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Influence of Drying Temperature on Nutritional and Bioactive Compounds of (*Blighia sapida*) Ackee Apple Seeds

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Abstract

Blighia sapida apple seed is among one of the wasted and under-utilized seeds in Nigeria. Which have been highly utilized as an ornamental tree with non-commercially purpose? The research was aimed to evaluate the effect of different drying temperatures on nutritional and bioactive constituent's ackee apple seed. Freshly harvested ackee apple seed with a moisture content of approximately 45% (w.b.), the seeds were dried at different temperatures (40, 50, 60, 70°C and sun drying) until reaching moisture content of less than 11.00 ± 0.7% (w.b.), and they were subsequently analysis for proximate and bioactive constituents (flavonoid, phenolic and vitamin c) using standard method. Nutritional value of ackee seeds at drying temperatures exceeding 50°C results in reduction for the nutritive parameters and bioactive constituents. Dried ackee seed can have a longer shelf-life, produce diversity, and remarkable reduction in volume. In addition, due to its high-quality dried products that retain nutritional and the presence of bioactive compounds (flavonoids, phenolic and vitamin c) which could be a mean of generating another source of raw material for food, pharmaceutical industries and reduces wastage of these seeds during their season.

Keywords: Ackee Apple Seeds; Flavonoids; Phenolic; Vitamin C; Nutritional Parameters

Introduction

It was on diachronic record that human beings have seen the need to store seeds in order to preserve planting stocks and availability during off season. With recent conception, humans had broadened knowledge about the demands and strategies for keeping up viable seeds during storage. Essentially, seeds constitute an embryo, food store known as endosperm or cotyledons and an outer protective shell called seed coat or accessory structures. The seeds are influenced more significantly by the seed coat and hilum, which enable moisture to enter or exit the seed. Thus, a suitable drying is essential for seeds in order to maintain its physical and bioactive constituents.

Blighia sapida of the family Sapindacea is one of natural trees which have been highly utilized for for non-commercially important, but it is an ornamental tree, especially when decorated with the brightly coloured fruits It belongs to sub kingdom; tracheoblonta; rosidae, order; saphindales, family Sapindacea and genus; Blighia. Its bionomical name is *Blighia sapida*, the French name are aki and arbe fricassee. It is also considered useful for planting to improve soil fertility and to reduce erosion through its large rooting system.

Post-harvest technologies comprise of an inter-disciplinary science and skills applied to agricultural commodities as post-harvest for the purport of preservation, conservation, quality control/enhancement, processing, post processing (packaging and handling) and utilization to meet the food and nutritional requirements of the populace in relation to their needs. The research is on the study of drying as a means of preserving the seeds and the need to analyse effects of drying on nutritive and phytochemical properties of ackee apple seeds which will enhance post-harvest technologies and handling. Drying is the mechanism of removal of water from hygroscopic materials moisture contents by means of hot air.

The main purpose of drying agricultural products is to reduce their water content for minimizing microbial spoilage and deterioration reaction during storage. Drying fruits and vegetables preserves them and ensures that they retain all of their nutritional goodness. A lot of the food that small-scale farmers grow can go to waste in the market because of surpluses at harvest time.

Oven drying may be a an effective method for drying and preserving phytochemicals, in that it can be concluded in a shorter time and closely monitored conditions than the other drying methods [1]. The thermal processing can cause the breakdown in phytochemicals by thermal that affect the integrity of the cell structure which then results in the movement of components, leading to losses by escape or breakdown by various chemical reactions involving enzymes, light and oxygen [2]. The availability of the ackee seed and quick disintegration of the seed which is accessible for a brief period. Scarce record of its wide ranges of medicinal and health makes it to be term as a waste product.

Materials and Methods

Source of Raw Materials

The ackee fruits were randomly collected from trees in Ijare via Akure in Ondo State, Nigeria and classified into two stages of maturity (matured ripe and matured unripe) according to the scale described by Bowen Forbes CS, et al. [3]. The fruits were selected according to their appearance, discarding ruised or rotten fruit. Fresh ripe Ackee fruits apple were harvested using a sickle. The Ackee apple seeds were sorted manually to remove unmatured and infected ackee seeds.

