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Comparative study of physicochemical properties of freeze dried and tray dried raw jackfruit flour

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Abstract

Sliced raw jackfruit was dried using Tray drier (TD) and Freeze drier (FD). The comparison of effect of these drying methods on the physicochemical properties were investigated. Different properties like proximate, color, pH, water absorption capacity, oil absorption capacity, water activity, bulk density were analysed. The result outcomes of the flour dried under two different driers were compared and discussed. The moisture content of TD and FD raw jackfruit flour were not significantly different ($p > 0.05$). The proximate content of the FD flour was higher than TD flour as much nutrients are retained in freeze drying process. The color of FD flour was lighter whereas TD flour had slight darker colour which affected the acceptability of the flour. The pH, water activity, water absorption capacity as well as oil absorption capacity values of TD and FD flour had slight variations. Freeze dried raw jackfruit flour shown better quality and nutritional retention than TD flour.

Keywords: Raw jackfruit, tray drying, freeze drying, nutritional retention, quality

1. Introduction

The locally available indigenous fruit/vegetable play a vital role in providing nutritional benefits. They can serve as a major source of minerals and vitamins for most of the population. Jackfruit is one among them commonly referred as 'poor man's food' and is the world's largest edible fruit (Goswami & Chacrabati, 2015) [7]. India ranks second in the production of Jackfruit and it is considered as its motherland. Jackfruit was most commonly grown in Sri Lanka, Bangladesh, Philippines, Indonesia, Burma, Thailand, Brazil and Malaysia. Assam, West Bengal, Uttar Pradesh, Maharashtra, Kerala, Tamil Nadu and Karnataka were the states which have the large production of jackfruit in India (Vazhacharickal, Prem Jose *et al.*, 2015) [25]. Due to lack of proper storage facilities and its perishable nature, most of them gone underutilised (Chandrakanth Reddy, Prabakar, Sita Devi, Ponnarasi, & Shelton Peter, 2019) [5]. Raw jackfruit (*Artocarpus heterophyllus* L.) was rich in vitamin B and C, protein, fibre, iron, calcium, potassium, and carbohydrates. It was also rich in dietary fibre which can prevent from colon cancer (Mondal, 2013) [14]. The raw immature chunks boiled in low concentrated brine can be served in salad and also the tender one can be pickled (Benkeblia, 2018) [2].

Drying is one of the processing method where the moisture content is reduced below the point where no bacterial growth occurs (Swami, Thakor, Orpe, & Kalse, 2016) [22]. The reduction of water available in the food either by vaporisation or by sublimation to the point where there was no chances for enzymatic, chemical and microbial degradation refers to drying (Ceballos, Giraldo, & Orrego, 2012) [4]. The rate of drying was influenced by vapour pressure of the food, vapour pressure of drying air, air velocity, moisture diffusion in the product, temperature, thickness of the food and the surface area (Guiné, 2018) [8]. Drying the sample to the moisture content of below 10% have higher storage stability and also dried flour would have the least water activity which won't promote bacterial growth (Kasaye Atlaw, 2018) [10].

The physicochemical properties such as texture, density, color, sorption characteristics and porosity of materials can be affected by the different methods of drying (Abera, Solomon, & Bultosa, 2017) [1]. One of the most advanced dehydration method was freeze drying which aids in porous structured product with better rehydration properties and better nutrient retention (Koç, Eren, & Kaymak Ertekin, 2008) [11]. For the drying of agricultural products containing heat-sensitive antioxidant components, freeze drying is highly preferred and those freeze dried products have the characteristics same as that of fresh products.

Attributes such as appearance, taste, nutrients, porosity, color, texture, flavour and biological activity of the fresh products were much retained after drying which makes this technique most fascinating (Shofian *et al.*, 2011) [21]. Thus the present study was conducted to evaluate the effect of tray and freeze drying methods on the physicochemical properties of the raw jackfruit flour so that various value added products can be formulated from the flour with minimal nutritional loss.

2. Materials and Methods

The raw jackfruit was purchased from the local market in Thanjavur, Tamil Nadu. Raw tender jackfruit was taken of about 6-7 week maturity and it was washed thoroughly to remove the dirt and other foreign matters. The outer skin was removed and the entire flesh was cut into smaller cubes. Pre-treatment was done using citric acid to prevent browning. Then it was dried under two different drying methods: tray drying (TD) and freeze drying (FD). The preconditioned raw jackfruit was tray dried at 60°C for 24 hours and the other part of preconditioned raw jackfruit pieces were pre-frozen at -10 °C for 8 hours and kept in freeze drier for 24 hours for complete drying. The freeze dried and tray dried raw jackfruit pieces were powdered using electronic mixer and stored in airtight containers for further studies.

