [5]. From the above results, it was observed that the addition of GMS with 4% level were used to produce foam mat dried blended powder.

3.2 Effect of drying on foam thickness of foamed pulps

A comparative study of blended foamed pulp with 2mm and 4mm foam thickness at 50˚, 60˚ and 70˚C was done using 4% GMS. The effect of drying rate with respect to time at 70˚C with 2 and 4 mm foam thickness were shown in the Fig.4.3.From the figure, it was observed that drying rate for drying 2mm and 4mm foam thickness were 0.006, 0.003 g H_2O/g solids/min. Thus the drying rate get increased with reduction in the foam thickness level due to more surface area exposed to drying air [15]. Similarly, effect of drying rate with respect to time at 60˚C with 2 and 4 mm foam thickness were shown in the fig.4.4. From the figure, it was observed that drying rate for drying 2mm and 4mm foam thickness were 0.006, 0.001 g H_2O/g solids/min and at 50˚C the effect of drying rate were shown in the fig 4.5 with drying rate of 0.005, 0.0024 g H_2O/g solids/min for 2mm and 4mm foam thickness. Thus the drying rate increases with reduction in the foam thickness level due to more surface area exposed to drying air

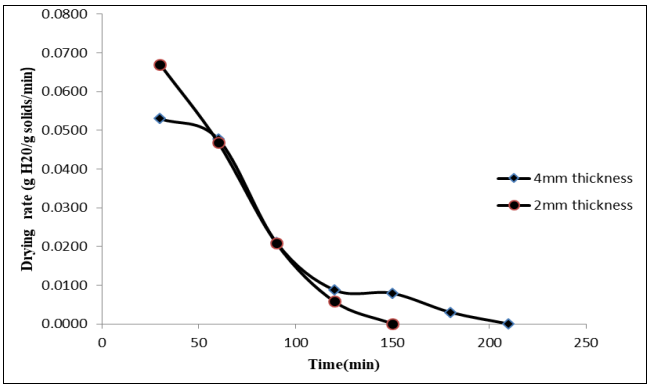

Fig 3: Effect of drying rate with respect to time at 70˚C with 2 and 4mm foam thickness

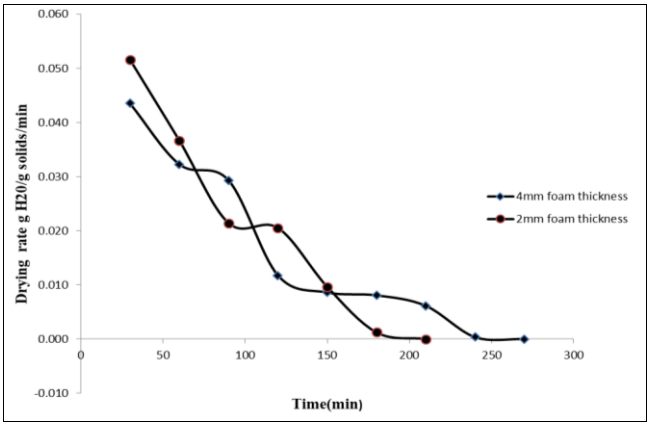

Fig 4: Effect of drying rate with respect to time at 60˚C with 2 and 4mm foam thickness

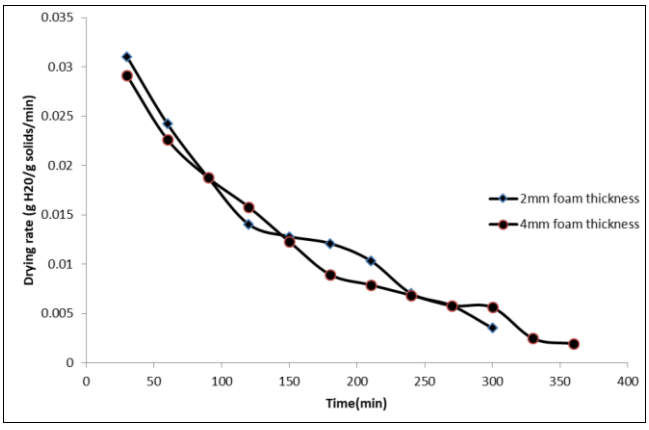

Fig 5: Effect of drying rate with respect to time at 50˚C with 2 and 4mm foam thickness

