ASUU JOURNAL OF SCIENCE
A Journal of Research and Development
Vol. 6, No. 1 & 2, December, 2019; pp 90-18

Effects of Cooking Methods on The Quality of Ripe Plantain *(Musa paradisiaca)* Fruit

Egwujeh, S.I.D. and Yusufu, A.

ABSTRACT

This study aimed at assessing the effect of cooking methods (boiling and roasting) on the chemical and sensory properties of peeled and unpeeled ripe plantain (Musa paradisiaca) pulp. Samples containing ten fingers of plantain were prepared from peeled and unpeeled. The samples were subjected to proximate, mineral, vitamin and sensory analyses using standard methods of analysis. Data generated were statistically analysed. Boiling increased the moisture contents of the samples while roasting in the oven and on charcoal led to reduction in the moisture contents of the samples. Boiling led to reduced protein while roasting resulted in slight increase in the nutrient. Similar trends were observed in the fibre, fat and carbohydrate. There was a significant ($p<0.05$) reduction of potassium during boiling but increased during roasting. There was slight increase in the magnesium, sodium and phosphorus during the treatments, calcium was not detected in all the samples. While vitamin A and C increased during roasting in the oven, boiling in water and roasting on charcoal reduced these vitamins. Samples cooked with peels retained more nutrients than the peeled samples. Roasting on charcoal led to higher reduction of nutrient than boiling and roasting in the oven. Samples roasted in the oven were significantly ($p<0.05$) not accepted although these retained more nutrients than samples boiled or roasted on charcoal. Nutrient compositions and sensory properties were grossly affected by the cooking methods. The result demonstrated that cooking with peels produced higher nutritional qualities than cooking without peels.

Egwujeh, S.I.D. and Yusufu, A.
Dept. of Food, Nutrition and Home Sciences,
Kogi State University, Anyigba, Nigeria
Correspondence address: idesnig@yahoo.com
Phone Numbers: 08037444259; 08059068420

Keywords: Processing, Ripe plantain fruit, Proximate, Mineral, Vitamins

Introduction

Plantain is an important staple crop in Nigeria and many tropical countries Plantain contains various carbohydrates and is a major source of energy to man (Ogbuji *et al.,* 2013) contributing to food security for millions of people in Africa. Plantain as a major source of carbohydrate, contributes to the food security for millions of people in Africa. The mode of consumption varies from one country to another depending on the eating habits (F.A.O. 2005). According to Ogbuji *et al.,* (2013), the starch content of plantain is converted to sucrose, glucose and fructose upon ripening, digestion and release of sugar is faster leading to higher glucose response.

Majority of food crops such as fruits and vegetables, roots and tubers require cooking to improve on their palatability and or digestibility. Cooking improves the digestibility, keeping quality and safety of foods for human consumption. The heat employed during the cooking can be dry (as in baking and roasting) or wet (as in boiling, steaming or frying). These sterilize the food by destroying pathogenic micro-organism and at the same time increase the availability of nutrient (Sigh and Heldman, 2009).

Processing in a number of ways alters the qualities of foods - physical, nutritional and sensory (Odenigbo and Obizoba, 2004; Egwujeh and Ariahu, 2014). Fellow (2007) reported that processing of foods, such as plantain can ensure all-year availability. This can be the basis for profitable small-scale business. Processed plantain serves the same nutritional function as root and tubers providing energy and vitamin B especially in the unripe state (Aremu and Udoessien, 1990). Information about the effects of processing methods on the quality of the products is lacking. Understanding the effects of thermal processing methods on the quality of ripe plantain fruit is of great importance as these products are consumed world-wide and would form a basis for determining the quality of the end product.

The objectives of this work therefore were to cook peeled and unpeeled ripe plantain fruit by boiling in water, roasting in hot air oven and on charcoal and to evaluate the effects of these cooking methods and sample forms on the chemical and sensory properties of the pulp.

Materials and methods

Sources of materials

Ripe plantain fruits were purchased from a plantain retailer opposite Kogi State University main gate along Anyigba/Egume road, Kogi State Nigeria. The equipment such as hot are oven, furnace, soxhlet and kjedahl apparatus, AAS, charcoal stove and so on used in this study were from the Department of Food Nutrition and Home Sciences, Department of Soil and Environmental Managements Laboratories both of Faculty of Agriculture, Kogi State University Anyigba.