Preparation of Sun and Oven Dried

The experiment was conducted at the Food Processing Laboratory, Federal University of Technology, Akure. All experiments were performed in triplicates. A portion of the ackee seeds was dried in the sun (30±2°C) until constant weight was attained. The second portion of the ackee seeds was dried in hot air laboratory oven (TT-9083; Gallenkamp Devices, UK) at temperatures 40, 50, 60 and 70°C with constant air velocity of 1.4 m/s^2. The weights of the samples were taken at an interval of 60 minutes until a constant weight was obtained.

Analytical Methods

Determination of the Chemical Composition: Proximate composition of the ackee seed was measured according to the standard AOAC methods [4]. Crude protein was determined using a Foss Tecator Kjeltec 2300 Nitrogen/Protein Analyzer. Fat was determined by Soxhlet extraction of the dry sample, using petroleum ether. Ash content was determined by dry ashing samples in a muffle furnace at 550°C for 24 hr, crude fibre was determined by acid and alkali hydrolysis, and moisture content was determined by the oven dry method.

Determination of Bioactive Composition

a. Determination of Flavonoids Content

Total flavonoid was determined using the method described by Mudoi I, et al. [5]. The sample extract (10 µl) was loaded into the tube. The solution of methanol (100%, 40 µl), distilled water (400 µl) and NaNO2 (5%, 30 µl) were added, and the tube was incubated (24°C, 5 minutes) then added AlCl3 (10%, 30 µl) and re-incubated (24°C, 5 minutes). After the incubation, NaOH (1 N, 200 µl) and distilled water (240 µl) was added. Absorbance was measured at 415 nm using UV-Spectrophotometer (U-2900, Hitachi, Japan), and the total flavonoid was calculated in quercetin equivalent (mg QE g^{-1}) against the quercetin standard curve.

b. Vitamin c

The nutrient compositions and Ascorbic acid of the samples was analyzed using standard method of AOAC [6].

c. Total Phenolic Content

i. The total phenolic was determined by Taga MS, et al. [7] method. Sample extract (5 µl) was put into a tube. Solutions of Folin-Ciocalteu (50%, 50 µl), and methanol (100%, 45 µl) were added, and the tube was incubated (24°C, 30 minutes). Absorbance was measured at 750 nm using UV-Spectrophotometer (U-2900, Hitachi, Japan), and the total phenolic was calculated in gallic acid equivalent (mg GAE g^{-1}) against the gallic acid standard curve. The analyses were done in triplicates. The antioxidant activity was expressed as mg of gallic acid equivalents (GAE) per grams of extract.

Results and Discussion

In this study, thin-layer drying characteristics of ackee seeds were conducted using air forced conventional dryer

and open sun drying. The drying air temperature were changing from 40°C to 70°C in steps of 10°C similar range of temperature interval was used for egg plants as reported by Doymaz I, et al. [8]. Dying acts as a very good method of food and nutrient preservation, as well as a way of increasing value and ultimately profits. The ackee seed being hydroscopic in nature, effects of the drying quality were evaluated based on the nutritional and bioactive compounds in the dried ackee seeds. Oscillations of moisture contents were observed in the open sun-dried sample of ackee seed due to lack of control of temperature, relative humidity and air velocity in the atmosphere.

Effect of Drying Temperature on Ackee Seeds

Temperature is one of the main important factors during the drying process, as it can affect both the physical and quality of bioproducts. Ambient temperature during drying was 28-32°C (mean 30°C). The time taken for the leaves to attain constant weight was 19, 22, 28, 33 and 39 h for oven at 70°C, 60°C, 50°C, 40°C and open sun drying, respectively. The drying temperature was a significant factor in drying operation as it determines the drying time and the drying rate, an increase in hot air temperature or velocity, can reduce the drying time of various agricultural products. The drying time decrease with increase in air temperature. The highest drying time was reported for open sun drying and the least with air temperature of 70°C.

Nutritional Quality

Proximate analysis was carried out to evaluate the nutritional value of ackee seeds for both oven and sun drying methods. The nutritional result was shown in Figure 1.

