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The Effects of Various Drying Methods on the Nutritional Composition of *Musa paradisiaca*, *Dioscorea rotundata* and *Colocasia esculenta*

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ABSTRACT

Food drying is one of the methods that are used to preserve some perishable food crops and this study was carried out to determine the effects of various drying techniques on these food crops. The effects of commonly used drying methods (viz; sun, oven and solar drying), on the nutritional composition of plantain (*Musa paradisiaca*), yam (*Dioscorea rotundata*) and cocoyam (*Colocasia esculenta*) were investigated. These food crops were dried using these various drying methods and their nutritional composition determined. Analyses of their nutritional composition showed that these drying methods significantly lowered the moisture content of these food samples ($p<0.001$), with solar dried samples having the lowest moisture content compared to the fresh samples. The carbohydrate content of all the dried samples were significantly lowered ($p<0.01$) compared to the fresh samples, however, the solar dried samples had the highest values except for the cocoyam sample. Protein and lipid contents of all the dried samples also decreased significantly ($p<0.001$). On the other hand, ash and fibre contents of all the dried samples increased significantly ($p<0.001$) compared to the fresh samples. Calcium content of the dried samples of yam and cocoyam decreased but that of the plantain samples increased, however, this increase was not significant except for the sun dried sample. The three drying methods used in this study resulted in an increase in the magnesium content of both plantain and yam samples, however, that of cocoyam decreased compared to the fresh samples. These results indicate that the effects of the various drying methods on the food samples were almost similar, with each drying method retaining the nutrients, without total loss of any nutrient; although, with some degree of loss to some nutrients.

Key words: Food crops, sun drying, oven drying, solar drying, nutrients

INTRODUCTION

Plantain (*Musa paradisiaca*), yam (*Dioscorea* spp.) and cocoyam (*Colocasia* spp.) are cultivated in the tropics and are important staple food in sub Sahara Africa. These food crops are rich sources of carbohydrate to the people in this region (Strosse *et al.*, 2006; Akissoe *et al.*, 2003; Olaniyan *et al.*, 2001).

These tropical food crops are abundant at a particular period, when they are in season and are scarce, during the off season (when they are out of season). Since these food crops are highly perishable after harvest; drying is a common practice for preserving them, in order to make them available throughout the year (Habou *et al.*, 2003; Eklou *et al.*, 2006).

Sun, oven and solar drying are the popular drying methods used in drying these food crops; sun drying being the most common practice (Matazu and Haroun, 2004). These food crops, when dried are processed to produce flour which can be reconstituted to form paste or dough (Emperatriz *et al.*, 2008; Bricas *et al.*, 1997). In Nigeria, West Africa, the plantain and yam flour is used to produce a paste known as amala that is eaten with soup by the consumers (Akingbala *et al.*, 1995; Akissoe *et al.*, 2001; Hounhouigan *et al.*, 2003; Mestres *et al.*, 2004).

These three drying methods (sun, oven and solar drying) utilize heat to remove water from food by evaporation. The removal of water by heat has been reported to affect the nutrient contents of food in various ways. It can either increase the concentration of some nutrients by making them more available or decrease the concentration of some nutrients (Hassan *et al.*, 2007; Morris *et al.*, 2004; Ladan *et al.*, 1997). This study was therefore carried out to establish the effects of these various drying methods on the nutrients of these important food crops, in order to determine the most suitable method that will not only increase their shelf life but also retain their nutrients adequately. Since, good nutritional value of food is important to the well-being of the consumers.

MATERIALS AND METHODS

Plant materials: Unripe plantain (*Musa paradisiaca*), white yam (*Dioscorea rotundata*) and cocoyam (*Colocasia esculenta*) were purchased in a market in Benin City, Nigeria. They were peeled, cut into small pieces and divided into four portions. Three of the four portions were dried to constant weight using sun, oven and solar drying methods respectively. The fourth portion was not dried and was used as the fresh sample which served as the control. This study was carried out from January 2010 to February 2010.

