THE HARVESTPLUS/ BIOVERSITY INTERNATIONAL/ FRI PROJECT

Title: Evaluating the potential of banana and plantain diversity to contribute to improved human nutrition

Effect of three cooking methods on the carotenoids, iron and zinc in two varieties of plantain, False Horn (*Apentu*) and French Horn (*Apem*)

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Contents

1.0 Introduction

Plantain is widely consumed in Ghana in three popular processed forms; boiled, roasted and fried forms. The effects of the cooking methods on the some of the micronutrients have not been exhaustively investigated. This short study was therefore to find out what happens to the carotenoids, iron and zinc contents when carried under controlled laboratory conditions.

2.0 Materials and Methods

2.1 Materials

2.1.1 Sample selection:

Two types of plantain, the False Horn (popularly referred to as *Apentu*) and the French Horn (*Apem*) were used for the study. Bunches of plantain samples were obtained from a farm close to Pokuase, a suburb of Accra. The fruit bunches were harvested when one of them had reached the 3-4 stage in ripeness. This was transported and stored at room temperature (28$\pm$1˚C) at the Food Processing laboratory of the Food Research Institute.

2.1.2 Sample preparation:

Samples of fruits were taken from the second bunch of fingers. These were cut and quartered. Two diametrically opposite halves were then cut into chunks and mixed. This sample was divided into three portions. One portion of was put into polyethylene bags and first stored at -20˚C, then lyophilized and stored again at -20˚C for determining the carotenoids contents. Another was acid-digested and used for iron (Fe) and zinc (Zn) determinations. The third portion was used for moisture determination. Sample preparation was from both the unripe (green) plantain were repeated for the ripe type (colour 7).

Fig.2.1 Plantain samples used for studies

2.2 Methods- Cooking Used

Three cooking methods were used. These were frying, roasting and boiling.

2.2.1 Frying

Samples of the ripe plantain were obtained. The weights of the samples were measured before and after peeling, with the unwanted ends removed. The pulp was cut into lamellas of 0.25cm thick and 7-8cm in lengths. These were deep-fat fried in a domestic fryer (model, Tefal Styléo, Paris, France) that was filled with 4.5 liters of vegetable cooking oil (Fig. 2.2). The plantain lamellas were maintained submerged by means of a metal basket. Frying was started after the oil attained a temperature of 180˚C. Frying was completed in 10 minutes.

For the unripe plantains, the pulp was cut into roundels after peeling. These were deep-fat fried using the same equipment and procedure as described above for the ripe. Frying was also completed in 10 minutes. This was done for both the *Apem* and the *Apentu* plantain samples.

Fig. 2.2 Deep-frying sliced plantain samples

2.2.2 Roasting

Samples of the ripe and unripe plantains were weighed before and after peeling. The pulps were cut into lamellas of 3.5cm thick and 10-12cm in lengths. Roasting was done using the General Electric cooker set at 375 ˚C. The samples were turned 2 to 4 intermittently to ensure uniform roasting of the samples. Roasting was completed in 25 minutes for both the unripe and ripe plantains of *Apentu* and *Apem*.

2.2.3 Boiling

The plantains were peeled and weighed. The *Apem* plantain samples were cut into cylinders whilst those of the *Apentu* were cut into lamellas. Distilled water was then added to the plantain samples in the ratio two parts of water to one part of the plantain samples. Cooking was carried out in an aluminium sauce-pan on the burner of the General Electric cooker set at medium-high temperature. The *Apentu* plantain sample was cooked for 20 and 10 min for the unripe and ripe samples, respectively, whilst the *Apem* sample was cooked for 15 min for both the unripe and ripe.

Fig. 2.3 **General Electric burner and oven used for the cooking and roasting.**

2.3 Methods- Determining the Time- Temperature Regimes

The time and temperature regimes used for all three cooking processes (boiling, frying and roasting) were experimentally determined. Treated samples considered well cooked were determined with the help of an in-house trained sensory panel of 6.

