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RESEARCH ARTICLE

Effect of Varying Drying Temperature on the Soluble Sugar and Nutritional Content of Banana

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Abstract:

Aims:

In this work, the effect of drying temperature on the available carbohydrate is investigated.

Background:

Nigerian climate favours the cultivation of banana and it is a ready fruit delight in almost all homes. Hybrids and polypoids of the species musa acuminata and musa balbisiana are very common. Unfortunately, post-harvest losses of 40 – 60%, of this energy rich fruit are encountered yearly. Drying is an age long method of preservation which has stood the test of time. Bananas are known to possess high carbohydrates with low glycaemic index which makes it a healthy fruit or snack.

Objective:

To determine the optimum drying temperature for the drying of Banana fruit.

Methods:

The banana fruit was peeled and sliced to about 5 mm thick and dried in a tray dryer at varying temperatures of 40 °C, 50 °C, 60 °C and 70 °C. The control sample was air dried at the average prevailing temperature of 30 °C.

Results:

Results obtained showed that increased drying temperature favoured more loss of moisture from the samples and in turn, favoured an increase in the available carbohydrate in the dried fruit. The ash, fat and crude fibre content marginally changed with drying temperature.

Conclusion:

The optimum temperature for treated and untreated samples, from the results obtained, were 60 °C and 70 °C respectively.

Drying impacts positively on the available sugar in the Banana fruit.

Keywords: Available carbohydrate, Banana drying, Glycaemic index, Post-harvest loss, Proximate analysis, Cassava.

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1. INTRODUCTION

In Nigeria, ripe bananas are mostly eaten raw and in rare cases, made into flour. Dried fruits as snacks and toppings in cereals, pancakes, oat meals, etc are gradually being introduced and embraced in the community. Banana is one of the organic products most valued by buyers around the globe, basically because of its attributes. It is calorific nourishment, wealthy in starches and minerals, with a medium amount of sugar and vitamin A, and contains little protein [1]. This organic product is truly helpless to weakening by the microbial attack; prompting high misfortunes, especially in situations where strategies of collecting, post-gather and capacity utilization are lacking [2 - 5].

Most banana species found in Nigeria, have a very short

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shelf life of about 7 days. The moisture content of about 66% coupled with the storage temperature, which ranges between 28 °C and 35 °C, is a favourable combination for the physiological and quality alteration of fruit [6]. Microbial attacks are not an uncommon experience of this fruit because of the moisture and sugar content.

Dehydration or drying is basic and very much helps to salvage its nourishment that may some way or another disintegrate [7] with deterioration. Drying of fruits reduces the weight of the fruit and gives the advantage of reduced transport cost, longer shelf life and better availability all year round. Drying is an age-long technology for preserving fruits and vegetables and must be controlled painstakingly such that the quality traits of the dried natural products are retained and maintained [8]. This would permit to upgrade or change drying parameters continuously amid the drying procedure to guarantee great quality dried items [9]. Simple drying techniques which have stood the test of time are the open-air drying, which has the down-side of being contaminated with the atmosphere and also, there's the risk of being eaten by rodents and other animals. A lot of work has been done on the drying kinetics and characterization of the dried products using different tools.

Tray drying refers to drying out little bits of produce by subjecting to a source of hot dry air or to the sun until it is dried enough to be stored at ambient temperature with negligible decay [10]. Since dried bananas have various uses such as baby food, cereal, banana chips, banana bread, banana pudding and so many other delicious delicacies, it is imperative to choose a suitable method of drying for this specific product to maintain the nutrient levels in the fruit when dried.

A large array of varieties exists in bananas. They range from the green species to the yellow species and recently, the red species are beginning to gain attention – which are all hybrids and polyploids of the species, *Musa acuminata* and *Musa balbisiana*. Banana fruits majorly contain carbohydrates (presented as starch in unripe fruits but sugars in ripe fruits) and others like fibre, antioxidants and vitamins. Its low glycaemic index (GI) makes its consumption attractive due to the absence of fear of increased blood sugar levels. The starch in an unripe banana debases to a few monosaccharides, while the remainder of the starch is degenerated to sucrose [11]. Being low on the glycaemic index, bananas release their energy into the bloodstream immediately [12]. The glycaemic index of bananas rises as the fruit matures [12, 13]. This makes it a good food for diabetics [14].

