ISSN 2249-8516

Original Article

ASSESSMENT OF BIOCHEMICAL CHARACTERISTICS OF FOAM-MAT DRIED PAPAYA POWDER

Palani Kandasamy ¹ and Nachimuthu Varadaraju ²

¹Institute of Agriculture, Visva-Bharati University, Santiniketan 731 235, West Bengal, India
²Department of Food & Agricultural Process Engineering, AEC&RI, TNAU, Coimbatore, India

Corresponding author: Tel: +91-9434306277, E-mail: erkands@yahoo.co.in

Received 30 January 2014; accepted 13 February 2014

Abstract

The experiments were conducted to find out the effect of drying air temperatures (60, 65 and 70°C), foaming agents (methyl cellulose, glycerol-mono-stearate and egg white) and foam thickness (2, 4, 6 and 8 mm) on biochemical qualities of foam and non-foam dried papaya powder. It was observed that there was significant (p ≤ 0.05) variations in ascorbic acid and β-carotene content with temperatures, foaming agents and foam thickness. Total soluble solids, acidity and total sugars were significantly different (p ≤ 0.05) with foaming agents while not significant with temperatures and foam thickness. There was no significant change in pH value. Conclusively, using 15% egg white, foam thickness of 2 mm and drying at 60°C retained significantly higher (p ≤ 0.05) amounts of nutritional qualities.

Key words: Foaming agents, Foam-mat drying, Ascorbic acid, β-carotene, Total sugars

1. Introduction

Dehydration of fruits are carried out by means of sun drying and mechanical drying such as spray, drum, vacuum, freeze, hot air drying, etc. Among the methods of drying, foam-mat drying is comparatively cheap and simple. This method is suitable for any heat sensitive, sticky and viscous materials which cannot be dried by spray drying. Any liquid food material that needs to be dried gently could be dried by the foam-mat method provided it is capable of forming stable foam [1]. On the commercial scale, it is finding an increasing application and importance in drying liquids that render a high quality concentrate such as milk, fruit juices soluble coffee and tea [2]. The quality of conventionally dried products is often low compared to the original material considering color, rehydration ratio, texture, and biochemical characteristics. This could be due to the long exposure to heat during drying [3]. Thus, the time for dehydration needs to be minimized to avoid losses in nutritional and sensory qualities. Foam-mat drying is the best option to reduce the time of drying of any liquid and semi liquid food materials. In this method, a liquid food concentrate whip along with a suitable foaming agent to form a stable foam and is subjected to dehydration in the form of a mat of foam at relatively low temperature [4]. Rate of drying in this process is comparatively high and is suitable for any heat sensitive, sticky and viscous materials which cannot be dried by spray and drum drying [5]. Renewed interest in foam-mat drying could be due to its simplicity, cost-effectiveness, rapid drying rate, and enhanced product quality. The dried product is also reduced to light and porous form which, when packaged in polyethylene material, allow for good stability. Unlike other drying methods, foam-mat drying does not require a large capital outlay and the throughput of the dryer as the moisture is removed from the thin layer of the foam; hence, the material spread per unit surface of drying area is small [6].

Papaya (Carica papaya L.) is an important tropical and subtropical fruit consumed throughout the world. It is highly perishable in nature with limited shelf life. Over the last two decades, the global production of papaya reached 10.5 million tones with post-harvest losses of 25.49% [7]. The fruit is rich in carotenoids, vitamins, minerals, carbohydrates and good source of energy. Conversion of this excellent fruit into powder form could be useful not only to minimize the post-harvest losses but also to retain the nutritional qualities in the processed products. The dehydrated papaya by-products can be used for preparation of many food product formulations such as ready to eat fruited cereals, ice cream flavors, nectar, instant soup cubes, etc., thus new processed food products from papaya are highly desirable. As the papaya pulp is highly viscous and sticky, it is therefore highly suitable for foam mat drying technology. One of the main objectives of this...
investigation was to study the selected biochemical attributes of foam mat dried papaya powder.

2. Material and Methods

The experiments on foam-mat drying of papaya were carried out with ‘CO-2’ variety at the Department of Food and Agricultural Process Engineering, Tamil Nadu Agricultural University, Coimbatore, India.

2.1. Papaya powder preparation

The foaming agents such as methyl cellulose (MC), glycerol monooleate (GMS) and egg white (EW) were selected and used within the limits stipulated in section-60 of the Prevention of Food Adulteration Act (1955), India. The papaya fruits used in the experiments were purchased from the orchard of the University. The fruits were washed in running water and kept at atmospheric condition till the desired peel colour was attained. Fully ripened fruits were peeled manually using a stainless steel knife and the flesh portions were pulped using a mixer grinder (Sumeet, India). The papaya fruit pulp was homogenized and was treated with potassium metabisulphite at 0.05% (w/w) to inhibit the microbial and enzymatic activity. The homogenized papaya pulp was whipped with selected foaming agents (0.25, 0.5, 0.75 and 1% MC; 1, 2, 3 and 4% GMS; 5, 10, 15 and 20% EW on w/w basis) using laboratory scale foaming device for 10-15 min to obtain maximum reliable foam. The optimum level of each foaming agent was determined based on foaming properties such as foam expansion, density and stability. Maximum consistent foam was obtained at the level of 0.75% MC, 3% GMS and 15% EW.