Sun drying: A portion of the various plant samples was kept in the sun between 10 am to 4:30 pm daily and was dried to constant weight for four days.

Oven drying: A second portion of the plant samples was also placed in an electric oven and dried to constant weight at 70°C for 48 h.

Solar drying: A third portion of the plant samples was dried in a solar dryer at the Nigerian Institute for Oil Palm Research (NIFOR) in Benin City, Nigeria, at 60°C for 30 h.

Analyses of the nutritional composition of the plant samples: Moisture, ash, crude fibre, calcium and magnesium contents of the plant samples were determined by the procedures of Association of Official Analytical Chemists (AOAC, 1995). Crude lipid was determined using Soxhlet extraction method of AOAC (1995), while the crude protein was also determined by the micro Kjeldahl procedure of AOAC (1995). Carbohydrate content was determined by difference (Otitoju, 2009).

Statistical analysis: Data obtained were analyzed statistically by the Tukey-Kramer multiple comparison test at 0.1% significance level. Linux/JMP spreadsheet was used to analyze the data.

RESULTS

Table 1a and b show the nutritional composition (% dry matter) of fresh and dried plantain (*Musa paradisiaca*) samples. The moisture content ranged from 60% in the fresh sample (control)

Table 1a: Proximate composition of fresh and dried plantain (*Musa* paradisiaca)

Drying method	Protein*	Carbohydrate*	Lipid*	Fibre*	Ash*
Fresh	4.50±0.13[a]	86.08±1.00[a]	2.75±0.13[a]	5.00±0.12[a]	2.75±0.16[a]
Sun	2.30±0.06[b]	82.66±0.13[b]	1.38±0.12[b]	10.43±0.26[b]	4.80±0.09[b]
Oven	3.50±0.02[c]	80.19±0.43[c]	1.57±0.12[b]	10.11±0.27[b]	5.45±0.21[b]
Solar	3.12±0.62[c]	83.08±0.22[b]	1.38±0.14[b]	9.14±0.07[c]	5.50±0.30[b]

Values are Mean±SEM (n = 3). Means with the same letter(s) on the same column are not significantly different at p<0.001.*% Dry matter

Table 1b: Moisture and mineral contents of fresh and dried plantain (*Musa* paradisiaca)

Drying method	Moisture*	Calcium (mg/100 g)	Magnesium (mg/100 g)
Fresh	60.00±0.61[a]	49.31±0.10[a]	22.11±0.28[a]
Sun	13.00±0.09[b]	52.10±0.24[b]	25.00±0.28[b]
Oven	11.03±0.15[c]	50.00±0.77[a]	23.00±0.17[a]
Solar	6.80±0.25[d]	49.87±0.18[a]	25.80±0.35[b]

Values are Mean±SEM (n = 3). Means with the same letter(s) on the same column are not significantly different at p<0.001. *% Dry matter

Table 2a: Proximate composition of fresh and dried white yam (*Dioscorea rotundata*)

Drying method	Protein*	Carbohydrate*	Lipid*	Fibre*	Ash*
Fresh	5.30±0.16[a]	88.00±0.20[a]	0.60±0.09[a]	3.10±0.10[a]	1.10±0.04[a]
Sun	4.10±0.22[b]	84.30±0.50[b]	0.35±0.02[b]	7.80±0.30[b]	3.50±0.16[b]
Oven	3.70±0.06[b]	84.80±0.60[b]	0.11±0.01[c]	7.80±0.33[b]	3.60±0.25[b]
Solar	3.30±0.02[b]	85.20±0.10[b]	0.28±0.01[b]	7.60±0.10[b]	3.50±0.18[b]

Values are Mean±SEM (n = 3). Means with the same letter(s) on the same column are not significantly different at p<0.001. *% Dry matter

Table 2b: Moisture and mineral contents of fresh and dried white yam (*Dioscorea rotundata*)