The banana fruit is also rich in potassium, magnesium and copper [15]. Potassium can be found in different fruits, vegetables and even meats, but a single banana supplies about 23% of potassium needed on a daily basis by an adult [14]. Potassium is a vital element of cell and body fluids, it aids muscles and nerves. It also controls heartbeat and blood pressure and counters the effect of sodium [15].

Almost all parts of the banana are used in different aspects [13]. The fruit, just like cassava, may vary in composition according to the variety [16]. The banana fruit can be eaten raw or cooked, processed into flour and can be fermented to produce beverages such as banana juice, beer, vinegar or wine [13, 17]. In traditional medicine, the sap of the banana plant is used to treat a wide variety of ailments, including leprosy, hysteria, fever, digestive disorders, haemorrhage, epilepsy and so on [14]. The peel and pulp of the banana fruit have also shown to have both antifungal and antibiotic components [14].

This study aims at obtaining banana drying data with particular focus on the effect of temperature on the availability of the composite nutrients, especially carbohydrates, of the banana fruit after drying at different temperatures, for treated and untreated bananas.

2. METHODOLOGY

Fully ripe and ready to eat banana of the *Musa acuminata* descent were bought from Cafeteria 2 in Covenant University, Ota, Ogun State, Nigeria.

2.1. Sample Preparation

The bananas were peeled and cut into an average width of 5 mm using a banana slicer. 100 g slices were treated using a 1:4 lemon to water juice and allowed to dunk for 10 minutes. It was then allowed to drain in a sieve for another 10 minutes before placing it on the tray dryer. The untreated samples were also cut into 5 mm sizes and dried on the tray dryer.

2.2. Drying Procedure

The tray dryer was preheated to the different working temperatures of 40 °C, 50 °C, 60 °C and 70 °C before 100 g of sliced banana samples were fed into it. Drying was monitored by taking a sample out of the oven every 30 minutes for weight measurement until no change in weight was observed in the samples.

2.3. Analysis of Dried Samples

The standard procedure for proximate analysis [18] was used in determining the composition of all fresh and dried banana samples.

3. RESULTS AND DISCUSSION

Results obtained are tabulated in Tables **1** and **2**, while the graphical representation of the results is presented in Figs. (**1**-**6**) for both untreated and treated samples, respectively. Increasing the drying temperatures favoured the expulsion of more water from the samples. For example, the air-dried sample (E) had a final moisture content of 21.481% while it was 13.262% when dried at 70 °C. Higher temperatures provide more energy for the water molecules to escape from the sample surface than lower temperatures.

The ash content and crude fibre content increased marginally with increased drying temperature. The most sensitive composition to drying temperature was carbohydrate, which increased to almost 4 times the original percentage as the temperature was almost doubled.

Drying is one of the ways to reduce the moisture content, increasing the shelf life of fruits and vegetables generally. The temperature of drying air has a significant effect on the drying time - allowing more moisture to leave rapidly. Most fruits

contain significant amounts of natural sugars and as the water is removed from the fruit by drying, the percentage of the nutrients present in the fruit seems to increase. For this reason, the carbohydrate content of the dried fruit, for example, is very high when compared to the fresh fruit. The fat content in most samples was undetected which means that the level in the raw and dried fruit was negligible.

Table 1. Proximate analysis for untreated banana samples.

