American Journal of

Food Technology

ISSN 1557-4571

Academic
Journals Inc.

www.academicjournals.com

American Journal of Food Technology 6 (11): 994-1001, 2011
ISSN 1557-4571 / DOI: 10.3923/ajft.2011.994.1001

Impact of Three Cooking Methods (Steaming, Roasting on Charcoal and Frying) on the β-Carotene and Vitamin C Contents of Plantain and Sweet Potato

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ABSTRACT

This study aimed at determining the best cooking method which preserves the β-carotene and vitamin C in plantain; variety Big Ebanga (unripe and ripe) and sweet potato, varieties TIb1 (dark yellow flesh) and 1112 (yellow flesh). These nutrients were analysed in raw, steamed, roasted and fried plantains and sweet potatoes. Fried plantain and sweet potato were obtained by frying 2 mm thickness slices in boiling refined palm oil bath at 170°C during 5 min. Steaming and roasting procedures were similar to those of Cameroonians households. The results obtained showed that in raw plantain, vitamin C contents were 41.43 and 45 mg/100 g Dry Matter (DM) in ripe and unripe plantain, respectively. These contents were 70.64 and 77.66 mg/100 g DM in varieties 1112 and TIb1 of sweet potato. β-carotene contents were 1135.60, 829.66, 577.01 and 241.66 μg/100 g DM in unripe and ripe plantains; varieties TIb1 and 1112 of sweet potatoes respectively. Total carbohydrates were 74.91 g/100 g DM in unripe and ripe plantain, 72.72 and 76.39 g/100 g DM in varieties TIb1 and 1112 of sweet potato, respectively. These contents varied significantly ($p<0.05$) with the cooking methods. Significant losses ($p<0.05$) of β-carotene and vitamin C were observed in all processing techniques studied. Losses of β-carotene were higher after frying and vitamin C losses were smaller after frying, but higher after roasting. Significant losses of total carbohydrate were also observed after steaming and frying. On the contrary, total lipids content were significantly ($p<0.05$) higher after frying but did not vary with roasting or steaming. Steaming was then the best cooking method which preserves the above nutrients contents in plantain; variety Big Ebanga and sweet potato; variety TIb1 and 1112.

Key words: Plantain, sweet potato, cooking method, frying, steaming and roasting

INTRODUCTION

Staple foods have varied micronutrients which are important for human nutrition and thus, contribute to good health. Plantain and sweet potato are among the major tropical staple foods (Dzomeku *et al.*, 2007). Apart from supply of energy, with orange/yellow varieties, they provide vitamin C and carotenoids to humans (Wakjira *et al.*, 2011). β-carotene is the most abundant carotenoids in yellow or orange flesh of ripe plantain and sweet potato (Rodriguez-Amaya and Kimura, 2004; Engelbeger *et al.*, 2006). Its vitamin A activity is twice higher than those of other provitamin A carotenoids (Rodriguez-Amaya,1999; Grune *et al.*, 2010). In most developing countries, 70 to 90% of dietary vitamin A are from carotenoïds (Donald and Martin, 2002). Thus, provitamin A carotenoïds of staple foods are very important in fighting Vitamin A Deficiency (VAD) in these countries, where VAD is a real public health problem. The most vulnerable groups are children under five, pregnant and lactating women (Stephensen, 2001; WHO, 2009). In Cameroon, vitamin A deficiency constitutes a major public health problem (Gouado *et al.*, 2007). This situation affects all regions and population groups (Kollo *et al.*, 2001). Nevertheless, provitamin A carotenoïds rich foods are available in Cameroon. The persistence of the deficiency may be due to the low availability of vitamin A in ready to eat foods (Demasse *et al.*, 2009; Leng *et al.*, 2011). It is known that cooking methods or processing techniques of foods often lead to losses of provitamin A and others nutrients such as vitamin C up to 90% depending of the cooking or processing method used (Penelope and Ritu, 2003). In Cameroon, steaming, roasting and frying are the most commonly used cooking methods. Cooking of foods leads to the improvement of microbiological and organoleptic qualities, destroy toxins and antinutritional factors, increase digestibility and nutrients bioavailability (Erdman and Schneider, 1994). Unfortunately these procedures cause the loss of some of the micronutrients in the foods (Yang and Gadi, 2008). Micronutrients such as β-carotene and vitamin C though thermo sensitive are important in the stimulation of immune system and the fight against cancer and cardiovascular diseases (Bendich and Schapiro, 1986; Farvin *et al.*, 2009). In view of their importance in human health, this work was initiated to evaluate the effects of steaming, roasting on charcoal and frying in boiling oil bath on the β-carotene and vitamin C contents of plantains and sweet potatoes. This will allow determining the best cooking method which preserves most these micronutrients. Water, total lipids and total carbohydrate were also evaluated.