2.1 Physicochemical Analysis

The physicochemical properties of the freeze dried and tray dried raw jackfruit flour like the proximate analysis, flour properties such as bulk density, water absorption capacity, oil absorption capacity, water activity, pH and color were analysed.

2.1.1 Color measurement

The color measurement of the TD and FD raw jackfruit flour was done using hunter lab colorimeter (ColorFlex EZ, Austria, USA). The standardization of the colorimeter was done using the black and white tiles. Then the sample port was filled with the sample and the readings was taken as “L” (darkness to lightness), “a” (greenness to redness) and “b” (blueness to yellowness) values.

2.1.2 Bulk density

A 10 ml measuring cylinder was taken and take 5g of FD/TD raw jackfruit powder in it. The volume occupied by the freeze dried/tray dried jackfruit flour is noted. The bulk density is expressed as g/ml. (Haruna, Akanya, Adejumo, Chinma, & Okolo, 2019) [9].

$$\text{Bulk density} = \frac{\text{mass(g)}}{\text{volume(ml)}}$$

2.1.3 Proximate Analysis

The moisture, ash, protein, carbohydrate and fiber was determined according to AOAC methods (1990). The protein content was determined after estimating the crude nitrogen content using the Kjeldahl method. The fat content of the sample was determined by Soxhlet apparatus. The ash content was measured by igniting the sample in muffle furnace maintained at 550°C. Hot air oven method was used to determine the moisture content. Fibre content was determined using subsequent acid and alkali digestion.

2.1.4 pH

The pH of the TD/FD raw jackfruit flour was analysed using digital pHmeter LI 120 (ELICO Pvt Ltd). The 10 g flour was

diluted with 50 ml distilled water and the glass electrode was dipped in the solution to display the pH of the sample digitally.

2.1.5 Water activity

The non-bound water that is available for the growth of microbes refers to the water activity and the water activity of the TD/FD raw jackfruit flour was determined using Aqua Lab 4TE Dew point water activity meter. The flour was filled in the sample holder and the meter was allowed to read which directly shows the water activity of the sample within a shorter period of time as the dew point sensor measures the a_w of the flour.

2.1.6 Oil absorption capacity

The oil absorption capacity of the TD/FD raw jackfruit flour was also determined using centrifugation method. In pre-weighed centrifuge tubes, 1g of the freeze dried/tray dried raw jackfruit flour was taken and mixed with 10 ml of oil each. Then it was stirred for 5 minutes and held for 30 minutes. It is centrifuged for 30 mins with rpm of 3500. The separated oil is removed and the tubes are allowed to drain the excess oil. Triplicate readings were taken and the average value is noted. The oil absorption capacity was expressed as grams of oil bound per 100g of the sample on dry basis. (Mishra & Dubey, 2020) [13].

2.1.7 Water absorption capacity

The water absorption capacity of the TD/FD raw jackfruit flour was determined using centrifugation method. Approximately 1g of the dried flour was taken in centrifuge tubes as triplicates and allowed to disperse in 10ml of distilled water (each). Then it was stirred, held for 30 minutes followed by centrifugation for 30 mins at a rpm of 3500. The supernatant was decanted and the excess moisture was dried at 50°C for 30 mins and after cooling the sample weight was taken. (Mishra & Dubey, 2020) [13].

3. Results and Discussion

3.1 Color

The first parameter of quality perceived by the customer is the color. The “L”, “a” and “b” color value readings of the FD jackfruit flour and TD raw jackfruit flour were measured from the Hunter lab colorimeter and the values were as follows:

Table 1: Raw Jackfruit flour

Raw Jackfruit flour	Color Value			
	L*	a*	b*	a*/b*
Tray dried(TD)	61.53±0.04 ^b	1.74±0.04 ^a	13.54±0.03 ^b	0.12±0.02 ^a
Freeze dried(FD)	75.50±0.03 ^a	1.62±0.06 ^b	21.71±0.02 ^a	0.056±0.04 ^b

The superscript letters a and b within the column represents the significant differences among the samples (Two samples assuming unequal variance; $p < 0.05$)

From the analysis it is determined that the FD flour has lighter colour and better-quality parameters than that of TD flour. Also the FD flour has a b^* value of 21.71 which indicates the pale yellowish colour of the flour which is slightly reduced in TD flour. The L^* , a^* , b^* values obtained in this study was similar to the value mentioned for the color of 6–7-week immature jackfruit by Ranasinghe & Marapana (2019) [19]. Narpinder Singh (2005) mentioned that the freeze dried corn gluten meals had lighter colour compared to oven dried corn gluten meals. The slighter dark color of the TD flour was due to the chemical reaction occurring between the proteins and

sugar-Maillard reaction and also due to the processing temperature (Caparino *et al.*, 2012)^[3].