2.4 Methods-Analysis Carried Out

2.4.1 Moisture determination

Moisture of both the fresh and the cooked samples was determined using standard procedures (AOAC, 1990). These were done in five replicates for both the ripe and the unripe prepared samples of both the *Apem* and the *Apentu*.

2.4.2 Colour measurement:

This was measured on cut halved fruits of both unripe and ripe plantains. The colour of the cut halves were measured against egg yolk, H+ fan under artificial light set against. The colours were measured using *Musa* descriptors.

2.4.3 Iron and Zinc determination

The iron and zinc contents were determined using the AOAC (1990) method 25.007. Uncooked and cooked samples were acid-digested and the Fe and Zn determined using the atomic absorption spectrophotometer, model Chermo. The determinations were done in triplicates.

2.4.4 Carotenoids Determination

The carotenoids were determined in ripe and unripe False Horn (Apentu) plantains that were variously cooked (untreated, boiled, fried and roasted). The analysis was carried out according to the protocol by Rodiguez-Amaya and Kimura (2004).

Extraction

The lyophilized plantain samples were finely milled into flour using laboratory blender. Two grams (2g) of the flour were measured into a 125 ml conical flask containing 25 mg of magnesium carbonate ($MgCO_3$). Fifty ml (50ml) of cold acetone (acetone refrigerated for about two hours before used) was added. The solution was vortexed for 3 - 5 minutes. The solution was filtered with suction through a sintered glass funnel. Where necessary, the extraction was repeated until the residue was devoid of traces of colour. The extraction was done in triplicates.

Partition

The extracted acetone was poured into a 250 ml separating funnel containing 40 ml petroleum ether (PE). 250 ml distilled water was added along the walls of the funnel. The two phases were allowed to separate and the lower aqueous phase discarded. The washing was repeated three times with 100 ml distilled water per washing. The lower aqueous phase was discarded completely in the last washing. The petroleum ether phase was collected into a 50 ml volumetric flask through a funnel containing small amount of sodium sulphate. More petroleum ether was added to make up the 50 ml mark.

Fig. 2.4 Partitioning using the separating funnel

Spectrophotometric Readings

The absorbance of the sample solutions were read at 450 nm in the CECIL spectrophotometer, CE 1021, 1000 series (Cecil instruments, England, Cambridge). Three readings were taken from each solution making a total of nine readings per sample. The carotenoids were calculated using the formula:

$$\text{Total carotenoids content } (\mu g/g) = \frac{A \text{ x volume (mL) x } 10^4}{A^{1\%}_{1cm} \text{ x sample weight (g)}}$$

Where A= absorbance; volume total volume of extract (50mL), $A^{1\%}$ = absorbance coefficient of β-carotene in petroleum ether (2592).

The value obtained is then multiplied by 100 to give the carotenoid content in µg/100g.

3.0 RESULTS AND DISCUSSION

3.1 Preliminary Results to Determine Cooking Parameters

The results of the preliminary studies to determine the cooking methods are given in the Appendix.

3.2 Moisture content of Plantains

From Table 3.1, it is evident that in the raw fresh state, the French Horn (*Apem*) variety has more moisture than False Horn (*Apentu*) variety. In general, the ripe plantains have more moisture than the unripe. This may be due to break down of the food matrix during ripening. As a result water that hitherto was unavailable becomes available. The table also indicates that boiling results in an increase in moisture whilst roasting and frying caused a reduction in moisture. The increased moisture with boiling is as a result of water ingress during the boiling process, whilst with the roasting and frying there is rather loss of water. The highest reduction in moisture was observed in fried samples of the ripe and unripe plantain samples of the two varieties.

