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# Effect of temperature and moisture content on the nutritional properties of African breadfruit (*Treculia africana*) seed

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## Abstract

African breadfruit seeds (*Treculia africana*) are underutilised crops at risk of extinction, found widely in the tropics and have been reported to contain all the essential nutrients for novelty in food and industrial uses. The seeds contain an array of nutrients; 12-23% crude protein, 11- 20% crude fat, 2.3% ash, 1.6% fibre and 50 - 73% carbohydrate with other essential vitamins and minerals. This research is aimed at evaluating the effect of temperature and moisture content (MC) on the nutritional properties of dehulled breadfruit seed at varied temperatures and MC to determine adequate techniques in processing breadfruit seed for best nutritional yield and further processing without adverse effect on its nutritional characteristics. A conventional oven dryer was used to dry the samples at varied temperatures and MC of 40, 50, 60 and 70°C and 15, 12, 9 and 6%, respectively. Proximate analysis was done on the dried and blended breadfruit seed samples to analyse the processing effect on the nutritional composition. Results from this study showed that temperature and MC had a significant ($P<0.05$) effect on the nutritional component of breadfruit seed as carbohydrate content ranged between 42.81 to 54.39%, whereas protein and fat content ranged between 11.46 to 16.92% and 13 to 27%, respectively. It was observed that a drying temperature of 60°C at 9% MC gave the highest carbohydrate and protein content compared to other temperature variations while a drying temperature of 50°C at an MC of 15% gave the highest fat content. Therefore, when processing breadfruit seed for maximum yield in carbohydrate and protein content, the best processing temperature and MC is 60°C and 9% whereas, for maximum fat yield, the best drying temperature is 50°C at an MC of 15%. Knowledge from the study can be applied to targeted drying for maximum yield in specific nutritional components of agricultural food produce.

## 1. Introduction

The African breadfruit tree (*Treculia africana*) is a tropical tree that belongs to the Moraceae family, with about 1000 species in the *Treculia* genus. The large and greenish flowers of the African breadfruit plant are believed to be native to a vast area from New Guinea to western Micronesia and are dominant in the tropics of west African countries like Nigeria, Ghana, and Sierra Leone (Oyetayo and Oyetayo, 2020). The tree bears large seeded fruits sought after for its edible seeds and oil. Under optimum environmental conditions, the plant species can yield up to 200 kg of dried seeds annually (Ojimelukwe and Ugwuona, 2021). It is of great socioeconomic value, contributing income and cheap additional nutrient sources, especially in Southeast Nigeria where the seed is an important natural resource. The flour of breadfruit seed extract is gluten-free, containing essential nutrients with a medium glycemic index range of 56 to 69% (Liu *et al*., 2020). Breadfruit seed contains an array of nutrients; 12-23% crude protein, 11- 20% crude fat, 2.3% ash, 1.6% fibre and 50 - 73% carbohydrate with other essential vitamins and minerals (Osabor *et al*., 2009; Shittu and Raji, 2011). The fresh seed contains about 30% MC (Akubor and Badifu, 2004), with a wide array of nutritive elements (Ca, Zn, Fe, Mg) and antinutrients (phytate, oxalate, tannin and hydrogen cyanide) which are altered during seed processing (fermentation, toasting, drying and boiling). In southeastern Nigeria, the seeds are processed by fermentation and boiled with "potash" into a popular food product known as "*ukwa*" (Ojimelukwe and Ugwuona, 2021). It is also capable of supplementing

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lysine deficient wheat protein when processed to flour, which is nutritionally adequate in making bread especially in combination with wheat (Olapade and Umeonuorah, 2014). Its high content of essential amino acids and carbohydrate commends it as a suitable replacement for wheat, corn, rice, potato, soybean and yellow pea when scarce (Liu *et al*., 2020). However, due to improper processing technique, 60 to 80% of breadfruit seed produced in Nigeria is wasted, resulting in high post-harvest losses which is a major challenge in its utilisation (Ajayi and Adebolu, 2013). This challenge, which is integrated with processing technique and ripeness levels, affects every other common agricultural food produce (Nnodim *et al.,* 2019; Adeleke *et al*., 2021; Christopher *et al.,* 2022). Consequently, only fruits for immediate needs are harvested thus reducing the opportunities for development of a large-scale international trade in breadfruit seed. Drying is a simultaneous heat and mass transfer process in which heat facilitates the evaporation of moisture from agricultural products, thereby extending its shelf life (Ojediran *et al*., 2020). This process increases the shelf life of agricultural produce by slowing down microbial growth and enzymes by reducing water activity and chemical reactions (Vega-Mercado *et al*., 2001; Zhang *et al*., 2017). According to Jayas and Ghosh (2006), this preservation technique is frequently used for agricultural produce, as it improves the shelf life by reducing the water activity It also reduces bulkiness and volume through moisture loss which eases handling and processing operations, thereby reducing the costs of packaging, handling, storage and transportation (Olalekan, 2020). According to Ayoade *et al*. (2015), using different processing operations showed significant differences in the chemical properties of breadfruit seed as protein, carbohydrate and dry matter contents in the processed sample increased, but fibre, fat and antioxidant (oxalate, phytate and tannin) contents decreased, compared to the raw sample. Also, water absorption and foaming capacities were significantly reduced in boiled and roasted samples but bulk density was higher in boiled samples than in roasted samples. Bao *et al*. (2021) reported that drying damages the surface and even the inside structures of starch granules, in the long run influencing their functional properties, such as gelatinization, retrogradation, and pasting properties. The optimum drying temperature for agricultural products should be in the range of 40 to 60°C beyond which changes in colour occur indicating a sign of decreasing quality (Sari and Lestari, 2017).