MATERIALS AND METHODS

Plant material and handling: The unripe and ripe orange flesh plantain (Big Ebanga variety); and yellow flesh (1112) and dark yellow flesh (TIb1) varieties of sweet potato were used in the study. All the samples were harvested at Njombe (littoral region of Cameroon) in the month of August 2008. The samples were put in perforated polyethylene bags, carried to the laboratory and washed with tap water before processing.

Steaming, roasting and frying were done using Cameroonian household methods. For each stage of maturity and variety, the procedures were performed in duplicate.

Steaming: The 250 to 350 g of each sample of the biological material was boiled with 750 mL of water at 100°C in an aluminium pot, covered with lid for 30 min. After boiling, the tubers and plantains were drained on absorbent paper and cooled for 20 min in desiccators.

Roasting: The 250 to 350 g of each sample of the biological material was roasted on a grill above heated charcoal. The temperature around the charcoal was about 200°C and the distance between grill and charcoal was 5 cm. During roasting, samples were turned regularly. The roasting time was 30 min for the two varieties of sweet potato and 19 and 17 min for unripe and ripe plantain, respectively. After roasting, sample was wrapped with absorbent paper and cooled in desiccators for 20 min.

Frying: The 250 to 350 g of each sample of the biological material was chopped up into 2 mm slices. Slices of 20 g each were fried in one liter of boiling refined palm oil bath at 150°C for 5 min The fried plantains and sweet potatoes were drained on absorbent paper and cooled for 20 min in desiccators.

Steamed, roasted, fried and raw sample of plantain and sweet potato were divided into three sets. The first set was used immediately for the evaluation of vitamin C and moisture contents. The second set was stored at -18°C for subsequent analysis of β-carotene content. The third set was dried on an oven at 45°C until constant weigh for the assessment of total lipids and carbohydrates contents.

Nutrients analysis: Moisture content was determined according to the AOAC (1980). Vitamin C was evaluated by titration with 2,6 dichlorophenol indophenol (Harris and Ray, 1935). Total lipids were determined by continuous extraction in a Soxhlet apparatus using hexane as solvent (AOAC, 1980). Total carbohydrates were evaluated using sulphuric and phenol (Dubois *et al*., 1956). β-carotene was assessed using method described by Simpson *et al*. (1987).

Statistical analysis: All statistical analysis were performed using X-L STAT. Results are presented as Means±SD. One way ANOVA was used to determine the effect of varieties, stage of maturity and cooking methods on the nutrients analyzed. When the effect of species was significant, differences between the processing methods were determined using Fisher's Least Significant Difference (LSD) test at 5% level was used.

RESULTS AND DISCUSSION

Effect of cooking methods on the water content: The effect of cooking methods on the water content of plantain and sweet potato sample is presented on Table 1. Water contents of raw plantain were 61.08 and 60.03 g/100 g FW in unripe and ripe plantain, respectively. These contents are found to be within the range of values obtained by Rojas-Gonzale *et al*. (2006) and Demasse-Mawamba *et al*. (2007). In raw sweet potato; water contents were 64.26 (TIb1 variety) and 63.08 g 100 g^{-1} FW (1112 variety). Bahado-singh *et al*. (2006) found 63.72 g/100 g FW in India. After boiling, the water content increased significantly ($p<0.05$) in unripe (64.89) and ripe plantain (64.05 g/100 g FW). The same effect was observed by Dadzie and Orchard (1997). This increase is probably caused by the interaction between water and polar compounds (starch, free sugar, protein) of the food or osmotic phenomenon (Dadzie and Ochard, 1997). However, the increase of water content in sweet potatoes was not significant ($p>0.05$). This result is probably due to the fact that they were boiled with skin (unpeeled) which could constitute a barrier for water absorption. At the contrary, water content decreased significantly ($p<0.05$) when the samples was

Table 1: Effect of cooking methods on the water content (g/100 g FW) of plantain and sweet potato

	Plantain		Sweet potato	
Cooking method	Unripe	Ripe	Variety TIb1	Variety 1112
Raw	61.08±6.00^{bc}	60.03±0.34^{bc}	64.26±2.46^{a}	63.08±5.32^{a}
Steamed	64.89±4.48^{a}	64.05±1.31^{a}	64.73±2.62^{a}	63.26±0.48^{a}
Roasted	52.40±1.79^{d}	55.77±1.72^{d}	59.66±1.41^{b}	57.13±1.53^{b}
Fried	2.31±1.07^{e}	3.13±1.02^{e}	3.58±0.51^{c}	1.64±0.13^{c}

Values that do not share the same superscript letter(s) are significantly different, using at LSD test $p<0.05$

roasted or fried. These cooking methods are on dry heat. It is known that dry heat dehydrates foods causing water loss. This dehydration was deeper in fried products/chips (water content less than 4%) because the surface area exposed to heat was higher. The low water content of chips is an advantage for its storage.