It is also observed that time taken for drying the foam at 50˚C were higher compared to 60˚C and 70˚C.Time taken for drying 50˚C with 2mm and 4mm foam thickness were around 300, 360 min. From this it was observed that foam thickness with 2mm foam thickness were dried at faster rate

compared to 4mm foam thickness. Similarly, lower foam thickness 2mm were dried at faster rate at 60˚C and 70˚C. Reduction of moisture content of fresh pulp at any point of time were lower compared to foamed pulp [15]. This is due to the high viscosity and bulk density of papaya, mango pulp, which has less surface area exposed during drying, demonstrating that foaming was beneficial in reducing drying time.

3.3 Fitting of drying curves

Moisture content data at different drying air temperature were converted to moisture ratio. The curve fitting computations with drying time were done by using thin layer drying models (Newton, Henderson and Pabis, Logarithmic, Two term model, midilli kucuk model).

Table 3: R^2 and RMSE values for fitting of drying curves at 50˚C with 2mm and 4mm foam thickness

Models	2mm foam thickness		4mm foam thickness	
Newton model	R^2= 0.9899 RMSE=0.0324	k =0.008802	R^2=0.9967 RMSE=0.01772	k =0.008025
Henderson and Pabis model	R^2=0.9907 RMSE=0.03287	a = 1.023 k =0.008996	R^2=0.9971 RMSE=0.01749	a =1.016 k =0.008151
Two term model	R^2=0.9741 RMSE=0.06205	a = 0.2285 b =0.008189 c =0.6889 d = -0.08031	R^2=0.9964 RMSE=0.02152	a = 0.2436 b =0.007968 c =0.7499 d = - 0.007979
Logarithmic model	R^2=0.9994 RMSE=0.008674	a =1.137 c = - 0.1446 k =0.006606	R^2=0.9998 RMSE=0.004826	a =1.059 c = -0.0607 k =0.007016
Midilli kucuk model	R^2=0.9995 RMSE=0.008382	a =0.9946 b =-0.000329 k =0.007394	R^2=0.9998 RMSE=0.004851	a =1 b =-0.00013 k =0.007409

In all the cases R^2 were greater than 0.96 indicating a good fit with high R^2 value and lowest RMSE values. Here, at 50˚C midilli kucuk model have highest R^2 value, lowest RMSE value with 0.9998, 0.004851 in 4mm thickness, whereas R^2, RMSE value of 2mm foam thickness is 0.9995, 0.008382. Thus the midilli kucuk model may be assumed to represent the thin layer tray drying behaviour of foam mat drying with 4mm foam thickness to produce foam mat drying of blended papaya mango pulp.

Table 4: R^2 and RMSE values for fitting of drying curves at 60˚C with 2mm and 4mm foam thickness

Models	2mm foam thickness		4mm foam thickness	
Newton model	R^2=0.9895 RMSE=0.03703	k =0.01735	R^2=0.9947 RMSE=0.02454	k =0.01405
Henderson and Pabis model	R^2=0.9902 RMSE=0.03869	a = 1.023 k =0.01768	R^2=0.9953 RMSE=0.02446	a = 1.023 k =0.01433
Two term model	R^2=0.9843 RMSE=0.05986	a = 0.3176 b =0.01656 c =0.638 d = -0.01687	R^2=0.995 RMSE=0.02907	a = 0.2448 b =0.014121 c =0.7626 d = -0.01414
Logarithmic model	R^2=0.9966 RMSE=0.02499	a =1.081 c = -0.07182 k =0.01476	R^2=0.9974 RMSE=0.01946	a =1.049 c = -0.0355 k =0.013
Midilli kucuk model	R^2=0.9959 RMSE=0.02752	a =1.011 b =-0.000285 k =0.01592	R^2=0.9971 RMSE=0.02058	a =1.014 b = -0.001153 k =0.01356