The aim of this research is to determine the effect of temperature and MC on the nutritional properties of breadfruit seed, to determine an effective technique for maximum yield in processing breadfruit seed for storage and further processing without adverse effects on its nutritional characteristics.

## 2. Materials and methods

### *2.1 Materials and equipment*

Approximately 10 kg of freshly extracted breadfruit seed was purchased from a local processor in Lagos. Foreign matters like sand, pebbles and physically damaged seed were manually removed from the seed after which the seed was steeped for 15 mins in excess water at 50 - 60°C to enable easy dehulling, the seed is de-hulled and winnowed using traditional methods described by Okwunodulu *et al.* (2019). The equipment used in this research are Genlab Oven (Model: DHG 9053), Ohaus pioneer weighing balance (Model: PA 2102), Silver crest blender (Model: SC 1589), Ceramic Trays: 415 × 370 × 345 mm, a 0.25 mm standard sieve and desiccator.

### *2.2 Drying of breadfruit seed*

The hot air oven dryer was kept running for 30 mins on zero load before introduction of the sample to achieve desirable drying conditions at a constant air speed of 1.3 m/s.

Approximately 50 g of breadfruit samples in three replicates (Figure 1) were introduced into the hot air dryer (Figure 2) at temperature variations of 40, 50, 60 and 70°C, respectively. Change in weight was recorded at a 10-minute interval. Using equation (1), the MC is determined throughout the drying process to desired MC variation of 15%, 12%, 9% and 6%, respectively. The dried sample at varied MC was blended to fine flour powder and sieved. These blended samples were packaged in airtight and properly labelled polythene sachets for proximate analysis to determine the effect of temperature and MC on the nutritional composition of breadfruit seeds.

$$MC\ wet\ basis\ (wb) = \frac{W1 - W2}{W1} \times 100 \quad (1)$$


Figure 1. Raw sample A, B, C.

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Figure 2. Sample introduction into the dryer.

*2.3 Nutritional analysis of breadfruit seed*

Standard methods of the Association of Official Analytical Collaboration (AOAC, 1984) are used to perform proximate analysis for determination of crude protein, crude fat, total ash and crude fibre contents of each sample.

*2.3.1* MC *determination*

MC was determined by heating 2.0 g of each fresh sample to a constant weight on a flat ceramic plate and placed in an oven maintained at 105±1°C. The dry matter was used in the determination of the other parameters.

*2.3.2 Crude protein determination*

Crude protein (% total nitrogen × 6.25) was determined by the Kjeldahl method, using 2.0 g samples.

*2.3.3 Crude fat determination*

Crude fat was obtained by exhaustively extracting 5.0 g of each sample in a Soxhlet apparatus using petroleum ether (boiling point range 40-60°C) as the extractant.

*2.3.4 Ash content determination*

Ash was determined by the incineration of 10.0 g samples placed in a muffle furnace maintained at 550°C for 300 mins.

*2.3.5 Crude fibre content determination*

The crude fibre was obtained by digesting 2.0 g of sample with $H_2SO_4$ and NaOH and incinerating the residue in a muffle furnace maintained at 550°C for 300 mins.

*2.3.6 Carbohydrate content determination*

Carbohydrate content was determined by difference (100% - (moisture, crude protein, crude fat, total ash and crude fibre contents). Each analysis was carried out in triplicate.

*2.4 Statistical analysis*

Using two-way ANOVA, data generated from this study was subjected to the Duncan Multiple Range Test (DMRT) to determine the main and interactive effect with least significant difference fixed at <0.05. Analysis was done using statistical software package SPSS for window version 23 (SPSS Inc., USA).

## 3. Results

At 6% MC (wb) (Figure 3), carbohydrate content was observed to vary with increase in temperature within the range of 47.91 to 52.76%. Carbohydrate content at 40°C had the highest content of 52.76% while 60°C had the lowest carbohydrate content of 47.91%. The trend from this curve shows a linear decrease in carbohydrate content with an increase in temperature from 40 - 60°C but increases slightly from 60 to 70°C.

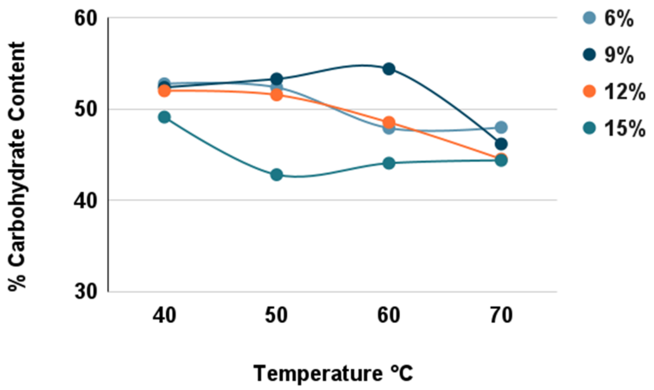


Figure 3. Curve of the carbohydrate content versus the drying temperature at a constant moisture content of 6, 9, 12 and 15%, respectively.