Drying method	Moisture*	Calcium (mg/100 g)	Magnesium (mg/100 g)
Fresh	65.00±0.60[a]	42.30±0.70[a]	10.30±0.20[a]
Sun	12.60±0.40[b]	38.50±0.40[b]	15.30±2.70[b]
Oven	10.30±0.30[c]	38.90±0.40[b]	14.10±1.50[c]
Solar	10.00±0.60[c]	39.60±1.20[c]	16.50±0.10[d]

Values are Mean±SEM (n = 3). Means with the same letter(s) on the same column are not significantly different at p<0.001. *% Dry matter

to 6% in solar dried sample. The carbohydrate level was highest in the fresh sample (86. 08%) while it was lowest in the oven dried sample (80.19%); protein and lipid levels were also highest in the fresh sample (4.50 and 2.75%, respectively) and lowest in the sun dried sample (2.30 and 1.38, respectively). The fresh sample had the lowest ash, calcium and magnesium contents of 2.75%, 49.3, 22.11 mg, respectively. The fibre content was also lowest in the fresh sample (5%).

Table 2a and b show the nutritional composition (% dry matter) of fresh and dried white yam (*Dioscorea rotundata*) samples. The moisture content ranged from 65% in the fresh sample (control) to 10% in solar dried sample. The fresh sample had the highest carbohydrate level of 88.00% while it was lowest in the sun dried sample (84.30%); Protein and lipid levels were also highest in the fresh sample (5.30 and 0.60%, respectively). However, protein was lowest in the solar dried sample (3.30%), while lipid was lowest in the oven dried sample 0.11%. The fresh sample had the lowest ash and magnesium contents of 1.10% and 10.30 mg, respectively; but highest calcium content of 42.30%. The fibre content was also lowest in the fresh sample (3.10%).

Table 3a: Proximate composition of fresh and dried cocoyam (*Colocasia esculenta*)

Drying method	Protein*	Carbohydrate*	Lipid*	Fibre*	Ash*
Fresh	4.00±0.01[a]	94.00±0.04[a]	2.40±0.01[a]	3.80±0.02[a]	1.60±0.02[a]
Sun	2.84±0.02[b]	91.72±0.03[b]	1.14±0.02[b]	6.88±0.04[b]	4.66±0.04[b]
Oven	3.39±0.02[c]	90.78±0.05[b]	1.33±0.02[b]	6.67±0.65[b]	3.65±0.07[c]
Solar	3.35±0.02[c]	89.69±0.07[c]	1.10±0.03[b]	6.59±0.05[b]	4.95±0.03[b]

Values are Means±SEM (n = 3). Means with the same letter(s) on the same column are not significantly different at p<0.001. *% Dry matter

Table 3b: Moisture and mineral contents of fresh and dried cocoyam (*Colocasia esculenta*)

Drying method	Moisture*	Calcium (mg/100 g)	Magnesium (mg/100 g)
Fresh	75.00±2.65[a]	49.37±0.10[a]	26.12±0.28[a]
Sun	11.74±0.06[b]	13.20±0.08[b]	7.90±0.26[b]
Oven	10.50±0.23[c]	10.85±0.05[c]	8.50±0.25[b]
Solar	9.38±0.13[d]	12.93±0.12[b]	8.10±0.20[b]

Values are Mean±SEM (n = 3). Means with the same letter(s) on the same column are not significantly different at p<0.001. *% Dry matter

Table 3a and b show the nutritional composition (% dry matter) of fresh and dried cocoyam (*Colocasia esculenta*) samples. The moisture content ranged from 75% in the fresh sample (control) to 9.38% in solar dried sample. The carbohydrate level was highest in the fresh sample (94. 00%) while it was lowest in the solar dried sample (89.69%); protein and lipid levels were also highest in the fresh sample (4.00 and 2.40%, respectively). However, protein was lowest in the sun dried sample (2.84%), while lipid was lowest in the solar dried sample (1.10%). The fresh sample had the lowest ash (1.60%) but the highest calcium and magnesium contents of 49.37 and 26.12 mg, respectively. The fibre content was also lowest in the fresh sample (3.8%).