Samples preparations

The ripe plantain fruits were washed under tap water and divided into seven parts of ten fingers each and coded 500, 501, 503, 505, 507 509 and 511. Samples coded 501, 505, and 509 were peeled using a stainless steel kitchen knife while those coded 503, 507 and 511 remained unpeeled before cooking. The sample coded 500 which received no treatment served as the control. Samples 501 and 503 were boiled; 505 and 507 were roasted on charcoal while 509 and 511 were roasted in the hot air oven.

Analytical procedures

Analyses carried out on these samples include the determination of proximate composition, mineral content, vitamin composition and the sensory properties. All the experiments were carried out in triplicate, and the mean values taken.

Proximate composition

The proximate composition, including the moisture, protein, fat, ash, crude fibre and carbohydrate contents of ripe plantain samples was determined according to standard methods. Moisture content was determined by oven drying method while the ash content was determined by incinerating the samples at 550^{o}C in a muffle furnace as described respectively by Onwuka (2005). The crude fibre content of the samples was determined using trichloroacetic acid after the samples had been defatted according to Adeniji *et al.,*(2006) and Adekalu *et al.,*(2011). Soxhlet apparatus (Onwuka, 2005) was used for the determination of fat while Kjedahl method described by AOAC (2000) was used to determine the protein content of the plantain samples. Carbohydrate was calculated

by difference as:
Total carbohydrate (%)=100 –(%ash + % crude fiber + % moisture + %Protein + %Crude Fat)

Determination of vitamins

The vitamin C content of the plantain was determined by 2, 6-dichlorophenolindophenol titrimetric methods of AOAC (1990) described by Adekalu et al. (2011) while the estimation of vitamin A (retinol) was carried out according to the methods of Adamu, (1979) described by Adamu and Yusuf (2012). The method involves homogenization, extraction (using hexane and diethylether) and colorimetric estimation after a colour was developed using triflouroacetic acid (TFA) at 620nm.

Mineral content

Minerals such as sodium, potassium, calcium, magnesium and phosphorus contents of the samples were analysed using Atomic Absorption spectrophotometer (Buck scientific model 210 VGP) according to AOAC (1990).

Sensory evaluation

A panel of 20 judges, comprising of students and staff members of the faculty of Agriculture who are familiar with plantain was used for the sensory evaluation. The panellists were served with 7 coded samples in randomized order to be assessed for colour, taste, texture, flavour, after taste, consistency and the overall acceptability using a 7-point Hedonic scale as described by Onwuka (2005) and Iwe, (2002). Datagenerated were subjected to analysis of variance (ANOVA) and the means were separated by the least significant different (LSD) test at $p \leq 0.05$ level using SPSS package.

RESULTS

The effects of cooking methods (boiling and roasting) on the proximate composition, mineral, vitamin contents and sensory quality of peeled and unpeeled ripe plantain fruit pulp are shown in Tables 1, 2, 3 and 4 respectively.

Table 1: Effects of cooking method on the proximate composition of ripe plantain fruit pulp.

Sample	Moisture (%)	Ash (%)	Fibre (%)	Fat (%)	Protein (%)	Carbohydrate (%)
500	49.25±4.59^{b}	1.74±0.36^{c}	1.11±0.14^{a}	2.15±0.70^{a}	1.11±0.36^{c}	44.63±4.87^{b}
501	58.25±2.47^{a}	2.70±0.28^{b}	0.81±0.98^{b}	1.42±0.28^{b}	0.26±0.00^{d}	36.59±2.35^{c}
503	58.23±3.88^{a}	2.90±0.14^{b}	1.04±0.00^{b}	1.77±0.42^{b}	0.33±0.28^{d}	35.71±3.67^{c}
505	44.50±1.41^{b}	2.65±0.14^{b}	0.80±0.00^{b}	1.02±0.28^{c}	1.07±0.28^{c}	46.66±1.62^{b}
507	46.75±1.76^{b}	3.10±0.14^{a}	1.92±0.28^{a}	1.28±0.82^{b}	1.27±0.00^{c}	48.39±1.32^{b}
509	37.50±2.82^{c}	2.65±0.35^{b}	1.22±0.28^{a}	2.40±0.00^{a}	2.08±0.28^{a}	54.36±2.68^{a}
511	37.25±1.76^{c}	2.75±0.21^{b}	1.14±0.00^{a}	2.55±0.70^{a}	1.81±0.91^{b}	54.49±2.00^{a}