At 9% MC (wb) (Figure 3), carbohydrate content was observed to vary with increase in temperature within the range of 46.17 to 54.39%. Carbohydrate content at 60°C had the highest content while 70°C had the lowest carbohydrate content of 46.17%. The trend from this curve shows a linear increase in carbohydrate content from 40 - 60% but decreases at 70°C.

At 12% MC (wb) (Figure 3), carbohydrate content was observed to vary with increase in temperature within the range of 44.52 to 51.99%. Carbohydrate content at 40°C had the highest content while 70°C had the lowest carbohydrate content of 44.52%. The trend from this curve shows a linear decrease in carbohydrate content from 40 to 70°C.

At 15% MC (Figure 3), carbohydrate content was observed to vary with increase in temperature within the range of 42.81% to 49.12%. Carbohydrate content at 40°

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C had the highest content while 50°C had the lowest carbohydrate content. The trend from this curve showed a decrease in carbohydrate content from 49.12 to 42.81% as temperature increases from 40 to 50°C, but increase linearly to 42.81 at 50°C to 44.38% at 70°C.

At 6% MC (wb) (Figure 4), the variation of protein content with increase in temperature was observed within the range of 12.61 to 13.75%. Protein content at 40°C had the highest content of 13.75% while 60°C had the lowest protein content of 12.61%. This trend shows a linear decrease in protein content from 40 to 60°C and a subsequent increase at 70°C to 13.62%.

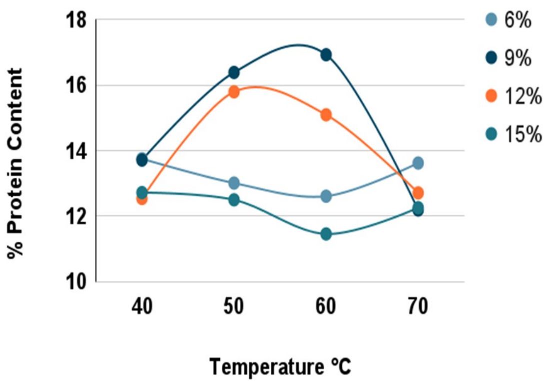


Figure 4. Curve of the protein content versus the drying temperature at a constant moisture content of 6, 9, 12 and 15%, respectively.

At 9% MC (wb) (Figure 4), the variation in protein content with increase in temperature was observed within the range of 12.19 to 16.92%. Protein content at 60°C had the highest content of 16.62% while 70°C had the lowest value of 12.19%. The trend in this curve shows a linear increase in protein content from 13.71% at 40°C to 16.38% at 50°C and 16.92% at 60°C but decreases to 12.19% at 70°C.

At 12% MC (wb) (Figure 4), the variation in protein content with an increase in temperature was observed within the range of 12.54 to 15.79%. 50°C had the highest protein content of 15.79% while 40°C had the lowest protein content at 12.54%. The trend in this curve shows an increase in protein content from 12.54% at 40°C to 15.79% at 50°C followed by a subsequent linear decrease to 15.09% at 60°C and 12.71% at 70°C.

At 15% MC (wb) (Figure 4), the variation in protein content with an increase in temperature was observed within the range of 11.46 to 12.72%. 40°C had the highest protein content of 12.72% while 60°C had the lowest content of 11.46%. The curve shows a linear decrease in protein from 12.72 at 40°C to 11.46 at 60°C and a subsequent increase to 12.26% at 70°C.

At 6% MC (wb) (Figure 5), the variation of fat content was observed within the range of 16.50 to 21.50%. Fat content at 50°C had the highest fat content of 21.50% while 70°C had the lowest fat content of 16.50%. The trend from this curve shows an insignificant increase in fat content from 21.33% at 40°C to 21.50% at 50°C, followed by a decrease to 20.33% at 60°C and 16.50% at 70°C.

At 9% MC (wb) (Figure 5), the variation in fat content was observed within the range of 13.00% to 23.50%. Fat content at 40°C had the highest fat content of 23.50% while 60°C had the lowest fat content of 13.00%. The trend from this curve shows a linear decrease in fat content from 21.33% at 40°C to 18.17% at 50°C and 13.00% at 60°C, followed by a subsequent increase to 20.83% at 70°C.

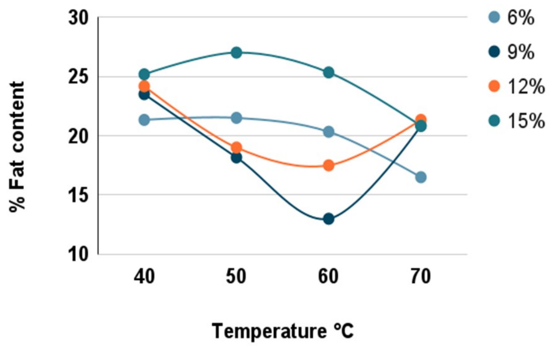


Figure 5. Curve of the fat content versus drying temperature at a constant moisture content of 6, 9, 12 and 15%, respectively.