The papaya foam slurry at optimum levels of 0.75% MC (F1), 3% GMS (F2) 15% EW (F3) and Non-foam (F0) were taken for drying experiments. The papaya foam and non-foam slurry was evenly spread on the food-grade stainless steel trays at four levels of depth (thickness) such as D1 = 2 mm, D2 = 4 mm, D3 = 6 mm and D4 = 8 mm. The foam thickness was determined by dividing the known volume (mass/bulk density) of foam by drying area. During preliminary drying tests, it was found that the dried papaya pulp firmly stuck to the stainless steel tray, and scraping off the dried papaya pulp became a serious problem. To prevent sticking and to facilitate easy removal of the foamed fruit pulp after drying, the trays were lined with a non-stick food-grade Teflon sheet. The foamed and non-foamed papaya pulps were dried at three levels of air temperature viz. T1 = 60°C, T2 = 65°C and T3 = 70°C with an air flow rate of 2.25 cu.m min⁻¹. The dried product was scraped and pulverized before packing for further studies. The moisture content of the foam-mat dried papaya powder was 4.5 ± 0.3% on dry basis whereas non-foam dried papaya product was ranging between 15 and 18 ± 2% on dry basis.

2.2. Determination of biochemical characteristics

The biochemical characteristics such as total soluble solids (TSS), pH, acidity, total sugars, ascorbic acid and β-carotene content were determined for the foam mat dried papaya product after reconstituting the powders to their original moisture content. To distinguish the relative changes in nutrients during drying, the fresh papaya pulp also analyzed for biochemical attributes. For determination of TSS, Abbe hand refractometer (Model Ni; Atago, Japan) was used. The TSS in degree Brix was obtained from direct reading of the refractometer and digital pH meter was used to measure the pH of the samples [8]. Total sugars and ascorbic acid content in the papaya powder sample were determined by phenol sulphuric acid method and 2,6-Dichlorophenol-Indophenol visual titration method respectively as per method described [9]. The Titratable acidity and β-carotene in the papaya powder sample were estimated as described [10].

2.3. Statistical analysis

The biochemical characteristics of the reconstituted foam mat dried papaya powder and non-foamed product with three replications were statistically analyzed as completely randomized block design at 5% level to check the effect of different treatments and safety of food quality.

3. Results and Discussion

Various biochemical attributes of fresh papaya pulp were determined as TSS (13°Brix), acidity (0.33 g/100 g of fresh pulp), ascorbic acid (145 mg/100 g of fresh pulp), total sugars (37.8 g/100 g of fresh pulp), β-carotene (4.056 mg/100 g of fresh pulp) and pH (5.2). The moisture content of the fresh papaya pulp was 85.2%.

3.1. Total soluble solids

The mean TSS of the foam-mat and non-foam dried papaya powder was 12.71 and 11.67°Brix respectively (Fig. 1) whereas in fresh fruit it was 13°Brix. The TSS has a decreasing trend with the increasing temperatures. All treatments with different temperatures, foaming agents and foam thickness have no significant (p ≤ 0.05) effect on TSS of the powder. Mean comparison showed the foamed papaya pulp irrespective of foaming agents dried at 60°C with 2 and 4 mm foam thickness was the best with highest TSS among different temperatures. A similar observation was made for foam mat drying of alphonso mango pulp [11] and for foam-mat drying of apple [12].

![Fig. 1. Individual effect of different treatments on TSS of foam and non-foam dried papaya powder.](image)

*n=3, treatments were not significant at 5% level, CV = 8.49%*

3.2. Titratable acidity

Fig. 2 shows the effect of drying air temperatures, foam thickness and foaming agents on titratable acidity. The titratable acidity of reconstituted dried powder ranges from 0.408 to 1.562% whereas its value in fresh sample was 0.33%. The level of acidity in egg white treated (F1) papaya powder was significantly higher as compared to other treatments. The higher level of acidity in foam-mat
dried powder may be the influence of foaming agents. Statistically, the effect of foaming agents on acidity shown significant (p ≤ 0.05) difference but such significance was not found in foam thickness and temperatures. Various researches with Alphonso mango [11], mango [13] and tomato [14] reported similar results on titratable acidity.

3.3. pH value

The influence of foaming agents, foam thickness and air temperature on pH was shown in Fig. 3. The pH value of non-foam (control) and foam-mat dried papaya powder ranged between 4.73 to 4.85 and 4.82 to 5.18 respectively while the fresh fruit ranged from 5 to 5.2. Among the treatments, powder obtained from egg white treatment (F3) is having higher pH. This is because of the influence of alkali of egg white. The pH value was not significant at foaming agents, thickness of foam and temperatures. Generally, most of the fruits are acidic in nature having pH of less than 7. A low pH range of the foam-mat dried sample was significant from a safety point of view. The results were confirmed to observations made for the influence of foam mat drying on quality of tomato [14].