Table 3.1:
***Moisture content of plantains cooked in the laboratory*.**

Plantain	Processing type	% Moisture	
		Unripe	Ripe
Apem	Raw	62.32 ± 0.4869^{a}	64.3933 ± 0.7128^{b}
Apem	Boiled	63.8967 ± 0.7583^{c}	63.8567 ± 0.1677^{d}
Apem	Fried	11.8033 ± 2.5177^{e}	29.52 ± 0.9208^{f}
Apem	Roasted	46.2633 ± 0.4260^{g}	48.1233 ± 1.3744^{g}
Apentu	Raw	57.67 ± 0.8747^{h}	63.05 ± 0.4195^{j}
Apentu	Boiled	69.2367 ± 0.8776^{k}	66.94 ± 0.5196^{m}
Apentu	Fried	24.7033 ± 0.9047^{n}	27.52 ± 1.6200^{n}

Apentu	Roasted	48.76 ± 1.9662p	48.2567 ± 1.0819p

The values represent mean of triplicate (n=3) and their standard deviations (S.D)* Different superscript on the same row shows significant difference ($p \leq 0.05$) while same superscript shows no significant difference.

Table 3.2 shows the moisture content of cooked plantains from two communities in a farming area (Old and New Tafo) in the Eastern Region of Ghana. The trend established for cooked plantains as seen in the laboratory samples was also true with the plantains from Tafo. The boiled samples showed increased moisture content while the fried ones showed reduction. While the size of plantain samples in this case may be a factor contributing to the observed differences in moisture content, the more efficient removal of moisture by heat from the frying oil cannot be overlooked. Thus frying results in moisture reduction. Table 3.2 also shows ripening results in increased moisture as is evident in the Apentu plantains.

Table 3.2:
Moisture content of cooked plantains obtained from household in Old Tafo and New Tafo in the Eastern region of Ghana

Plantain	Processing type	% Moisture Old Tafo	New Tafo
Apentu	Raw	59.92 ± 0.3451	57.4367 ± 1.1461
Apentu	Boiled	62.77 ± 1.1846	62.64 ± 0.5549
Apentu (ripe)	Fried	43.14 ± 5.1089	54.22 ± 2.1617
Apentu (ripe)	Raw	61.64 ± 0.3315	63.0533 ± 0.2765
Apem	Raw	58.14 ± 0.8058	58.3933 ± 0.5084
Apem	Boiled	60.86 ± 0.3676	66.3 ± 0.2452

The values represent the means of triplicates (n=3) and the standard deviations (S.D)

Table 3 shows the moisture content of raw and cooked plantains obtained in households in Accra. The two house-holds had different socio-economic characteristics. Madina is a peri-urban poor area in Accra and Dzorwulu is an emerging middle-class settlement. The table shows that boiling as was the case in the laboratory processed samples, resulted in increased moisture in comparison to the raw. Also, frying resulted in reduction in moisture content. Ripening also resulted in an increase in moisture. The reasons given for the laboratory samples hold for this also.

Table 3.3:
Moisture content of cooked plantains from households in Madina and Dzorwulu (Suburbs of Accra)

Plantain	Processing type	% Moisture	
		Madina	Dzorwulu
Apem	Boiled	63.4967 ± 0.1721	62.84 ± 0.1609
Apem	Raw	56.9 ± 0.0520	Non-available
Apentu	Raw	58.7967 ± 1.9812	Non-available
Apentu	Boiled	64.84 ± 0.1480	64.6733 ± 0.1724
Apentu (ripe)	Fried	33.47 ± 3.0414	48.1733 ± 0.5707

The values represent the means of triplicates (n=3) and the standard deviations (SD)

3.3 Effect of cooking methods on the iron and zinc contents of plantain under controlled laboratory conditions.

The iron concentrations in unripe and ripe stages of the two plantain varieties that have been variously processed (boiled, fried and roasted) are shown in Fig. 1 and 3. In Fig. 1, there is a significant difference between the iron contents of the unripe and ripe samples (AP/UC and AP/RC). From Fig. 2, there are understandable decreases in the iron contents of the plantain after processing by boiling and roasting. The boiled samples in both the ripe and unripe showed the lowest iron concentrations. Leaching of the mineral into the boiling water and/or dilution of the mineral content from absorbed water might have accounted for the observed low values. However when the plantain was fried, there was rather an increase in the iron content. It is difficult to immediately explain the cause of this increase. From Table 1, the moisture content of fried plantain was the lowest, 24.7% compared to respective values of 69.24 and 48.76 % of the boiled and roasted plantain. Thus when considered on the dry matter basis, it would be appear that the high values of the iron contents of the fried plantain was mainly due its comparatively high dry matter content.