At 12% MC (wb) (Figure 5), the variation in fat content with an increase in temperature was observed to range between 17.50 to 24.17%. 40°C had the highest fat content of 24.17% while 60°C had the lowest fat content of 17.50%. The trend from this curve shows a decrease in fat content from 24.17% at 40°C to 19.00% at 50°C and 17.50% at 60°C, followed by an increase in fat content to 21.33% at 70°C.

At 15% MC (wb) (Figure 5), the variation in fat content with an increase in temperature was observed within the range of 20.83 to 27.00%. 50°C had the highest fat content of 27.00% while 70°C had the lowest fat content of 20.83%. The trend from this curve shows an increase in fat content from 25.17% at 40°C to 27% at 50°C and a subsequent decrease in fat content to 25.33% at 60°C, followed by an decrease to 20.83 at 70°C.

At 40°C drying temperature (Figure 6), the variation of carbohydrate content with increase in MC was observed within the range of 49.12 to 52.78%. MC at 9% had the highest carbohydrate content of 52.78% while MC at 15% had the lowest carbohydrate content of 49.12%. As MC increases from 6 to 9%, there is a slight increase in carbohydrate content though insignificant from 52.76 to 52.78%, followed by a subsequent decrease in carbohydrate content from 52.78 to 49.12% as MC increases from 9 to 15%.

At 50°C drying temperature (Figure 6), the variation of carbohydrate content with increase in MC was observed within the range of 42.81 to 53.29%. MC at 9% had the highest carbohydrate content of 53.29% while 15% moisture had the lowest carbohydrate content 42.81%. The trend from this curve shows an increase in carbohydrate content from 52.37 to 53.29% as the MC increases from 6% to 9% and a subsequent decrease from 53.29 to 42.81% as the moisture increases from 9 to 15%.

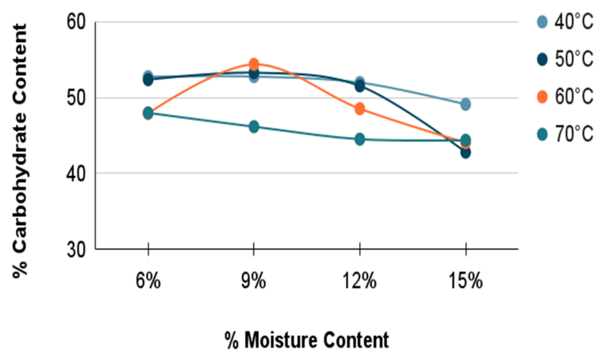


Figure 6. Curve of the carbohydrate content versus the moisture content at constant temperature of 40, 50, 60 and 70°C, respectively.

At 60°C drying temperature (Figure 6), the variation in carbohydrate content with increase in MC was observed within the range of 44.07 to 54.39%. MC at 9% had the highest carbohydrate content of 54.39% while MC of 15% had the lowest carbohydrate content of 44.07%. The trend from this curve shows an increase in carbohydrate content from 47.91% at 6% MC to 54.39% at 9% followed by a subsequent decrease to 44.07 at 15%.

At 70°C drying temperature (Figure 6), the variation in carbohydrate content with increase in MC was observed within the range of 44.38 to 47.99%. MC at 6% had the highest carbohydrate content of 47.99% while 15% had the lowest carbohydrate content of 44.38%. The trend from this curve shows a linear decrease in carbohydrate content as the MC increases from 6 to 15%.

At 40°C (Figure 7), the variation in protein content with increase in moisture was observed within the range of 12.54 to 13.75%. MC at 6% had the highest protein content of 13.75% while MC at 12% had the lowest protein content of 12.54%. The trend from this curve shows a linear decrease in protein content from 13.75% at MC of 6% to 12.54 at 12% MC, followed by a significant increase to 12.72% at 15% MC.

At 50°C (Figure 7), the variation in protein content with increase in MC was observed within the range of 12.50 to 16.38%. MC at 9% had the highest protein content of 16.38% while MC at 15% had the lowest protein content of 12.50%. The trend from this curve shows an increase in protein content from 13.01% at 6% MC to 16.38% at 9% MC, followed by a subsequent linear decrease to 15.79% at 12% MC and 12.50% at 15% MC.

At 60°C (Figure 7), the variation in protein content with increase in temperature was observed within the range of 11.46 to 16.92%. MC at 9% had the highest protein content of 16.92% while MC of 15% had the lowest protein content of 11.46%. The trend from this curve shows an increase in protein from 12.61% at MC of 6% to 16.92% at 9% followed by a linear decrease to 15.09% at 12% MC and 11.46% at 15% MC.