DISCUSSION

Preservation of food by drying is a common practice in different parts of the world and it is used to extend the shelf life of food. Drying allows food to be preserved by removing the moisture in the food, in order to prevent the growth of microorganisms that cause deterioration (Mukhtar, 2009).

In this study, the three drying methods used, were capable of removing 80-90% of the moisture in the tropical food crops, with solar drying having the highest moisture removal capability (Table 1b-3b). Reduction in the moisture content as observed in this study decreases the perishability of these food crops, adds value and also extends the shelf life, thereby making them available throughout the year, similar to the report of Demirel and Turhan (2003) and Emperatriz *et al*. (2008).

The carbohydrate, protein and lipid contents of the tropical food crops were lowered by the three drying methods employed in this study (Table 1a-3a). Although, there was no complete loss of these macronutrients but the percentage loss was highest in the lipid followed by that of protein, with carbohydrate having the lowest value. Decrease of these macronutrients due to drying may be attributed to the application of heat. Losses of these macronutrients by the application of heat have also been reported (Hassan *et al*., 2007; Enomfon-Akpan and Umoh, 2004; Morris *et al*., 2004), similar to our observation. Application of heat can be both beneficial and detrimental to nutrients. Heat improves the digestibility of food, promotes palatability and also improves the keeping quality of food, making them safe to eat. Heating process also results in nutritional losses by inducing biochemical and nutritional variation in food composition. Decrease in protein and carbohydrate contents probably occurred as a result of Maillard reaction; which results in complex changes in food due to the reaction between carbohydrate and protein (Boumendjel and Boutebba, 2003; Wiriya *et al.*, 2009). Enomfon-Akpan and Umoh (2004) also reported that the decrease in protein content of food on the application of heat could be as a result of the effect of tannins that form complexes with protein and reducing their availability. The decrease in lipid content of the tropical food crops observed in this study could be as a result of lipid oxidation. Nutrients have been reported to be lost as a result of chemical changes such as oxidation. Lipid oxidation is known to be increased by many factors such as heat, light and radiation (Savage *et al.*, 2002). Heat pretreatment was also reported to decrease the content of some lipids in spinach (Cho *et al.,* 2001) due to the application of heat that is capable of destroying them.

The three drying methods increased the ash, fibre contents of the tropical food crops (Table 1a-3a). Drying increased the Magnesium content of all the tropical food crops except cocoyam, while it decreased their calcium content except that of plantain (Table 1b-3b). This correlates with the report of Hassan *et al.* (2007), that the various drying methods used them, significantly increased the ash, fibre and mineral contents of the leaves of *Gynandropsis gynandra*. Ash is the inorganic residue remaining after the water and organic matter have been removed by heating in a food. The ash content is a measure of the total amount of minerals present within a food, whereas the mineral content is a measure of the amount of specific inorganic components present within a food. Minerals are not destroyed by heating and they have a low volatility compared to other food components. The increase in the ash, fibre and magnesium contents observed in this study could be as a result of the removal of moisture which tends to increase the concentration of nutrients (Morris *et al.*, 2004).

The decrease in the magnesium content of cocoyam and the decrease in the calcium content of yam and cocoyam after drying, suggest that the presence of antinutritional factors such as oxalate and phytate in these roots and tubers especially in cocoyam, made these minerals unavailable by reacting with them, similar to the report of Enomfon-Akpan and Umoh (2004).

CONCLUSION

Food drying is one of the methods that are used to preserve some perishable agricultural produce; in order to ensure their availability all year round, reduce post harvest losses and achieve food security. In this study, the various food drying techniques used were capable of preserving the nutrients in the food crops without total loss of any nutrient. Solar and oven drying were observed to be more hygienic and faster than the sun drying. However, solar drying was more cost effective than oven drying and it also gave the lowest moisture content in this study, suggesting a higher capacity to prevent microbial growth and decay in the dried samples, thus, confers a greater increase in shelf life on the dried samples. Consequently, solar drying may be the best technique for preserving these food crops.

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