Values represent triplicate determinations ± SD. Means in the same column with the same superscript letters are not significantly different at ($p \geq 0.05$). 500 = raw (control), 501 = peeled and boiled, 503 = unpeeled and boiled, 505 = peeled and roasted on charcoal, 507 = unpeeled and roasted on charcoal, 509 = peeled and roasted in oven and 511 = unpeeled and roasted in oven

MINERAL COMPOSITION

Table 2: The effects of cooking methods on the mineral contents of ripe plantain pulps

Sample	K(mg/100g)	Mg(mg/100g)	Na(mg/100g)	P(mg/100g)
500	23.55±0.21 [c]	31.16±0.84 [b]	0.90±0.00 [d]	64.00±0.56 [a]
501	16.80±0.14 [e]	33.66±0.24 [a]	0.90±0.14 [d]	66.57±0.98 [a]
503	19.80±0.00 [d]	36.99±0.18 [a]	1.80±0.14 [a]	68.56±1.90 [a]
505	26.35±0.70 [b]	28.47±0.23 [d]	1.10±0.00 [c]	58.04±0.21 [b]
507	30.10±0.14 [a]	29.71±0.54 [c]	0.60±0.00 [c]	57.04±0.91 [b]
509	24.60±0.14 [c]	27.86±0.23 [d]	1.10±0.14 [c]	60.94±0.15 [a]
511	27.20±0.14 [d]	29.54±0.39 [c]	1.30±0.14 [b]	61.52±0.16 [a]

Values represent triplicate determinations + SD
500 = raw (control), 501 = peeled and boiled, 503 = unpeeled and boiled, 505 = peeled and roasted on charcoal, 507 = unpeeled and roasted on charcoal, 509 = peeled and toasted in oven and 511 = unpeeled and roasted in oven

VITAMINS A ANDC CONTENTS OF RIPE PLANTAIN FRUIT PULP

Table 3 Effects of cooking methods on the vitamins A and C contents of ripe plantain fruit pulps.

Sample	Vitamin C (mg/100g)	Vitamin A (µg/g)
500	13.01 ± 0.44^{b}	47.13 ± 0.77^{b}
501	8.57 ± 0.44^{e}	30.05 ± 0.10^{c}
503	10.48 ± 0.00^{c}	43.59 ± 0.77^{b}
505	8.73 ± 0.22^{e}	21.63 ± 0.98^{d}
507	9.84 ± 0.44^{d}	38.09 ± 1.55^{c}
509	13.81 ± 0.22^{b}	48.46 ± 0.49^{b}
511	14.29 ± 0.00^{a}	53.20 ± 0.14^{a}

Values represent triplicate determinations ± SD. Means in the same column with the same superscript letters are not significantly different at ($p \geq 0.05$). 500 = raw (control), 501 = peeled and boiled, 503 = unpeeled and boiled, 505 = peeled and roasted on charcoal, 507 = unpeeled and roasted on charcoal, 509 = peeled and toasted in oven and 511 = unpeeled and roasted in oven