At 70°C (Figure 7), the variation in protein content with increase in temperature was observed within the range of 12.19 to 13.62%. MC at 6% had the highest protein content of 13.62% while MC of 9% had the lowest protein content of 12.71%. The trend from this curve shows a decrease in protein content from 13.62% at 6% MC to 12.19% at MC of 9%, followed by a subsequent increase in protein content to 12.71% at 12% MC and a decrease to 12.26% at 15% MC.

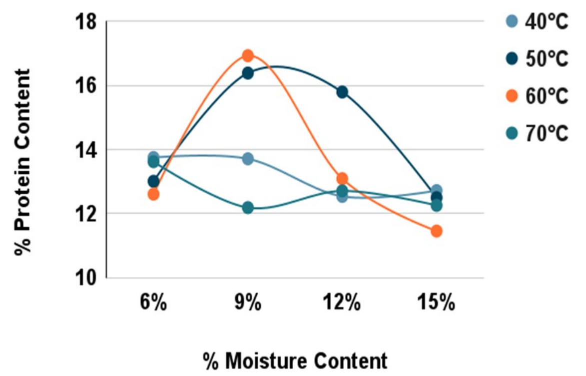


Figure 7. Curve of the protein content versus the moisture content at constant temperature of 40, 50, 60 and 70°C, respectively.

At 40°C (Figure 8), the variation in fat content with increase in MC was observed within the range of 21.33 to 25.17%. MC of 15% had the highest fat content of 25.17% while 6% had the lowest fat content of 21.33%. The trend from this curve shows a linear increase in fat from 21.33% at 6% MC to 23.50% at MC of 9% followed by subsequent increase in fat content to 24.17% at MC of 12% and 25.17% at MC of 15%.

At 50°C (Figure 8), the variation in fat content with increase in MC was observed within the range of 18.17 to 27.00%. MC at 15% had the highest fat content of 27.00% while MC of 9% had the lowest fat content of

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18.17%. The trend from this curve shows a decrease in fat content from 21.50% at 6% to 18.17% at MC of 9% followed by an increase to 19.00% at 12% MC and 27% at MC of 15%.

At 60°C (Figure 8), the variation of fat content with increase in MC was observed within the range of 13 to 25.33%. MC at 15% had the highest fat content of 25.00% while MC at 9% had the lowest fat content of 13.00%. The trend from this curve shows a decrease in fat content from 20.33% at 6% MC to 13.00% fat content at 9% MC, and a subsequent increase in fat content to 17.50% at 12% MC and 25.33% at 15% MC.

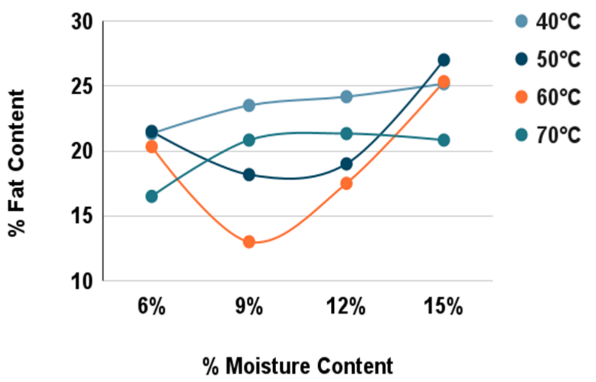


Figure 8. Curve of the fat content versus the moisture content at constant temperature of 40, 50, 60 and 70°C, respectively.

At 70°C (Figure 8) the variation in fat content with increase in MC was observed within the range of 16.50 to 21.33%. MC at 12% had the highest fat content of 21.33% while 6% MC had the lowest fat content of 16.50%. The trend in this curve shows an increase in fat content from 16.50% at 6% MC to 20.83% at 9% and 21.33% at 12% MC indicating an increase in fat content as MC increases from 16.50% at a MC of 6% followed by a subsequent decrease to 20.83% at 15% MC.

## 4. Discussion

### *4.1 Effect of temperature and moisture on the carbohydrate content of breadfruit seed*

The effect of temperature and MC on the carbohydrate content in this study (Table 1) is comparable with that of other researchers (50-72%) for breadfruit seed (Omobuwajo *et al*.,1999; Nwokocha and Ugbomoiko, 2008). This effect of temperature on carbohydrate content was observed to decrease with increase in temperature which could be as a result of gelatinization of the starch molecular arrangement, resulting in leaching of some starch monomers, primarily amylose (Zavareze and Dias, 2011). While the increase in carbohydrate content with temperature was as a result of the concentration increase in starch as MC decreases due to a higher drying rate compared to gelatinization rate, which increased the carbohydrate content with temperature. This increase in carbohydrate content with decrease in MC could be due to the concentration of carbohydrate content above 45% which according to Li *et al*. (2015) and Kong *et al*. (2018), prevents the gelatinization of starch molecules, resulting in greater

Table 1. Proximate composition of processed African breadfruit seed.