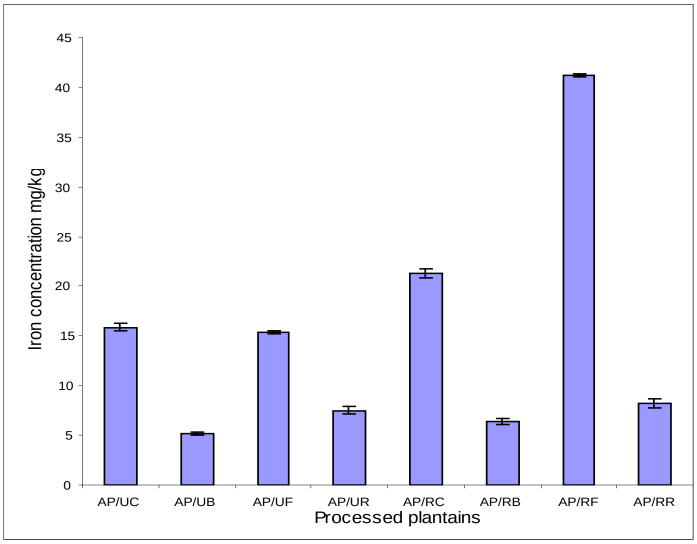

Fig. 3.1 Iron concentration mg/kg in processed Apentu plantains
Error bars represent standard deviations of three replicates (n=3)

Legend:
AP/UC = Unripe Apentu Plantain, Not treated (i.e control)
AP/UB = Unripe Apentu Plantain, Boiled
AP/UF = Unripe Apentu Plantain, Fried
AP/UR = Unripe Apentu Plantain, Roasted

AP/RC = Ripe Apentu Plantain, Not treated (i.e control)
AP/RB = Ripe Apentu Plantain, Boiled
AP/RF = Ripe Apentu Plantain, Fried
AP/RR = Ripe Apentu Plantain, Roasted

With reference to ripening stage and the iron content, it is also clear from Fig. 3.1 that ripening resulted in increase in iron concentration (AP/UC and AP/RC). This could be attributed to lose of some chemical constituents and water. It is also possible that iron migrated from the peel to the pulp during ripening (Ahenkora, *et al*. 1997).

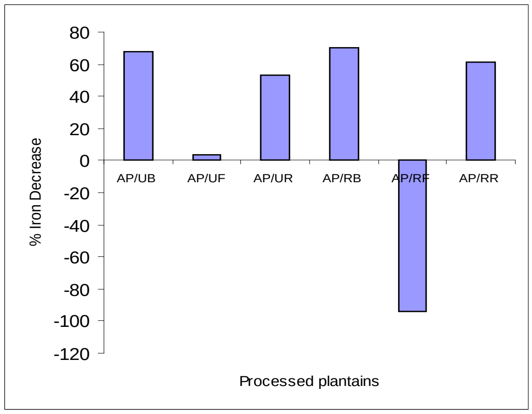

Fig. 3.2 **Percentage decrease in Iron in processed *Apentu* plantain**
Bars represent averages values of three replicates (n=3)