DISCUSSION

PROXIMATE COMPOSITION

Table 1 shows the proximate composition of thermally processed plantain fruit pulp. The moisture content of the raw sample (sample 500) was 49.25, while treatments resulted to moisture range of 37.25 to 58.25 with boiled samples (501 and 503) having higher values of 58.25% and 58.23 respectively. The increase in moisture might be due to water absorption during boiling. Egwujeh, *et al.,* (2016a) had reported that during heating, inter - molecular hydrogen bonds were disrupted allowing for moisture absorption. On the other hand, there was reduction of moisture in the roasted samples, an observation which agrees with Adegoke, et al.,(2004), Abayomi, *et al.,* (2002) and Mariod *et al.,* (2012) for peanut and safflower seeds respectively. However, samples roasted in the oven had lower moisture than those roasted on the charcoal. This could be due to hard surface crust formation resulting from high temperature and heat that sealed the intercellular spaces of the samples (Nweze, *et al.,* 2015). The retention of more moisture in the sample roasted on charcoal could be due to caking of the external surface of the samples during roasting. The lower moisture observed in roasted samples was an indication that they would be more stable on the shelffor dispensing than the boiled and raw sample. Egwujeh and Ariahu (2014) had earlier reported that moisture content of a food predicts its shelf life as it may encourage microbial activities, enzymatic and non-enzymatic (maillard) reaction leading to spoilage. The ash content of the samples ranged from 1.74 to 3.10 indicating that the cooked samples were significantly higher in ash content than that of the control at 5% level of probability. High ash content might mean that the samples contain high mineral elements. There was a reduction of protein content of the boiled samples, a resultant effect of leaching of the nutrient into the boiling water (Egwujeh, *et al.,* 2016b).The protein contents of the boiled sample (sample 501 and 503) were 0.26 and 0.33 respectively while those of roasted samples (505, 507, 509 and 511) ranged from 1.07 to 2.08%. The higher protein retentions observed in sample 503, 507 and 511 could be that the peels offered barrier on the exodus of the nutrient from the pulp during cooking. The fibre contents of samples 500, 507, 509 and 511 were not significantly different but are significantly different from 501, 503 and 505 at 5% levels of significance showing that boiling generally reduced the fibre most. Similar reduction in fibre resulting from boiling of African oak seeds had been reported (Egwujeh, et al., 2016b). It was observed that the fat contents of the boiled and charcoal roasted samples were reduced. The reduction in fat of the boiled sample could be due to dripping into the cooking water while those of charcoal roasted sample might be due to dripping and burning of the oil by the naked charcoal fire. The lowering of fat during this did not agree with earlier reports by Egwujeh, et al., (2016b) for African oak seeds.

The carbohydrate content of the control (sample 500) was 44.63, while those of the boiled samples (sample 501 and 503) were 36.59 and 35.7 respectively. This reduction could be a result of the nutrients leaching into the heating medium (water), in the form of sugar. The carbohydrates contents of the charcoal roasted samples (sample 505 and 507) and oven toasted samples (sample 509 and 511) were 48.39, 46.66, 54.36, and 54.49 respectively, showing a significant retention of the nutrient. This might be a resultof conversion of the starch content of the sample into sucrose, glucose and fructose and also the breaking down of the fruit tissue by dry heating, making the nutrient available. Increase in carbohydrate resulting from thermal processing of soybean curd (Obiegbuna et al., 2010) and African oak seeds (Egwujeh, et al., 2016a) had been reported.

Mineral contents of the ripe plantain pulp

Table 2 shows the mineral contents of thermally processed peeled and unpeeled ripe plantain fruits pulp.The potassium content of the raw sample (sample 500) was 23.55mg/100g. Roasting significantly increased the potassium contents of the samples while boiling reduced the minerals. Increase in potassium content of roasted plantain had been reported (Nweze et al., 2015). Sample 505 (peeled and roasted plantain) has the highest potassium content (30.10mg/100g) while sample 501 (peeled and boiled sample) has the least potassium contents (16.80mg/100g). The higher retention of the mineral in the sample peeled before roasting could be due to