| Temperature | %Moisture | %Carbohydrate | %Protein | %Fat | %Fibre | %Ash |
|---|---|---|---|---|---|---|
| 40°C | 6 | 52.76±0.30$^{gh}$ | 13.75±0.07$^{f}$ | 21.33±0.29$^{h}$ | 5.18±0.83$^{g}$ | 1.00$^{ab}$ |
| | 9 | 52.78±0.23$^{gh}$ | 13.71±0.56$^{f}$ | 23.50$^{i}$ | 2.84±0.04$^{b}$ | 1.17±0.29 |
| | 12 | 51.99±0.08$^{fg}$ | 12.54±0.16$^{d}$ | 24.17±0.29$^{j}$ | 4.14±0.14$^{g}$ | 1.17±0.29$^{ab}$ |
| | 15 | 49.12±0.85$^{e}$ | 12.72±0.13$^{d}$ | 25.17±0.29$^{h}$ | 5.83±0.04$^{hi}$ | 0.83±0.29$^{a}$ |
| 50°C | 6 | 52.37±0.05$^{fgh}$ | 13.01±0.03$^{e}$ | 21.50$^{h}$ | 3.12±0.02$^{c}$ | 1.00$^{ab}$ |
| | 9 | 53.29±0.22$^{h}$ | 16.38±0.06$^{i}$ | 18.17±0.29$^{d}$ | 2.16±0.03$^{a}$ | 1.33±0.29$^{b}$ |
| | 12 | 51.55±0.29$^{f}$ | 15.79±0.01$^{h}$ | 19.00$^{e}$ | 3.32±0.03$^{d}$ | 1.33±0.29$^{b}$ |
| | 15 | 42.81±0.32$^{a}$ | 12.50±0.06$^{ed}$ | 27.00$^{i}$ | 7.52±0.42$^{k}$ | 0.83±0.29$^{a}$ |
| 60°C | 6 | 47.91±1.51$^{d}$ | 12.61±0.22$^{d}$ | 20.33±0.29$^{f}$ | 5.26±0.03$^{g}$ | 1.00$^{ab}$ |
| | 9 | 54.39±0.28$^{i}$ | 16.92±0.04$^{j}$ | 13.00±0.50$^{a}$ | 3.36±0.01$^{d}$ | 1.00$^{ab}$ |
| | 12 | 48.54±0.50$^{de}$ | 15.09±0.04$^{g}$ | 17.50±0.50$^{c}$ | 5.87±0.03$^{hij}$ | 1.00$^{ab}$ |
| | 15 | 44.07±0.46$^{b}$ | 11.46±0.04$^{a}$ | 25.33±0.29$^{k}$ | 5.97±0.03$^{ij}$ | 1.17±0.29$^{ab}$ |
| 70°C | 6 | 47.99±0.35$^{d}$ | 13.62±0.03$^{f}$ | 16.50$^{b}$ | 6.06±0.08$^{j}$ | 0.83±0.29$^{a}$ |
| | 9 | 46.17±0.37$^{c}$ | 12.19±0.06$^{b}$ | 20.83±0.29$^{h}$ | 4.81±0.03$^{f}$ | 1.00$^{ab}$ |
| | 12 | 44.52±0.52$^{b}$ | 12.71±0.03$^{d}$ | 21.33±0.29$^{h}$ | 5.27±0.02$^{g}$ | 1.17±0.29$^{ab}$ |
| | 15 | 44.38±0.55$^{b}$ | 12.26±0.01$^{bc}$ | 20.83±0.29$^{h}$ | 5.69±0.02$^{h}$ | 0.83±0.29$^{a}$ |

Proximate composition of breadfruit seed at varying temperature (40, 40, 60 and 70°C) and moisture content (6,9,12 and 15%). Values are presented as mean±SD. Values with different superscripts within the same column are statistically significantly different (P<0.05).

 

starch crystallinity retention after heat treatment.

*4.2 Effect of temperature and moisture on the protein content of breadfruit seed*

The effect of temperature and MC on the protein content in this study (Table 1) is within the range to that of other researchers on breadfruit seed (12.5-23%) (Adindu *et al*., 2003; Osabor *et al*., 2009; Ojimelukwe and Ugwuona, 2021). This decrease in protein content with an increase in temperature conforms with work by other researchers (Raji and Famurewa, 2008; Famurewa and Raji, 2011), due to the denaturation of protein intermolecular bonds found in the secondary, tertiary and quaternary structure, causing the protein to unfold and become inactive. While the increase in protein content with increase in temperature could be as a result of increase in concentration of protein with decrease in MC due to high drying rate (Suryana *et al*., 2022).

*4.3 Effect of temperature and moisture on the fat content of breadfruit seed*

The fat content range of 13-27% in this study (Table 1) is comparable to 17-20% (Shittu and Raji, 2011) for breadfruit seed. The decrease in fat content with increase in temperature was as a result of thermal degradation of fat to fatty acid which increases as the temperature increases, thereby reducing the fat content (Shin *et al*., 2011). Also, as a result of increased drying rate of MC with increase in temperature, the concentration of fat increased thereby, increasing the fat content. Also as seen in Figure 8, the increase in fat content with an increase in MC may be a result of oxidation and hydrolysis by the lipase enzyme which reduces the amount of unsaturated fatty acid, leading to an increase in fat content (Orhevba *et al*., 2013).