A comparison of Fig. 3.1 and 3.3 shows that the iron content in the *Apem* plantain (var. French horn) plantain is higher than in *Apentu* plantain (var. False Horn). However, in *Apem*, it is the ripe fried sample that showed very high iron concentration while the unripe fried samples had comparable iron content. When the *Apem* plantain was fried, Fig 4 shows that there was a 150% increase in iron content over the unprocessed ripe *Apem*. Unfortunately, fried ripe *Apem* is not popular dish among plantain consumers in Ghana. Promotion of its consumption at the household levels and in restaurants could help in the goals of the project of improving the nutrition through Musa-based foods. The high/increased iron content in the fried plantains may be due to efficient removal of water by the frying process so that the iron in the plantain is more concentrated and/or due to higher dry matter content. From Fig. 3.3, boiling of the *Apem* plantain (ripe and unripe) all resulted in decreases in the iron content. The lost could be due to leaching or a dilution of the inherent iron content from water absorbed from the cooking process. It is important to note that ripening process did not result in a significant increase in the iron contents in the *Apem* (French Horn var.) plantain (Fig. 3.3).

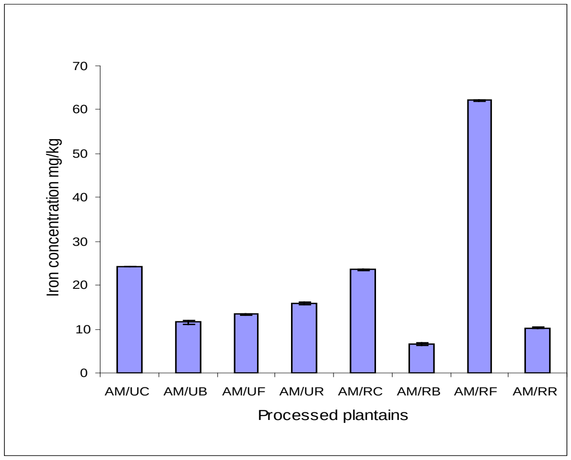

Fig. 3.3 Iron concentrations in processed Apem plantains
Error bars represent standard deviations of three replicates (n=3)

Legend:
AM/UC = Unripe Apem Plantain, Not treated (i.e control)
AM/UB = Unripe Apem Plantain, Boiled
AM/UF = Unripe Apem Plantain, Fried
AM/UR = Unripe Apem Plantain, Roasted

AM/RC = Ripe Apem Plantain, Not treated (i.e control)
AM/RB = Ripe Apem Plantain, Boiled
AM/RF = Ripe Apem Plantain, Fried
AM/RR = Ripe Apem Plantain, Roasted

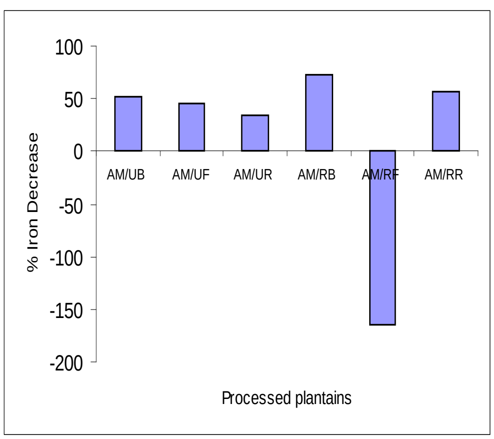

Fig. 3.4 Percentage decrease in Iron in processed Apem (French Horn) plantain
Bars represent average values of three replicates (n=3)

Fig. 3.5 and 3.7 show the zinc contents in two plantain varieties processed by boiling, roasting and frying. From Figure 3.5, it is evident that with the exception of ripe roasted plantain, all the cooking processes resulted in higher zinc levels than the unprocessed. The increases in zinc observed in the processed samples cannot be easily explained. While contamination from personnel cannot be completely ruled out, it is possible that the cooking utensil contributed. For instance, the boiled samples for both the ripe and the unripe recorded the highest zinc concentration in the respective categories. Similar contributions could have come from the oil used in frying or the frying vessel and also the tray used in the oven during roasting. The percentage increases in Zinc in the unripe and ripe boiled are about 700 and 650 respectively. These are quite high values.