Effect of cooking methods on the vitamin C contents: Vitamin C levels were 45; 41.43; 77.66 and 70.64 mg/100 g DM respectively in raw unripe, ripe plantain, varieties TIb1 and 1112 of sweet potato. These levels were significantly lower ($p<0.05$) in their respective processed foods. Losses of Vitamin C were higher as a result of roasting as compared to boiling and frying. These losses in unripe and ripe plantain were 76.07 and 86.81% after roasting as against 69.01 and 79.64% after boiling and 47.38 and 47.95% after frying (Fig. 1). These results are in accordance with those published in FAO (1990), where optimum retention of vitamin C was observed after frying than after boiling and roasting, losses were higher after roasting than after boiling. The losses of vitamin C in processed foods are probably caused by thermal oxidation at different temperatures and duration of cooking. Frying was carried out at 170°C during five min where as boiling was at 100°C for 30 min and roasting at about 200°C during 17 to 19 min for plantains and 30 min for sweet potatoes. After frying, vitamin C loss was similar to the one found by Haase and Weber (2003) in potato chips which was 26%. On the contrary, Demasse-Mawamba *et al*. (2007) found losses of 54 to 70% in plantain chips. In fact, higher temperature lead to important degradation of the vitamin C (Abong *et al*., 2011; Pirone *et al*., 2007). Manipulation of food before frying and packaging may also explain this differences. Manipulation of food before frying and packaging may explain this differences.

Effect of cooking methods on the β- carotene contents: The effect of cooking methods on the β-carotene contents of plantain and sweet potato is illustrated on Fig. 2. The β-carotene contents were 1135.60, 829.66, 577.01 and 241.66 μg/100 g DM in raw unripe and ripe plantain, varieties TIb1 and 1112 of sweet potato, respectively. These contents decreased significantly ($p<0.05$) in the processed foods with different intensities. Losses of β-carotene in unripe and ripe plantains were respectively 46.03 and 58.21% after frying against 25.00 and 43.17% after roasting and 3.36 and 6.57 after boiling. In varieties TIb1 and 1112 of sweet potato, respectively β-carotene retention was 36.62 and 47.69% after frying against 42.33 and 87.46% after roasting and 46.74 and 52.03 after boiling. In the review of Boy and Millof (2009) on the provitamin A retention in Orange Sweet Potato, the β-carotene retention ranges were: 50 to 130%; 40 to 110% and 67 to 95%, respectively

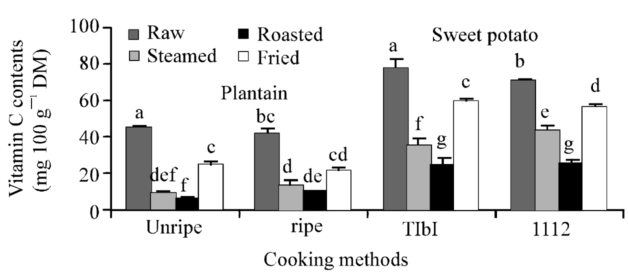

Fig. 1: Effect of cooking methods on the vitamin C contents of plantain and sweet potato. Values for the same stage of maturity or the same variety marked with different letters are significantly different ($p<0.05$)

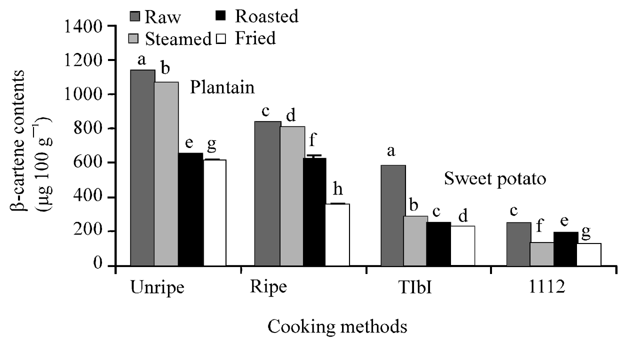

Fig. 2: Effect of cooking methods on the β-carotene contents of plantain and sweet potato. Values for the same stage of maturity or the same variety marked with different letters are significantly different ($p<0.05$)