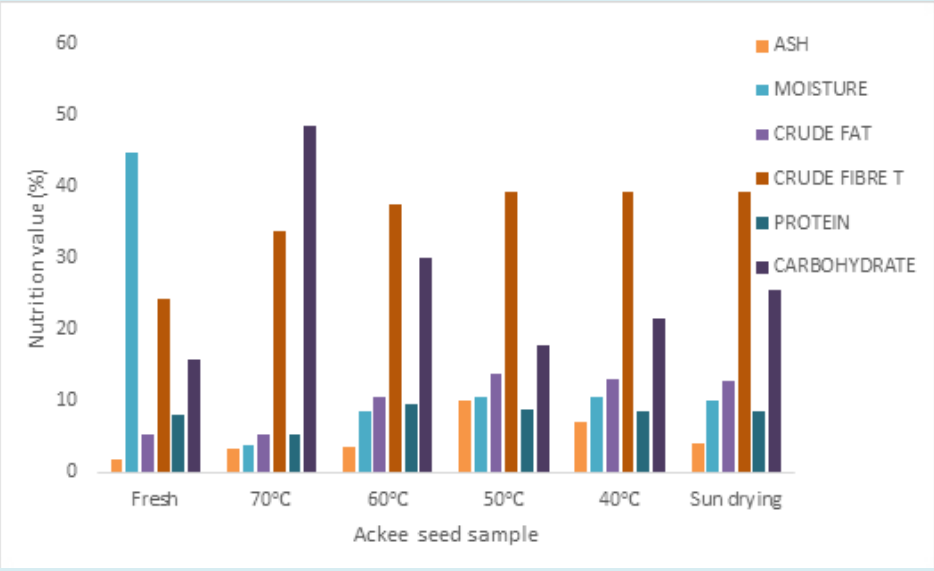

Figure 1: Nutritional quality of fresh and dried Ackee apple seeds.

a) Moisture Content: Moisture content of the samples was determining using oven method. The initial moisture content of 44.85% was recorded for fresh sample of Ackee seeds. The result of moisture content of ackee seeds were 3.865%, 8.613%, 10.039%,10.423% and 10.982% for oven drying at 70°C, 60°C, 50°C, 40°C and sun drying respectively. The moisture content of Ackee seed of 44.85% were reduced to moisture content less than 11% in the dried samples. The reductions in moisture content reduce their water content which also result in minimizing microbial spoilage and deterioration reaction during storage. Moisture removal by hot air broadly meliorates the digestibility of foods, increase concentration of nutrients and make some bioactive compounds available [9]. The observed increase or decrease in the nutrient and bioactive compounds of ackee seeds can be altered by heat during processing due to the decrease in the water molecules of the seeds. Dried ackee seeds were reducing in volume similar to kiwifruits as reported by Maskan M, et al. [10].

b) Carbohydrate: Carbohydrate was determined by percentage difference. The increase of hot air applied to the oven drying method was found to be commensurate with an increase in carbohydrate content of the ackee seed. There is increase in carbohydrate value for all the drying experiment. The drier samples had higher value of carbohydrate than the fresh ackee seeds. The highest carbohydrate value was recorded with 70°C and least

value from the fresh ackee seeds. Oven and sun drying significantly increased the carbohydrate value from 18.184 to 48.504 and 25.486 respectively.

c) **Fibre Content:** The result of crude fibre content of ackee seeds were 33.781%, 37.653%, 39.311%, 39.286% and 39.280% for oven drying at 70°C, 60°C, 50°C, 40°C and sun drying respectively. Oven and sun drying significantly increased the fibre value from 33.781 to 39.311 and 39.280, respectively. The highest fibre value was recorded with 50°C and least value from the fresh ackee seeds. Drying increase the fibre content of ackee seed, a higher value above 33.781% was recorded for dried samples and fresh sample had value of 24.368%. It was observed that all the dried ackee seed showed an increase in the fibre content. The intensity of hot air applied to the oven drying method was found to be commensurate with the decrease in fibre content of the ackee seed. Dietary fiber intake has been linked to the prevention and management of many diseases as reported by Weinstein JS, et al. [11]. Fontanari, et al. [12] recorded the value of 67.00g/100g for total dietary fibre for guava seed powder and also recommended that it could be used in formulating products formulated to prevent diseases, especially those related to the gastrointestinal tract and the cardiovascular system due to the fibre content value.