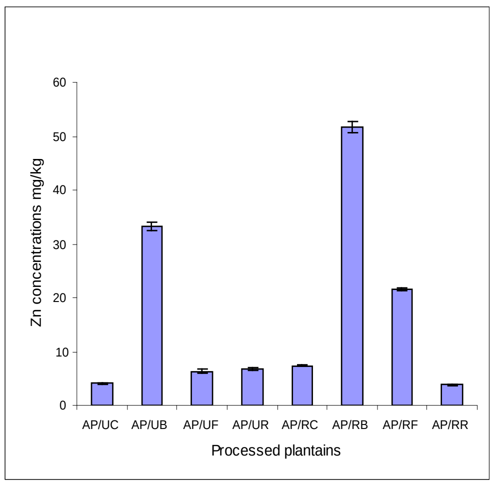

Fig. 3.5 Zinc concentration mg/kg in processed Apentu plantains

Error bars represent standard deviations of three replicates (n=3)

NB. Legend is as in Fig. 3.1

It is noteworthy that in the *Apentu* plantains, all the unripe processed plantains showed higher zinc concentration than the raw/unprocessed one. In the ripe samples however, but for the roasted sample, all of them recorded higher zinc levels than the unprocessed. The higher concentration of zinc observed in processed plantains could be due to the processing which makes iron in the plant material more available for analysis than in the raw.

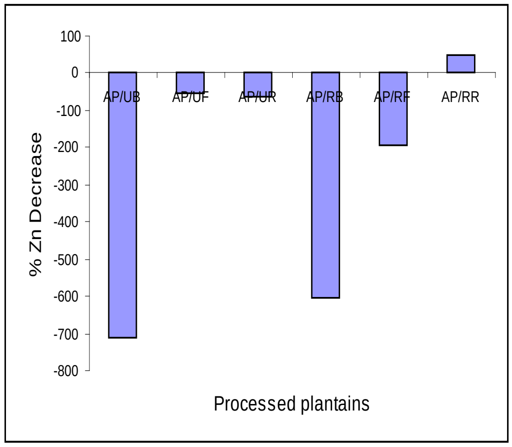

Fig. 3.6 **Percentage changes in zinc contents after processing False Horn plantains *(Apentu)* by boiling, frying and roasting**

Error bars represent averages values of three replicates (n=3)

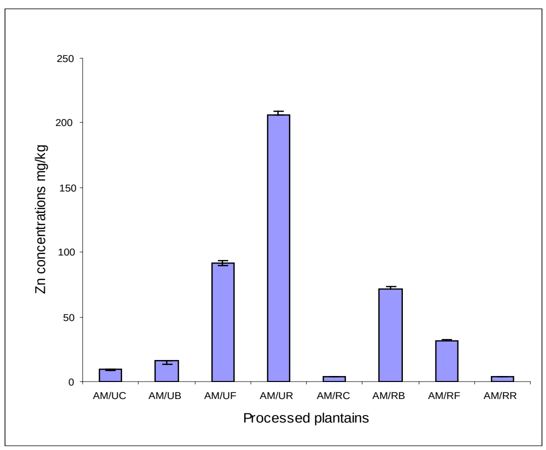

Fig. 3.7 **Zinc contents (mg/kg) in processed French Horn plantains (*Apem*)**
Error bars represent standard deviations of three replicates (n=3)

NB. Legend is as in Fig.3.3

In *Apem* (Fig. 3.7), all the processed plantains (boiled, fried and roasted) had higher Zinc concentrations than the raw unprocessed samples in both the ripe and unripe. The highest value was seen in unripe roasted *Apem* plantain. It is possible that processing (boiling, frying and roasting) resulted in the destruction or weakening of the food matrix so that Zinc that was not available for analysis in the raw food samples now becomes available.