PARAMETER/ SAMPLE	PROTEIN (%)	MOISTURE (%)	ASH (%)	FAT (%)	CRUDE FIBRE (%)	CARBO-HYDRATE (%)
A1i	5.02	18.5185	2.7021	ND	1.5873	72.1721
A1ii	5.19	17.5676	2.8037	ND	1.5849	72.8538
Mean ± SD	5.105 ± 0.120	18.043 ± 0.672	2.753 ± 0.072	ND	1.586 ± 0.002	72.513 ± 0.482
B1i	10.74	14.6341	1.6807	0.495	1.005	71.4452
B1ii	10.6	14.7929	1.6304	0.4924	1.0024	71.4819
Mean ± SD	10.670 ± 0.099	14.714 ± 0.112	1.656 ± 0.036	0.494 ± 0.002	1.004 ± 0.002	71.464 ± 0.026
C1i	6.02	13.4228	2.0134	ND	1.0638	77.48
C1ii	6.23	13.4146	2.139	ND	1.0612	77.1552
Mean ± SD	6.125 ± 0.148	13.419 ± 0.006	2.076 ± 0.089	ND	1.063 ± 0.002	77.318 ± 0.230
D1i	3.31	13.1579	2.0979	ND	1.6129	79.8213
D1ii	3.54	13.3664	2.0408	ND	1.6014	79.4514
Mean ± SD	3.425 ± 0.163	13.262 ± 0.147	2.069 ± 0.040	ND	1.607 ± 0.008	79.636 ± 0.262
E1i	3.84	21.9101	1.4085	0.5805	1.227	71.0339
E1ii	4.02	21.0526	1.8868	0.5822	1.2238	71.2346
Mean ± SD	3.930 ± 0.127	21.481 ± 0.606	1.648 ± 0.338	0.581 ± 0.001	1.225 ± 0.002	71.134 ± 0.142
F1i	10.8	66.6667	0.5348	0.334	1.0923	20.5722
F1ii	10.87	66.573	0.5181	0.3368	1.0948	20.6073
Mean ± SD	10.825 ± 0.049	66.620 ± 0.066	0.526 ± 0.012	0.335 ± 0.002	1.094 ± 0.002	20.590 ± 0.025

Legend: F = Fresh banana samples E = Air dried banana samples A = Banana samples dried at 40 °CB = Banana samples dried at 50 °CC = Banana samples dried at 60 °CD = Banana samples dried at 70 °CND = Not Detected i, ii – duplicate results of analysis 1 = Untreated banana samples.

Table 2. Proximate analysis for pre-treated banana samples.

PARAMETERS/ SAMPLE	PROTEIN (%)	MOISTURE (%)	ASH (%)	FAT (%)	CRUDE FIBRE (%)	CARBO-HYDRATE (%)
A2i	4.17	17.4359	1.7241	ND	1.5806	75.0894
A2ii	4.35	16.1137	1.7857	ND	1.5822	76.1684
Mean ± SD	4.26 ± 0.127	16.775 ± 0.935	1.755 ± 0.044	ND	1.581 ± 0.001	75.629 ± 0.763
B2i	12.52	16.2963	1.7391	0.494	1.0106	67.94
B2ii	12.56	15.9509	1.7857	0.4906	1.0136	68.1992
Mean ± SD	12.540 ± 0.028	16.124 ± 0.244	1.762 ± 0.33	ND	1.012 ± 0.002	68.070 ± 0.183
C2i	4.54	13.6364	1.8519	ND	1.0582	78.9135
C2ii	4.7	13.8889	1.8634	ND	1.0603	78.4874
Mean ± SD	4.620 ± 0.113	13.763 ± 0.179	1.858 ± 0.008	ND	1.059 ± 0.001	78.700 ± 0.301
D2i	6.44	14.557	2.439	ND	1.676	74.888
D2ii	6.58	14.3713	2.6087	ND	1.6779	74.7621
Mean ± SD	6.510 ± 0.099	14.464 ± 0.131	2.524 ± 0.120	ND	1.677 ± 0.001	74.825 ± 0.089
E2i	14.74	21.6418	1.8293	0.3029	1.1976	60.2884
E2ii	14.86	21.3483	1.8639	0.3023	1.1932	60.4323
Mean ± SD	14.800 ± 0.085	21.495 ± 0.208	1.847 ± 0.024	0.303 ± 0.00	1.195 ± 0.003	60.360 ± 0.102
F2i	7.85	69.5122	0.641	0.3296	1.0989	20.5683
F2ii	7.79	70.3488	0.6329	0.3247	1.0992	19.8044
Mean ± SD	7.820 ± 0.042	69.931 ± 0.592	0.637 ± 0.006	0.327 ± 0.003	1.099 ± 0.000	20.186 ± 0.540

Legend: F = Fresh banana samples E = Air dried banana samples A = Banana samples dried at 40 °CB = Banana samples dried at 50 °CC = Banana samples dried at 60 °CD = Banana samples dried at 70 °CND = Not Detected i, ii – duplicate results of analysis 2 = Pre-treated banana samples.