d) **Protein Content:** The result of crude fibre content of ackee seeds were 5.296%, 9.488%, 8.711%, 8.624% and 8.495% for oven drying at 70°C, 60°C, 50°C, 40 °C and sun drying respectively. The intensity of hot air applied due to efficiency of the dryers was found to be commensurate with the decrease in protein content at drying temperature at 70°C. The result reported increase in protein content except for highest temperature which showed a decrease in protein. It is clear from this work that macronutrients such as protein value increases when dried under medium heat.

e) **Ash Content:** The result of ash content of ackee seeds were 3.160%, 3.592%, 9.924%, 7.082% and 3.966% for oven drying at 70°C, 60°C, 50°C, 40°C and sun drying respectively. Ash content was increased in all the drying methods compared to fresh sample. Oven and sun drying significantly increase ash value from 9.9821 to 3.160 and 3.966, respectively. The ash content indicates mineral elemental composition of the sample [13]. The highest ash content value of 9.924% was recorded by 50°C and least value of 3.160% by 70°C. The result showed that 50°C had the highest mineral element.

f) **Fat Content:** The result of fat content of ackee seeds were 5.394%, 10.534%, 13.831%, 13.052% and 12.796% for oven drying at 70°C, 60°C, 50°C, 40°C and sun drying respectively. Oven and sun drying significantly increased the fat value from 13.831 to 5.394 and 12.796, respectively. The highest fibre value was recorded with 50°C and least value from the fresh ackee seeds. Drying increase the fibre content of ackee seed, a higher value above 5.394% was recorded for dried samples and fresh sample had value of 5.299%. It was observed that all the dried ackee seed showed an increase in the fat content. The intensity of hot air applied to the oven drying method was found to be commensurate with the decrease in fibre content of the ackee seed.

The nutritional value of dried ackee seeds showed decreased in value with higher drying air temperature. Nutritional value of ackee seeds at drying temperatures exceeding 50 results in reduction of for the nutritive parameters.

Bioactive Compounds

Natural phenolic and flavonoid compounds are plant additional metabolites that hold an aromatic ring bearing at least one hydroxyl group [14]. Natural non-nutrients in biomaterial could be destroyed by heat during processing [15].

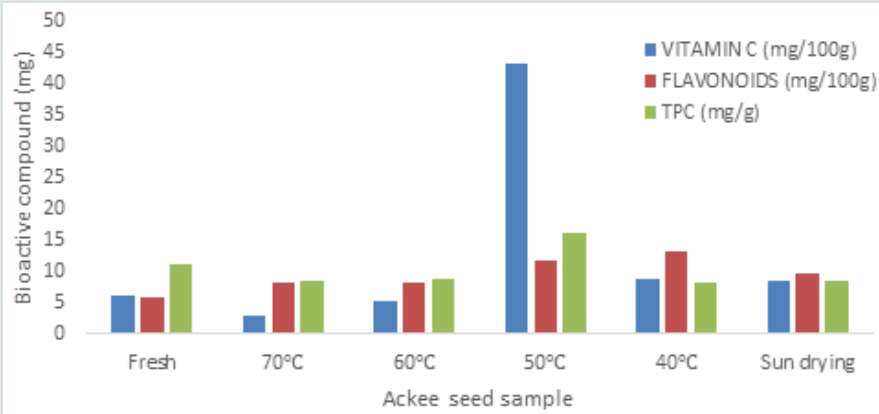

Figure 2: Bioactive quality of fresh and dried Ackee apple seeds.