high rate of moisture loss during roasting while the lower value of the mineral observed in the sample peeled before boiling might be due to leaching of the mineral into the boiling water. Nweze *et al.*, (2015) had reported minimal losses of minerals during roasting.
In general, the lower values of potassium and sodium in boiled samples might be a result of leaching of the minerals into the boiling water (Ebuehi, 2005; Egwujeh, *et al.,*2016b). The lower values of sodium in this study agreed with Baiyere and Unadike (2001), Baiyere *et al.,* (2009) Nweze *et al., (*2015). It was observed in all the samples that those cooked with peels retained more mineral. This might be because the peels had blocked the micro-pores on the fruit pulps thereby hindering them from leaching into the boiling water. Similar blockage had been reported for fluted pumpkin and spinach leafy vegetables by sulphite salt during blanching (Egwujeh, *et al.,* 2010). The magnesium content of the samples varies with varying cooking methods employed. The boiled sample (sample 501 and 503) had significantly higher magnesium contents (33.66 and 36.99mg/100g) than other samples at 5% level of probability. It has been reported that cooking methods such as baking, induction cooking etc., retains 100% minerals such as zinc, iron, copper, magnesium, phosphorus and potassium (Thompson, 20011). This could have accounted for higher values of magnesium observed in cooked samples over the raw. According to Nweze *et al.,* (2015), Na/K ratio lower than 1, is of great importance in the prevention of high blood pressure (HBP). In this study all the processing methods and or the sample form had good health implications in reducing the risk of HBP. There was no significant difference in value of phosphorus in the boiled samples, oven roasted sample and the control. These however were significantly ($p<0.05$) higher than those roasted on the charcoal.

Vitamins A and C

Table3 shows the vitamins C and A contents of thermally processed peeled and unpeeled ripe plantain fruit pulps. The vitamin C contents of the oven toasted samples (sample 509 and 511) were significantly higher than those of the boiled and charcoal roasted samples. This could be due to high moisture expulsion leading to concentration of the vitamin. The vitamin C content of the samples roasted on charcoal and those boiled in water were significantly less than the control sample. The lower value obtained in the boiled samples could be due to leaching of the vitamin into the boiling water while those of the samples roasted on charcoal could be due to oxidation. It has been reported that water soluble vitamins could be lost when processed products are washed and the resulting liquids are discarded (Lokuruka, 2011). Vitamin A contents of the oven toasted sample were also higher than the vitamin A contents of other samples, (Figure 3). Oven roasted samples (sample 509 and 511) had the vitamin A contents of 48.46 and 53.20 (µg/g) respectively, which were significantly higher than the vitamin A contents of the control (47.13 (µg/g). Lokuruka (2011) had reported that though vitamin A is fairly stable during thermal processing, different processing procedures have different effects on it depending on factors such as its structure and environmental condition leading to difficulties in predicting the results. In general, all the thermally treated plantain fruits with peels retained higher nutrients than those without peels. In like manner, oven roasted samples retained more vitamin A than the control. This observation is in agreement with earlier reports by Mbah *et al.,* (2012) for moringaolifera seed during boiling and roasting.

SENSORY ATTRIBUTES OF RIPE PLANTAIN FRUIT PULP.
The sensory assessments of the products are shown in Table4. The forms (peeled or unpeeled) of the samples had no significant effects on the sensory attributes analysed. However, there was significant difference ($p<0.05$) between the samplesroasted in the oven and the boiled ones for colour, flavour, taste and general acceptability. Similarly, difference existed between samples roasted on charcoal and those in the oven as well as the boiled samples for sensory parameters of colour, textures, taste and general acceptability. It was observed that samples roasted in the oven had insignificant low scores for all the sensory attributes analysed which might have accounted for their poor acceptability. The low acceptability of the oven roasted samples could also be due to formation of molecules on the surface of the samples which might be undesirable. This agrees

with earlier reports by Avallone et al., (2009) who reported that during frying, new compounds are formed that might be volatile and are released through the vapour or non-volatile and are retained in the solid matrix which add to the colour or flavour of the new product and hence its acceptability.

CONCLUSION

The nutrient compositions of the fruit were grossly affected by the various thermal processing methods used in the cooking of the fruit. Generally, the sample treated with peels retained more nutrients than those peeled before the cooking. There was no significant different in the acceptability of both samples boiled and roasted on charcoal and compared with the control in all the attributes analysed. These were significantly preferred over the samples roasted in the oven for acceptability although they retained much more of these nutrients.

ACKNOWLEDGMENTS

The authors are grateful to the Technologists in the Department of Food, Nutrition and Home Sciences, department of Soil and Environmental Management, Kogi State University, Anyigba Nigeria for their technical advice and support during this research. We are also thankful to Prof. A. O. Aduku, Prof. H. G. A. Oguche and Dr.Yusufu, P. A. for their moral support that made this work possible.

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