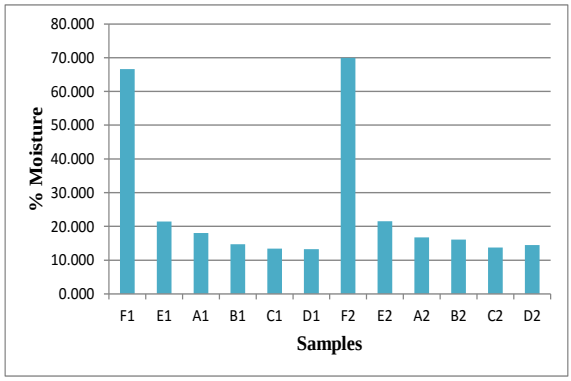

Fig. (1). Moisture present in fresh and dried samples.

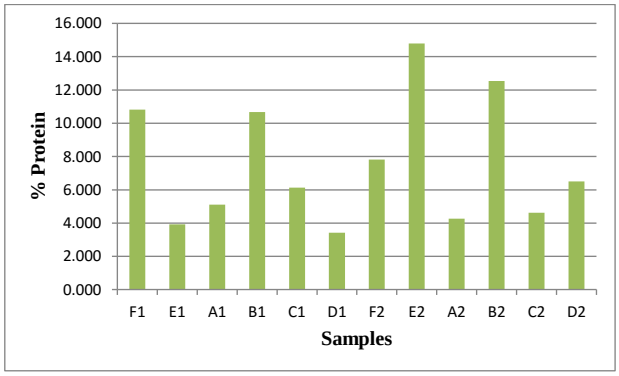

Fig. (2). Protein present in fresh and dried samples.

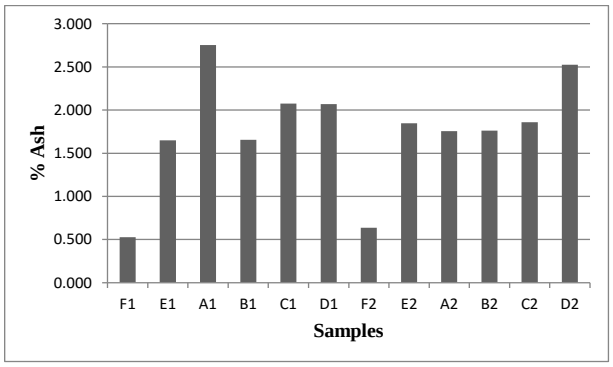

Fig. (3). Ash present in fresh and dried samples.

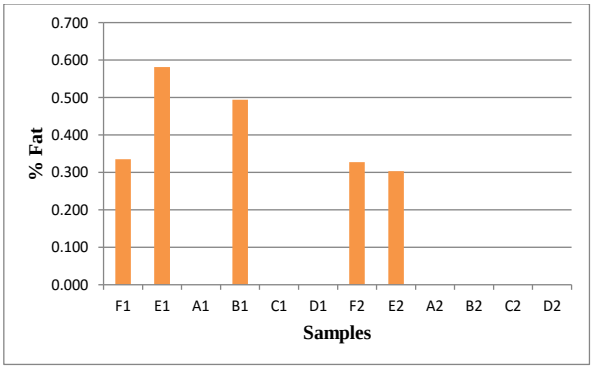

Fig. (4). Fat present in fresh and dried samples.

Pre-treatment is widely used before drying to improve or retain colour, inactivate enzymes, improve the quality of dried fruit products and sometimes to enhance the drying process. A similar trend of increased carbohydrate content was observed in the pre-treated banana slices as the drying temperature increased, as shown in Table **2**, but the values are slightly lower than that observed in the untreated slices in Table **1**. Phytochemical analysis studies have reported that lemon fruit is a rich source of nutrients and bioactive compounds, such as citric acid, ascorbic acid, limonoids, and phenolics, which exhibit multiple biological activities, thus promoting numerous health benefits. Limonoids in lemon juice has also been reported to improve colour and vitamin C content of dried fruit and is effective in lowering the sugar content of banana fruits [19, 20].

More water was present in the treated samples as expected, and it is shown in Fig. (**1**) Better moisture removal was observed as temperature increased from samples F (fresh sample) to D (dried at 70 °C).