In recent decenniums, phenolic and flavonoid-rich natural diets with antioxidant activity have been fostered in nutrition and food science [16]. Natural antioxidants from plants and its product play a vital role in protecting against the action of free radicals [17]. Many research studies have shown that the consumption of plants containing phenolic and flavonoid compounds with potent antioxidant activity are associated with a lower incidence of cardiovascular diseases, cancer, diabetes and neurodegenerative diseases [18]. The results of vitamin c, total phenolic and flavonoid were shown in Figure 2.

i. Vitamin c

The vitamin c content value of 2.855 ± 0.02, 5.367 ± 0.12, 13.188 ± 0.42, 8.765 ± 0.10, 8. 394 ± 0.09 mg/100g, for 70°C, 60°C, 50°C, 40°C and sun drying respectively were reported for dried ackee seed. The vitamin c value had the highest value of 13.188 mg/100g, followed by 8.7 65mg/100g and least value of 2.855 mg/100g for 50, 40 and 70 respectively. The vitamin C content of the ackee seeds were lower than that in orange (50 mg/ 100 g) and that in tomatoes (15 mg/100 g) as reported by Belitz HD, et al. [19]. The drying with the highest intensity of hot drying air registered the highest loss of vitamin c in all the dried samples probably because it exposed the seeds to direct ultraviolet light more than others, thereby reducing the value of the content. This could be the reason behind lower loss of vitamin c in lower temperature and open sun drying.

ii. Total Phenolic content

Phenolic compounds are good electron donors because their hydroxyl groups can directly contribute to antioxidant action [20]. Furthermore, some of them stimulate the synthesis of endogenous antioxidant molecules in the cell [21]. Researchers reported that phenolic compounds exhibit free radical inhibition, peroxide decomposition, metal inactivation or oxygen scavenging in biological systems and prevent oxidative disease burden [22]. The total phenolic content (TPC) in methanol extracts ranged from 8.345 to 16.150 mg GAE/g. The phenolic contents value of 8.522 ± 0.05, 8.751 ± 0.12, 16.150 ± 0.42, 8.345 ± 0.10, 8. 0510 ± 0.09 mg GAE/g, for 70, 60, 50, 40 and sun drying respectively were reported for dried ackee seed. The highest phenolic contents of 16.150 ± 0.42 while the least phenolic contents of 8.345 ± 0.10 mg GAE/g were found in oven drying for 50, and 40 respectively. The total phenolic content of fresh ackee seed was 11.186 0.12, it was higher than *S. nigrum* value of TPC 0.704 mg GAE/g fresh weight of *S. nigrum* in a water extract as reported by Adebooye OC, et al. [18]. It was also higher than total phenolic content of *P. oleracea* with value of 3.6 _ 0.089 mg GAE/g dry weight in the methanol extract as reported by Uddin MK, et al. [23].

iii. Flavonoid Content

The flavonoid content (TFC) in methanol extracts ranged from 5.847 to 13.213 mg QE/g. The flavonoid contents value of dried ackee seeds were 8.065 ± 0.15, 8.065 ± 0.12, 11.866 ± 0.62, 13.213 ± 0.30, 9. 7510 ± 0.09 mg QE/g, for 70°C, 60°C, 50°C, 40°C and sun drying respectively. The highest flavonoid contents of 13.213 ± 0.30 mg QE/g with oven drying for 40°C while the least flavonoid contents of 8.345 ± 0.10 mg QE/g were found in oven drying for both 60°C and 70°C respectively. The loss of flavonoids during hot air drying was reported to be due to the harsh intensity of hot air processing of the temperature. It was also observed that mild drying conditions with lower temperature improve the product quality but with decrease in drying rate but longer drying period, similar trend was reported by Kumar C, et al. [24].

Conclusion

Blighia sapida apple seed is among the wasted and under-utilized crops. The use of this wasted seed in food production and pharmaceutical products as additives could also be a mean of generating another source of raw material for food, pharmaceutical industries and reduces wastage of these seeds during their season. Dried ackee seed can have a longer shelf-life, produce diversity, and remarkable reduction in volume. In addition, due to its high-quality dried products that retain nutritional and the presence of bioactive compounds (flavonoids, phenolic and vitamin c) which provide additional health-promoting benefits. Because the majority of agricultural products are thermo-sensitive, chemical and bioactive constituents may change significantly because of excessive heat accumulation during drying. Therefore, temperature control during drying is crucial to obtain high-quality dried products. Nutritional value of ackee seeds at drying temperatures exceeding 50 results in reduction of for the nutritive parameters and bioactive compounds.

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