In all the cases R^2 were greater than 0.97 indicating a good fit with high R^2 value and lowest RMSE values. Here at 60˚C Logarithmic model have highest R^2 value, lowest RMSE value with 0.9974, 0.01946 in 4mm thickness, whereas R^2, RMSE value of 2mm foam thickness is 0.9966, 0.02499. Thus the Logarithmic model may be assumed to represent the thin layer tray drying behaviour of foam mat drying with 4mm foam thickness to produce foam mat drying of blended papaya mango pulp.

Table 5: R^2 and RMSE values for fitting of drying curves at 70˚C with 2mm and 4mm foam thickness

Models	2mm foam thickness		4mm foam thickness	
Newton model	R^2=0.9891 RMSE=0.04131	k =0.02554	R^2=0.9914 RMSE=0.03352	k =0.01969
Henderson and Pabis model	R^2=0.9896 RMSE=0.0458	a = 1.018 k =0.02589	R^2=0.9921 RMSE=0.03461	a = 1.025 k =0.02009
Two term model	R^2=0.9895 RMSE=0.06417	a = 0.2522 b =0.02572 c =0.7583 d =0.02577	R^2=0.9895 RMSE=0.06417	a = 0.2488 b =0.01994 c =0.7647 d = -0.01989
Logarithmic model	R^2=0.9943 RMSE=0.03864	a =1.07 c =-0.05889 k =0.03332	R^2=0.9947 RMSE=0.03125	a =1.05 c =-0.003734 k =0.01818
Midilli kucuk model	R^2=0.9895 RMSE=0.06417	a =1.013 b =-0.00032 k =0.02388	R^2=0.992 RMSE=0.03253	a =1.019 b =-0.00015 k =0.01904

In all the cases R^2 were greater than 0.98 indicating a good fit with high R^2 value and lowest RMSE values. Here, at 70˚C Logarithmic model have highest R^2 value, lowest RMSE value with 0.9947, 0.03125 in 4mm thickness, whereas R^2, RMSE value of 2mm foam thickness is 0.9943, 0.03864 Thus the Logarithmic model may be assumed to represent the thin layer tray drying behaviour of foam mat drying with 4mm foam thickness to produce foam mat drying of blended papaya mango pulp.

3.4 Biochemical properties of foam mat dried powder

pH and TSS

pH of reconstituted foam mat dried powder were in the range of 4.36 to 4.647. It was observed that pH had no significant difference ($p>0.05$) with respect to temperature and foam thickness. Generally, drying stage may alter the pH and cause osmotic imbalance during processing due to water removal and increase in the concentration of solute. Here, in foam mat drying pH had no influences. Even the change in foam thickness were also not affected the pH level Similar, results were reported in the foam mat dried powder [8]. There was decreasing trend ($p<0.05$) found for TSS. It was observed that TSS get decreased when increasing in temperature and there was minor differences in the foam thickness with respect to temperature. When increasing temperature, TSS get decreased due to the heat sensitive nature [15].

Ascorbic acid

Ascorbic content of foam mat dried powder ranged from 19.27 to 25.47. There was significant difference ($p<0.05$) in the ascorbic acid with increasing temperature. Ascorbic acid at 70˚C were lower compared to 60˚C and 50˚C. This may be due to the heat sensitive nature of ascorbic acid. Similar trend was also noticed for mat dried powder get decreased($p<0.05$) at higher temperature, when compared to lower temperature. Ascorbic acid decreased due to the heat sensitive nature. Similar results were reported in other studies mango [8], muskmelon [17].