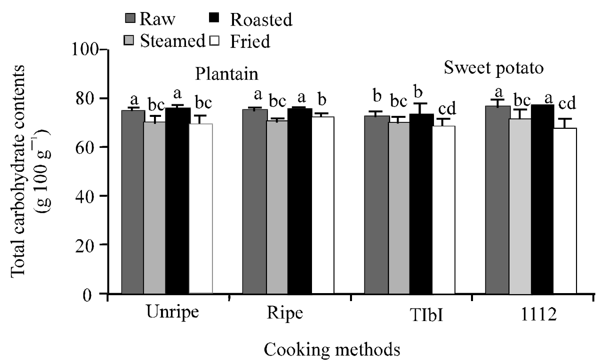

Fig. 3: Effect of cooking on total carbohydrate contents of plantain and sweet potato. Values for the same stage of maturity or the same variety marked with different letters are significantly different ($p<0.05$)

for boiled, roasted and fried sweet potato. The differences in the varieties used, may explain lower retention obtained in this study after frying and boiling. Kidmose *et al.* (2007) found that the percentage of retention of β-carotene in sweet potato varied significantly with variety. In variety TIb1 of sweet potato, losses of β-carotene were higher after roasting than after boiling. On the contrary, in variety 1112, losses were higher after boiling than after roasting. This lower retention may also be explained by the difference in duration and temperature of processing. During heat treatment, the oxidative degradation and trans-cis isomerisation of all-trans β-carotene occur with the intensity which depends on the extent of the heat. According to Mayer-Miebach *et al.* (2005) the presence of oil increases the trans-cis isomerisation during a short time treatment of foods. Thus, extensive losses during frying may be probably due to the presence of oil.

Effect of cooking methods on the total carbohydrate content: Figure 3 illustrates the effect of cooking on the total carbohydrate content of plantain and sweet potato. Total carbohydrate contents were: 74.90; 74.91; 72.72 and 73.39 g/100 g DM for unripe and ripe plantain, varieties TIb1 and 1112 of sweet potato. These values decreased significantly ($p<0.05$) after boiling than after frying. On the contrary, after roasting, total carbohydrate content was not significantly higher ($p>0.05$). Losses of total carbohydrate were 7% after boiling against 5 to 8% after frying. In

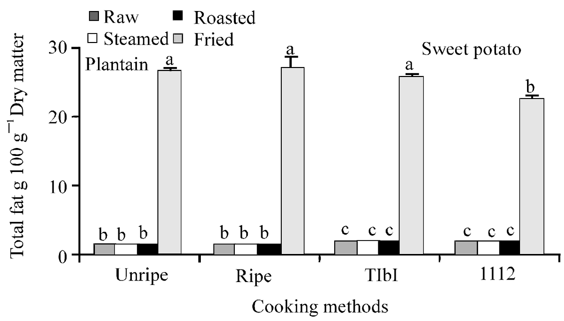

Fig. 4: Effect of cooking methods on total fat contents of plantain and sweet potato. Values for the same stage of maturity or the same variety marked with different letters are significantly different ($p<0.05$)

sweet potato, losses were 4 to 6% after boiling against 7 to 12% after frying. This was in agreement with the results of Bahado-singh *et al.* (2006). Diffusion of free sugar from food to oil during frying and boiling probably explain these losses.

Effect of cooking methods on the total fat contents: The effect of cooking methods on the total fat contents of plantain and sweet potato is presented in Fig. 4. Total lipid contents were 1.25;1.22; 1.82; 1.72 g/100 g DM respectively in raw unripe and ripe plantain, varieties TIb1 and 1112 of sweet potato. There was no significant difference ($p>0.05$) in total fat contents after boiling, frying or roasting. However after frying, fat content increased significantly ($p<0.05$). Absorption of fat was 25 to 26% in plantain and 21 to 24% in sweet potato. These results are similar to those of Demasse-Mawamba *et al.* (2007) who found values of 23.7 to 26% after frying of plantain. During frying, water loss is compensating by the uptake of fat resulting in the increase of this nutrient in the food. The total fat content of chips should be less than 35% to obtain good quality chips (Tchango and Ngalani, 1998).

CONCLUSION

Frying, roasting or steaming of unripe and ripe plantains of the Big Ebanga variety and sweet potato of varieties TIb1 (dark yellow flesh) and 1112 (yellow flesh) lead to significant losses of β-carotene and vitamin C. β-carotene retention was higher after boiling than after roasting or frying. Concerning vitamin C, retention was higher after frying than after roasting or boiling. In sweet potato, retention of β-carotene after cooking varied with variety. Thus, variety TIb1 could be recommended for consumption after boiling to increase provitamin A intake from these foods in Cameroon. Besides the fact that, the raw flesh of this variety had the highest β-carotene content, these foods are normally consumed cooked. Roasting is therefore recommended as the best processing method for the yellow flesh sweet potato. Unripe and ripe plantain is better to be consumed boiled since boiling retained more β-carotene than roasting or frying.

ACKNOWLEDGMENT

We are grateful to International Foundation for Science (IFS) for the financial support (grant E-3584-2).

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