## 5. Conclusion

This study determined the effect of temperature and MC on the nutritional properties as well as established an effective process of drying breadfruit seed for maximum nutritional yield. From this study, processing of breadfruit seed using conventional hot air oven dryer, the following conclusion were drawn: the drying temperature of 60°C at 9% MC gave the highest carbohydrate and protein content compared to other temperature and moisture variation while drying temperature of 50°C at a MC of 15% gave the highest fat content. Therefore, processing breadfruit seed for maximum yield in carbohydrate and protein content, the best processing temperature is 60°C and at 9% MC whereas, for maximum fat content yield, drying temperature 50°C and MC of 15%.

knowledge from the study can be applied to targeted drying for best yield of specific nutritional components in food processing. Also, data generated from this research work could serve as baseline information for future work.

## Conflict of interest

The authors declare no conflict of interest.


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## References


Adeleke, A.A., Ikubanni, P.P., Orhadahwe, T.A., Christopher, C.T., Akano, J.M., Agboola, O.O., Adegoke, S.O., Balogun, A.O. and Ibikunle R.A. (2021). Sustainability of Multifaceted Usage of Biomass: A Review. *Heliyon,* 7, e08025. https://doi.org/10.1016/j.heliyon.2021.e08025.

Adindu, M.N., Williams, J.O. and Adiele, E. (2003). Effect of Storage on Dehydrated African Breadfruit Seeds (*Treculia africana Decne*). *Plant Foods for Human Nutrition,* 58, 9. https://doi.org/10.1023/B:QUAL.0000041155.83351.f2

Ajayi, O.B. and Adebolu, T.T. (2013). Microbial Contribution to spoilage of African Breadfruit (*Artocarpus communis, Forst*) during Storage. *Food Science and Nutrition,* 1(3), 235-240. https://doi.org/10.1002/fsn3.28

Akubor, P.I. and Badifu, G.I. (2004). Chemical Composition, Functional Properties and Baking of Food. *Science and Technology,* 39(2), 223-229. https://doi.org/10.1046/j.0950-5423.2003.00768.x

Association of Official Analytical Collaboration (AOAC). (1984). Official methods of analysis. 14$^{th}$ ed. Arlington, USA: AOAC.

Ayoade, G., Aderibigbe, A. and Amoo, I. (2015). Effects of Different Processing Operations on Chemical Composition and Functional Properties of African Breadfruit (*Treculia africana*) seed. *American Journal for Food Science and Nutrition Research,* 2, 180-185.

Bao, H., Zhou, J., Yu, J. and Wang, S. (2021). Effect of Drying Methods on Properties of Potato Flour and Noodles Made with Potato Flour. *Foods*, 10(5), 1115. https://doi.org/10.3390/foods10051115


 

Christopher, C.T., Fath Elbab, A.M.R., Osueke, C.O., Ikua, B.W., Sila, D.N. and Fouly, A. (2022). A piezoresistive dual-tip stiffness tactile sensor for mango ripeness assessment. *Cogent Engineering,* 9 (1), 2030098. https://doi.org/10.1080/23311916.2022.2030098

Famurewa, J.A.V. and Raji, A.O. (2011). Effect of Drying Methods on the Physico-chemical Properties of Soy Flour. *African Journal of Biotechnology,* 10 (25), 5015-5019.

Kong, H., Yang, X., Gu, Z., Li, Z., Cheng, L., Hong, Y. and Li, C. (2018). Heat Pretreatment Improves the Enzymatic Hydrolysis of Granular Corn Starch at High Concentration. *Process Biochemistry,* 64, 193-199. https://doi.org/10.1016/j.procbio.2017.09.021

Jayas, D.S. and Ghosh, P.K. (2006). Preserving quality during grain drying and techniques for measuring grain quality, presented at the 9th International Working Conference on Stored Product Protection, 15-18 October, p. 969-980. Sao Paulo, Brazil.

Li, Z., Liu, W., Gu, Z., Li, C., Hong, Y. and Cheng, L. (2015). The effect of starch concentration on the gelatinization and liquefaction of corn starch. *Food Hydrocolloids*, 48, 189-196. https://doi.org/10.1016/j.foodhyd.2015.02.030

Liu, Y., Brown, P.N., Ragone, D., Gibson, D.L. and Murch, S.J. (2020). Breadfruit flour is a Healthy Option for Modern Foods and Food security. *PloS ONE,* 15(7), e0236300. https://doi.org/10.1371/journal.pone.0236300

Nnodim, C.T., Fath EL-Bab, A.M.R., Ikua, B.W. and Sila D.N. (2019). Design and Simulation of a Tactile sensor for Fruit Ripeness Detection, presented at The World Congress on Engineering and Computer Science*,* 22-24 October, p. 390-395. San Francisco, USA.