ß carotene

ß carotene of foam mat dried powder were in the range of 5.60 to 9.56. ß carotene had significant difference($p<0.05$) with respect to temperature, but there was not much influence in foam thickness($p>0.05$). This may be due to the heat sensitive nature of ß carotene when exposed to higher temperature. Higher carotene content at 50˚C with foam thickness 2mm and 4mm were 9.56, 9.49 mg/100g followed by 60˚C and 70˚C.This may be due to the higher exposure time of foamed pulp in hot air at 70˚C than 50˚C. Similar results were also reported by [18].

Acidity

Acidity of foam mat dried powder were in the range of 0.39 to 0.62% There is no significant reduction in terms of acidity ($p>0.05$) with in change temperature and foam thickness. From the results, it was observed that acidity content can able to retain same even at higher temperatures. Similar results were also observed by [15].

Table 6: Biochemical properties of foam mat dried blended powder

Biochemical compositions	Foam thickness at 50˚C		Foam thickness at 60˚C		Foam thickness at 70˚C	
	2mm	4mm	2mm	4mm	2mm	4mm
TSS(˚Brix)	$(10.17\pm0.29)^{b}$	$(11.13\pm0.29)^{ab}$	$(10.27\pm0.29)^{b}$	$(12.27\pm0.29)^{a}$	$(10.17\pm0.29^{a}$	$(10.83\pm0.76)^{a}$
Ascorbic acid(mg/100)	$(25.47\pm0.31)^{a}$	$(24.59\pm0.17)^{b}$	$(23.74\pm0.17)^{c}$	$(21.54\pm0.29)^{d}$	$(20.35\pm0.26)^{e}$	$(19.27.\pm0.25)^{f}$
ß carotene(mg/100g)	$(9.56\pm0.29)^{a}$	$(9.49\pm0.13)^{a}$	$(7.70\pm0.34)^{b}$	$(7.78\pm0.19)^{b}$	$(5.25\pm0.23)^{c}$	$(5.60\pm0.23)^{c}$
Acidity(%)	$(0.62\pm0.25)^{a}$	$(0.39\pm0.05)^{a}$	$(0.58\pm0.25)^{a}$	$(0.48\pm0.17)^{a}$	$(0.51\pm0.13)^{a}$	$(0.58\pm0.25)^{a}$
pH	$(4.36\pm0.036)^{a}$	$(4.54\pm0.283)^{a}$	$(4.637\pm0.309)^{a}$	$(4.523\pm0.310)^{a}$	$(4.647\pm0.24)^{a}$	$(4.53\pm0.56)^{a}$

The results comprise means ± standard deviation. Each analysis was conducted 3 times. Different letters in the same ratio indicates significant difference ($p<0.05$) according to the test of Tukey's**.**

Table 7: Physicochemical properties of foam mat dried blended powder

Physicochemical properties	Foam thickness at 50˚C		Foam thickness at 60˚C		Foam thickness at 60˚C	
	2mm	4mm	2mm	4mm	2mm	4mm
Bulk density	(0.703±0.0493)[a]	(0.656±0.1002)[a]	(0.6033±0.1361)[a]	(0.7033±0.0681)[a]	(0.7533±0.0252)[a]	(0.7367±0.0208)[a]
Apparent density	(1.347±0.220)[a]	(1.450±0.220)[a]	(1.2600±0.1572)[a]	(1.4433±0.1106)[a]	(1.4900±0.1670)[a]	(1.4433±0.1002)[a]
Solubility	(67.60±2.00)[a]	(68.60±2.00)[a]	(65.33±2.08)[a]	(63.33±2.08)[a]	(65.33±3.21)[a]	(64.67±4.51)[a]
Rehydration ratio	(4.367±0.252)[a]	(4.333±0.321)[a]	(5.333±0.208)[b]	(5.400±0.1000)[b]	(6.400±0.265)[c]	(6.5667±0.1155)[c]
Dehydration ratio	(5.367±0.208)[a]	(5.4000.1000)[a]	(6.5000±0.1000)[b]	(6.600±0.200)[b]	(7.17±0.1528)[c]	(7.2±0.1000)[c]

The results comprise means ± standard deviation. Each analysis was conducted 3 times. Different letters in the same ratio indicates significant difference ($p<0.05$) according to the test of Tukey's.