Results shown in Fig. (**2**) suggest that the pre-treatment seems to have suppressed the protein in the raw samples of F1 and F2 but upon drying, a higher percentage of protein is preserved in the treated than the untreated samples. However, the best protein content was recorded at E2 (air-dried sample) and followed by B2 (sample dried at 50 °C). No particular trend was observed in all temperatures considered. Results obtained are similar to findings of Correia *et al,* 2008 [21] but much higher than protein present in *Musa paradisiaca* (Ekpete *et al,* 2013) [2]

The ash content of a sample represents the incombustible part of the sample after combustion in a furnace and results obtained from fresh and dried samples are presented in Fig. (**3**). The fresh banana fruits have less ash content of less than 1% compared to about 12.51% in tamarind [22]. The ash content in the dried untreated samples show a progressive increase with temperature but samples dried at 40°C (A1) did not follow the trend. No particular trend is followed in the treated samples, but the highest ash content is recorded in the sample dried at 70 °C (D2).

The fat content of both the treated and untreated fresh samples are of the same fat content. Unfortunately, no meaningful inference can be drawn from Fig. (**4**), as the fat content in most of the samples could not be detected. This means that the fat content of bananas after drying is very small.

With the same level of crude fibres in both treated and untreated fresh samples, extreme temperatures considered, A1, A2 (dried at 40°C) and D1, D2 (dried at 70°C) seem to favour the retention of crude fibre in the dried samples as shown in Fig. (**5**).

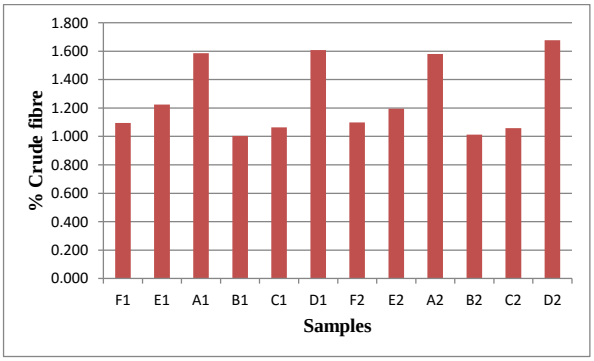

Fig. (5). Crude fibre present in fresh and dried samples.

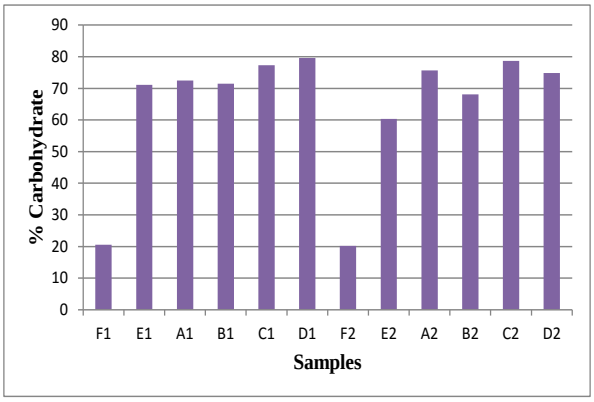

Fig. (6). Carbohydrate content of fresh and dried samples.

The carbohydrate content of the dried fruit is favoured by drying, as shown in Fig. (**6**). More sugars are present as more water is removed and also, as drying temperature is increased (D1, D2, E1, E2). This is in consonance with results obtained by Correia *et al.* (2008) [21] in dried chestnuts flours.

It has been shown that tropical storage of some fruits may positively affect the amount of soluble sugars, such as strawberries [23]. Ding *et al.* [6] recorded a drop in the sugar content of loquat fruit during storage, the sugar content of banana increased with drying as observed in our work. These sugars are present in glucose forms, which makes it readily available to the body. Therefore, drying of fruits helps to preserve the carbohydrate and other nutrients in the banana fruit.

3.1. Colour of Dried Fruit Samples

By physical observation, during the drying process, the treated samples appeared whiter and brighter than the untreated samples until dried. However, after 1 week, the samples were very close in colour.

CONCLUSION

Increasing the drying temperature was observed to make more nutrients available in the dried samples. This seems to be good for more energy from the dried fruit, which is fit for consumption. The drying of the banana fruit actually made the nutrients more available in dried banana samples, as opposed to the belief that drying destroys the nutrients in fruits.

Dried fruits are recommended to people engaged in weight loss programs. Being low in the glycaemic index makes it attractive to reduce blood sugar levels and also a good enough snack option for sufferers of Type 2 diabetes.

CONSENT FOR PUBLICATION

Not applicable.

AVAILABILITY OF DATA AND MATERIALS

The authors confirm that the data supporting the findings of this study are available within the article.

FUNDING

None.

CONFLICT OF INTEREST

The authors declare no conflict of interest, financial or otherwise.

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