3.4. Ascorbic acid content

Effect of foaming agents, foam thickness and temperatures on ascorbic acid is presented in Fig. 4. The ascorbic acid content of non-foam dried papaya powder was found to be 84.07 mg/100g of dried product and foam-mat dried papaya powder ranges between 99.6 and 132.56 mg/100g of dried powder whereas in fresh fruit 145 g/100g fresh pulp. The ascorbic acid content in foam-mat dried powder was found to be less as compared to fresh fruit but higher than the non-foam dried powder. The former may be due to destructive effect of the prolonged thermal treatment causing oxidation of the ascorbic acid and the latter due to the foaming condition reducing the drying time by minimizing the destruction of ascorbic acid. Moreover, higher the drying air temperature and foam thickness lowers the ascorbic acid content vice versa. There were significant (p ≤ 0.05) variations with different foaming agents, drying air temperatures and increasing foam thickness. The statistical analysis showed that the papaya pulp treated with egg white (F3) and dried at 60°C (T1) with foam thickness of 2 mm (D1) was found to be the best. Similar decline in ascorbic acid content at increasing air temperature was noticed in other foam mat drying studies with alphonso mango [11], mango [13] and tomato [14].

3.5. Total sugars

The influence of foaming agents, thickness of foam and drying air temperatures on sugar content of foam-mat dried papaya powder is shown in Fig. 5. From the figure, it is clearly seen that the level of sugar content in foam-mat dried powder ranges between 35.01 and 35.82 g/100g of dried powder which was higher than non-foam dried powder (33.68 g/100g of dried product). The inherent sugar content of foaming agents may be contributed for this increase in total sugar content. Whereas the level of total sugar content in fresh fruit (37.8 g/100g of fresh pulp) was found to be higher than foam-mat dried powder. Moreover, Figure 5 clearly indicates that the level of sugar content decreased as there is an increase in the thickness of foam and temperatures. The loss of sugar content in dried powder may be an exposure at high temperature and the higher foam thickness took longer time to dry up. The treatments F2, F3 and T1 showing higher sugars compared to other treatments. The foaming agents showed a significant variation (p ≤ 0.05) from each other. GMS and egg white foamed papaya pulp dried at 60C with a foam thickness of 2 mm was the best among treatments. Similar trends in sugar content was reported for quality of foam mat dried papaya powder.
alphonso mango pulp [11] and for quality of foam mat dried tomato powder [14].

3.6. β-Carotene content

Fig. 6 shows the effect of foaming agents, foam thickness and temperatures on β-carotene content. The overall mean of β-carotene content in non-foam dried powder was 3.14 mg/100g of dried product whereas foam-mat dried powder ranges between 3.8 and 4.58 mg/100g of dried powder. The β-carotene content in fresh fruit was determined as 4.056 mg/100g of fresh pulp. The β-carotene content was found to be decreased with increase in foam thickness causing for prolong exposure to heat treatment result destruction in β-carotene. It was also found that there was decreasing trend with increase in drying air temperature. Among the foaming agents, egg white (F1) treated powder has higher β-carotene content. This may be due to the high volume and stability of egg white treated foam that reduces the drying time by a little loss of β-carotene content as compared to other foaming agents treated powder. Drying air temperature, foaming agents and thickness of foam have significant (p ≤ 0.05) change in the β-carotene. The statistical analysis showed the treatments T1 (60°C), D1 (2 mm) and F1 (egg white) were best among the treatments. The results were confirmed to findings reported for dehydrated mango powder [15] for Taiwanese mango [16], for alphonso mango [11], and for tomato [14].

4. Conclusion

From the biochemical analysis, it was concluded that the foaming agent of 15% egg white, drying air temperature of 60°C and foam thickness of 2 mm retained significantly higher (p ≤ 0.05) amount of nutritional value when compared to other foaming agents (Glycerol-mono-stearate and methyl cellulose), temperatures (65 and 70°C) and foam thickness (4, 6 and 8 mm). The study indicates that the processing of papaya could be conserved in the form of powder without losing much of its nutritive value. Thus, foam-mat drying is a good alternative to other drying processes and a promising potential for the food and fruit processing industry.

References

1. O.A. Akintoye, A.O. Oguntunde, Preliminary investigation on the effect of foam stabilizers on the physical characteristics and reconstitution properties of foam-mat dried soymilk, Drying Technol. 9(1), (1991), 245-262.
15. T.V. Hymavathi, V. Khader, Carotene, ascorbic acid and sugar content of vacuum dehydrated ripe mango

Fig. 5. Individual effect of different treatments on total sugars of foam and non-foam dried papaya powder. n=3, treatments were not significant at 5% level, CV = 8.85%

Fig. 6. Individual effect of different treatments on β-carotene content of foam and non-foam dried papaya powder. n=3, treatments were significantly different at 5% level, CV = 16.77%

Source of support: Nil; Conflict of interest: None declared