3.5 Physicochemical properties of foam mat dried powder

Bulk density and absolute density

Bulk density and absolute density are the physical low cost determinations to analyse the quality of products. Bulk density is a factor that correlates with reconstitution, packaging and transportation. Bulk density varied between 0.603 to 0.7533 g/cm^3 for the foam mat dried powder. It was observed that there was much influence ($p>0.05$) in both bulk density and a density. Bulk density for foam mat dried blended at 50˚C with 2mm and 4mm foam thickness were 0.7033 & 0.6567, 60˚C were 0.6033 &0.7033, 70˚C were 0.7533 & 0.7367 g/cm^3.This indicates that the bulk density have not much varied between the foam thickness and also with respect to temperature. Here the temperature changes only between 50-70˚C, so there was no change in bulk density, apparent density. Temperature at above 100˚C, the evaporation rate were higher which results in higher water removal from the product that causes the structure collapse with low density powder. The similar results were also reported by [19].

Solubility

Solubility is an important parameter that indicates the powder ability to retain homogenously mixed with water. Solubility of foam mat dried powder were in the range of 63.33 to 68.60% which was not much influenced ($p>0.05$) by variation in the drying condition and foam thickness. There was no change in solubility on the drying condition because solubility depends on the foaming agent concentration. In this study, the addition of foaming agent same at all concentration levels so there was no effect in solubility with respect to higher temperature [20]. This blended mango papaya juice powder were less soluble than the foam mat dried yacon juice powder [13]. Solubility was less due to the viscous nature of both the pulp.

Rehydration and Dehydration ratio

Rehydration and dehydration ratio had significant difference with respect to temperature. Rehydration ratio of foam mat dried blended powder at 70˚C with 2mm and 4mm thickness were 6.4 to 6.6 which was higher compared to 50 and 60˚C. Dehydration ratio at 70˚C with 2mm and 4mm foam thickness were 7.17 to 7.2. It was observed that increasing drying time and temperature leads to decrease in moisture content of the sample since the evaporation rate increases with increasing temperature. Rehydration rate increased with increase in temperature due to high penetration of water through pores at higher temperature [21].

Microbial load

Microbial load for fungi and bacteria was determined for reconstituted blended powder. There was no fungal and bacterial growth found in the freshly prepared mango powder as the water content of blended pulp was reduced during drying.

4. Conclusion

The conversion of the fruit into powder could be useful not only to reduce the post-harvest losses but also to retain nutritional quality in the processed products. New processed food from mango-papaya blend is highly desirable and dehydrated mango can be used in many food formulations. Blending of these two-fruit pulp helps in improving nutrient elements, reducing cost of production by using less expensive fruits. Thus the foam mat drying is suitable for all type of food materials with rapid drying at lower temperature, retention of nutritive value and bioactive components. GMS were used at 1, 2, 3 and 4% concentration, it was found that 4% level had higher foam expansion and lower foam density. Pulp concentration with 10˚Brix with 4% GMS level were whipped for 10 min followed by drying at 50, 60 and 70˚C with 2 and 4mm foam thickness. The effect of drying rate of foamed blended pulp at 70˚C with 2mm foam thickness were high compared to 50 and 60˚C. Statistical analysis results showed that the logarithmic model was the best model with 4mm foam thickness provided the highest R2 and the lowest RMSE at 60˚C and 70˚C temperatures and midilli kucuk model at 50˚C with 4mm foam thickness. Biochemical analysis of foam mat dried powder showed that ascorbic acid, TSS, ß carotene get decreased whereas pH, acidity were remain unchanged. Physicochemical analysis showed that bulk density in the range of 0.603 to 0.7533 g/cm^{3,} absolute density (1.26 to 1.49 g/cm^3), solubility (63.33 to 68.60%), rehydration ratio(6.4 to 6.6) and dehydration ratio(7.17 to 7.2).

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5. References

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