3.2 Bulk density

The bulk density is defined as the ratio of the mass of the flour to that of the volume occupied by it in the measuring cylinder. It was a measure of heaviness of the sample and was significant for determining material handling, packaging requirements and application in wet processing. The bulk density differs with the particle size of the flour (Ocloo, Bansa, Boatin, Adom, & Agbemavor, 2010)^[15]. The Bulk density of the FD and TD raw jackfruit flour was 0.52 and 0.56 respectively which shows that there is no much difference in bulk density between the flours dried under both the methods. Freeze dried flour had showed the lowest bulk density value as this process allows sublimation of ice leaving void spaces within the structure thereby forms the porous structured product (Koç *et al.*, 2008)^[11]. The bulk density value obtained here was lower than the values mentioned (0.61 g/ml) in the study of 'Functional Properties of Raw and Heat Processed Jackfruit (*Artocarpus heterophyllus*) Flour' by Odoemelan (2005). The other study reported that the bulk

density of raw jackfruit bulb flour was 0.96 g/cm³ which was much higher than our result value. This was due to the fact that the particle size of the flour generally affects the bulk density as there are variations in the particle sizes of the flour studied (Kumari & Divakar, 2016)^[12].

3.3 Proximate Analysis

The proximate analysis for FD as well as TD raw jackfruit flour was done and compared to determine the effect of drying conditions on the nutritional composition. From the study it was identified that both tray dried and freeze dried raw jackfruit flour have very low fat content of below 1% and also the FD flour shown high carbohydrate content than the tray dried flour.

Low fat content of the flour can help to reduce the risk of heart disease and contributes no cholesterol. Also much retention of nutrients was observed in FD raw jackfruit flour than the TD raw jackfruit flour. The nutrient loss in TD flour was due to the fact that application of heat can improve the food digestibility and the food quality but also it can cause loss of nutrients by inducing variation in biochemical and nutritional composition of the flour (Yarkwan, 2015)^[26].

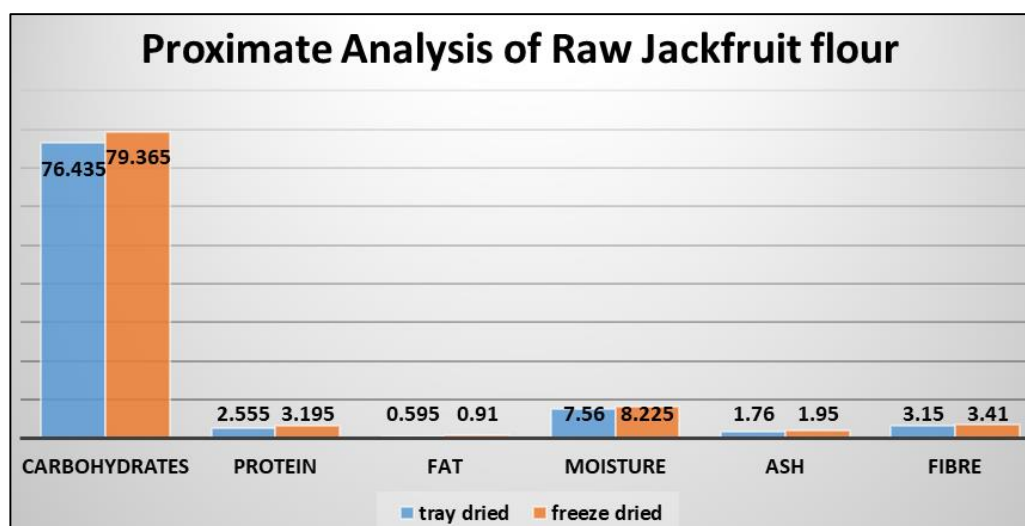


Fig 1: Proximate analysis of tray dried and freeze dried raw jackfruit flour

The carbohydrate content of TD flour was 76% and of FD flour was 79%. The crude fibre content analysed in this study for TD and FD raw jackfruit flour was about 3.15% and 3.41% which was lower than the value of 4.06g analysed by Kumari (2016)^[12] and that of 1.8 g per 100 g by Munishamanna (2012). This change in crude fibre may be associated with the variety and stage of maturity. Moisture content provides a measure of the water present in the sample and was also an index of storage stability (Kumari 2016)^[12]. The moisture content of TD and FD raw jackfruit flour obtained in this study was 7.56% and 8.2% where FD flour has higher moisture than that of TD flour. Kumari & Divakar (2016)^[12] reported that the moisture content of jackfruit bulb was 7.23% and a moisture content of 5.2% was mentioned by Munishamanna (2012). The duration of drying process plays a major role in determining the moisture content and the product was self-stable and better in quality if it has lower moisture content.