Nwokocha, L.M. and Ugbomoiko, J.O. (2008). Effect of parboiling on the composition and physicochemical properties of *Treculia africana* seed flours. *Pakistan Journal of Nutrition*, 7(2), 317-320. https://doi.org/10.3923/pjn.2008.317.320

Ojediran, J.O., Okonkwo, C.E., Adeyi, A.J., Adeyi, O., Olaniran, A.F., George, N.E. and Olayanju, A.T. (2020). Drying characteristics of yam slices (*Dioscorea rotundata*) in a convective hot air dryer: Application of ANFIS in the prediction of drying kinetics. *Heliyon*, 6(3), e03555. https://doi.org/10.1016/j.heliyon.2020.e03555

Ojimelukwe, P.C. and Ugwuona, F.U. (2021). The traditional and medicinal use of African breadfruit (*Treculia africana Decne*): an underutilised ethnic food of the Ibo tribe of South East, Nigeria. *Journal of Ethnic Foods,* 8, 21. https://doi.org/10.1186/s42779-021-00097-1

Okwunodulu, I.N., Mmeregini, I.P. and Nwabueze, T.U. (2019). Phytochemical and antinutrient contents of toasted African breadfruit seeds (*Treculia africana*) as influenced by dehulling. *Nigerian Food Journal,* 37(1), 53-60. https://doi.org/10.9734/afsj/2019/v9i230009

Olalekan, A.S.A. (2020). Banana Drying Kinetics. In Jideani, A.I.O. and Anyasi. T.A. (Eds.), Banana Nutrition - Function and Processing Kinetics. IntechOpen E-Book. https://doi.org/10.5772/intechopen.84669

Olapade, A.A. and Umeonuorah, U.C. (2014). Chemical and sensory evaluation of African Breadfruit (*Treculia africana*) seeds processed with alum and trona. *Nigerian Food Journal,* 32(1), 80-88. https://doi.org/10.1016/S0189-7241(15)30099-0

Omobuwajo, T.O., Akande, E.A. and Sanni, L.A. (1999). Selected physical, mechanical and aerodynamic properties of African breadfruit (*Treculia africana*) seeds. *Journal of Food Engineering,* 40(4), 241-244. https://doi.org/10.1016/S0260-8774(99)00060-6

Orhevba, B.A., Chukwu, O., Oguagwu, V. and Osunde, Z.D. (2013). Effect of Moisture Content on Some Quality Parameters of Mechanically Expressed Neem Seed Kernel Oil. *International Journal of Engineering and Science,* 2(8), 1-7.

Osabor, V.N., Ogar, D.A., Okafor, P.C. and Egbung, G.E. (2009). Profile of the African Breadfruit (*Treculia africana*). *Pakistan Journal of Nutrition*, 8 (7), 1005-1008. https://doi.org/10.3923/pjn.2009.1005.1008

Oyetayo, F.L. and Oyetayo, V.O. (2020). The African Breadfruit (*Treculia africana*) Decne Plant Seed: A Potential Source of Essential Food and Medicinal Phytoconstituents. In Preedy, V.R. and Watson, R.R. (Eds.) Nuts and Seeds in Health and Disease Prevention. 2nd ed., p. 45-50. USA: Academic Press. https://doi.org/10.1016/B978-0-12-818553-7.00004-8

Raji, A.O. and Famurewa, J.A.V. (2008). Effect of Hull on the Physico-Chemical Properties of Soy Flour. *Agricultural Engineering International: the CIGR Ejournal,* 10, FP 07018.

Sari, D.K. and Lestari, R.S.D. (2017). The Production of Breadfruit Flour: Effect of Heater Temperature to the Drying rate and time of the Breadfruit. *Journal*

 

*Bahan Alam Terbarukan,* 6(1), 20-24. https://doi.org/10.15294/jbat.v6i1.7168

Shin, H.Y., Lim, S.M., Bae, S.Y. and Oh, S.C. (2011). Thermal Decomposition and Stability of Fatty Acid Methyl Esters in Supercritical Methanol. *Journal of Analytical and Applied Pyrolysis,* 92(2), 332-338. https://doi.org/10.1016/j.jaap.2011.07.003

Shittu, T.A. and Raji, A.O. (2011). Thin Layer Drying of African Breadfruit (*Treculia africana*): Modelling and Rehydration Capacity. *Food and Bioprocess Technology,* 4(2), 224-231. https://doi.org/10.1007/s11947-008-0161-z

Suryana, A.L., Rosiana, N.M. and Olivia, Z. (2022). Effect of drying method on chemical properties of local soy flour. *IOP Conference Series: Earth and Environmental Science,* 980, 012030. https://doi.org/10.1088/1755-1315/980/1/012030

Vega-Mercado, H., Góngora-Nieto, M.M. and Barbosa-Cánovas, G.V. (2001). Advances in Foods. *Journal of Food Engineering,* 49(4), 271-289. https://doi.org/10.1016/S0260-8774(00)00224-7

Zavareze, E.D.R. and Dias, A.R.G. (2011). Impact of Heat-moisture Treatment and Annealing in Starches: A review. *Carbohydrate Polymers*, 83(2), 317-328. https://doi.org/10.1016/j.carbpol.2010.08.064

Zhang, M., Ma, L., Bhandari, B. and Gao, Z. (2017). Recent Developments in Novel Shelf Life Extension Technologies of Fresh-cut fruits and Vegetables. *Trends in Food Science and Technology,* 64, 23-38. https://doi.org/10.1016/j.tifs.2017.03.005

 