3.4 pH

pH is defined as the measurement of acidity or alkalinity of a solution measured on a scale of 0 to 14 where 7 is considered as neutral while lower pH values were considered as acidic

and higher values being alkaline (Tyl & Sadler, 2017). pH is a direct measure of acid content as it plays a major role in food processing. The pH of the FD and TD raw jackfruit flour obtained in this study was 5.38 and 5.3 respectively. The difference in pH between the flours dried under TD and FD was not shown much difference in this study. This value was slightly low as compared to the pH of the jackfruit seed flour (5.78) in the study by Roy Chowdhury, Bhattacharyya, & Chattopadhyay (2012)^[19] and that of the pH (5.70) of raw jackfruit mentioned in the study by Mondal (2013)^[14]. Tulyathan, Tananuwong, Songjinda, & Jaiboon (2002)^[23] mentioned the pH of the jackfruit flour was 5.68 which was slightly higher than the obtained value.

3.5 Water activity

Water activity (a_w) is defined as the ratio of the vapour pressure in a food to the vapour pressure of pure water. The water activity of tray dried as well as freeze dried raw jackfruit flour was analysed using water activity meter. Water activity of the food decreases when freeze dried or added with solutes. The water activity values obtained for FD and TD flour were 0.462 and 0.52 which was slightly lower compared with the water activity (0.59) of the tray dried

cassava flour in the study conducted by Kasaye Atlaw (2018)^[10]. Pui *et al* (2020)^[18] reported that the water activity of Cempedak' (*Artocarpus integer*) fruit powder was of 0.22 which was much lower than the obtained value. Other deteriorative reactions such as nonenzymatic browning, enzymatic activity lipid oxidation and microbial contamination can be prevented in a dried food with low water activity. Therefore the flour obtained was microbial safe for consumption.

3.6 Water absorption capacity

Water absorption capacity was defined as the flour – water binding ability under limited supply of water. The increase in water absorption capacity may be due to the effect of loss of moisture which may increase the hygroscopicity of milled products when exposed to moisture.(Haruna *et al.*, 2019)^[9]. The high water absorption capacity can be assured as product cohesiveness and the difference in water absorption capacity depends on the nature and level of hydrophilic constituents present in it (Ogunlakin, Oke, Babarinde, & Olatunbosun, 2012)^[16]. Here, the water absorption capacity of TD and FD

flour was 3.2ml/g and 4.1ml/g which was higher when compared with the values of WAC(2.3ml/g) given by Odoemelan (2005).Based on the capillary size, size of the pore, charge of the protein particles water absorption capacity differs. The water absorption capacity of FD flour was higher than the TD flour and this may be due to the strong correlation of hydration of protein with polar molecules along with hydrophilic interaction through the hydrogen bonding (Oladapo, Adepeju, Akinyele, & Adepeju, 2017)^[17].

3.7 Oil absorption capacity

Oil absorption capacity is also an important parameter in food product development because it imparts flavor and mouth feel to foods (Ejiofor, J., E. A., & N. I., 2014)^[6]. The oil absorption capacity of TD and FD raw jackfruit flour was 2.1ml/g and 1.8ml/g which was found to be significantly lower than the value (2.8ml/g) mentioned in the study by Odoemelan (2005).The oil absorption capacity of TD flour was higher than FD flour and it was based on the hydrophobic nature of proteins present in the flour (Oladapo *et al.*, 2017)^[17].

Table 2: Properties of Freeze dried and Tray dried raw jackfruit flour

Raw jackfruit flour	Flour properties				
	Bulk density (g/ml)	pH	Water Absorption Capacity(g/ml)	Oil Absorption Capacity(g/ml)	Water activity
Tray dried(TD)	0.56±0.03 ^b	5.3±0.01 ^a	3.2±0.02 ^a	2.1±0.03 ^b	0.52 ±0.07 ^a
Freeze dried (FD)	0.52±0.02 ^a	5.38±0.04 ^b	4.1±0.03 ^b	1.8±0.02 ^a	0.462±0.09 ^b

The superscript letters a and b within the column represents the significant differences among the samples (Two samples assuming unequal variance; $p < 0.05$)

4. Conclusion

In this study the raw jackfruit flour was dried using tray drier and freeze drier and their physicochemical properties were compared systematically. The color of the FD flour showed better acceptance in quality than the TD flour and the FD flour were more porous as compared to TD flour. The pH, bulk density values had not shown much difference for both TD and FD flour. The FD flour had shown better retention of nutrients than the TD flour. The water absorption capacity of FD flour was higher which was due to the higher carbohydrate retention than TD flour so that the raw jackfruit flour can be used in soups, dough and baked products. The oil absorption capacity of TD flour was attributed to the nature of its protein binding ability and therefore can be used in the preparation of sausages. Overall the Freeze-dried flour had better flour properties as compared to that of Tray dried raw jackfruit flour.

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