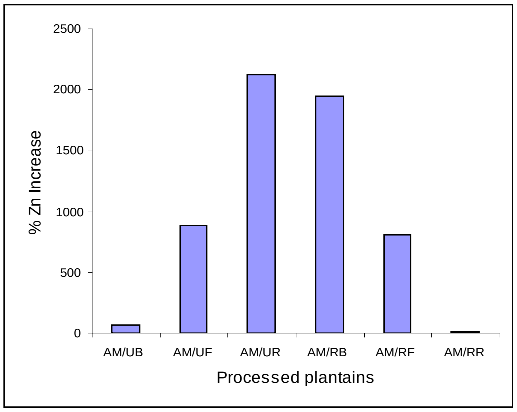

Fig. 3.8: Percentage increase in Zinc in processed *Apem* plantains
Bars represent mean of three determinations (n=3)

In the Apem plantain, there were only increases in zinc in the processed plantains (Fig. 3.8). The highest increase over the raw /uncooked plantain was seen in roasted unripe plantain. The ripe boiled sample also showed quite a high increase. The suggestion is therefore that processed plantains have more zinc than the unprocessed.

3.4 Iron and Zinc Contents in Households Cooked Plantains

Table 3.4:

Iron concentrations (mg/kg) of cooked plantains from Madina and Dzorwulu households (Accra)

Plantain	Processing type	Iron	
		Madina	Dzorwulu
Apentu	Raw	5.4567 ± 0.0833	Non available
Apentu	Boiled	7.0533 ± 0.0404	23.68 ± 0.2524
Apentu (ripe)	Fried	11.51 ± 0.3236	7.42 ± 0.0436
Apem	Raw	7.3667 ± 0.1804	Non available
Apem	Boiled	14.5367 ± 0.2458	4.38 ± 0.05

The values represent the means of triplicates (n=3) and the standard deviations (SD)

Table 3.4 shows the iron concentration of plantains obtained from two different households in different communities in Accra. The iron concentration in the Madina plantains all increased after cooking (boiling and frying). Although the data from

Dzorwulu is not complete, it seems to suggest a similar trend as seen in the Madina samples. The values for the raw samples are comparable with what is available in food composition data on plantain (Eyeson & Ankrah, 1975). The differences in the plantains in the two households could be the results of different sources since the soil content of iron will affect the iron concentration in the product and also the cooking conditions (temperature, time and utensil used in cooking).

Table 3.5:
Iron content (mg/kg) of cooked plantains from rural area, Old and New Tafo (Eastern Region- Ghana)

Plantain	Processing type	Iron Old Tafo	 New Tafo
Apentu	Raw	5.6267 ± 0.2026	6.4467 ± 0.1305
Apentu	Boiled	4.0233 ± 0.0208	4.61± 0.1015
Apentu (ripe)	Raw	10.4733 ± 0.1795	7.46 ± 0.4151
Apentu (ripe)	Fried	7.52 ± 0.2364	3.5567 ± 0.2355
Apem	Raw	9.7976 ± 0.0379	5.5467 ± 0.0902
Apem	Boiled	9.66 ± 0.2163	3.4133 ± 0.1436

The values represent the means of triplicates (n=3) and the standard deviations (SD)

In Table 3.5, the results are consistent with what the laboratory prepared samples gave. For all the two communities, the iron concentration decreased after cooking (boiling and frying). Generally the samples from Old Tafo showed higher iron concentration than the samples from New Tafo. The values are comparable with those reported by Eyeson and Ankrah (1975).

Table 3.6:
Zinc content (mg/kg) of cooked plantains from Madina and Dzorwulu households (Accra).

Plantain	Processing type	Zinc Madina	 Dzorwulu
Apentu	Raw	3.6533 ± 0.1589	Non-available
Apentu	Boiled	15.68 ± 0.1778	13.3233 ± 0.2419
Apentu (ripe)	Fried	6.81 ± 0.1652	5.5167 ± 0.4219
Apem	Raw	5.58 ± 0.2390	Non-available
Apem	Boiled	7.6 ± 0.2910	16.5767 ± 0.4834

The values represent the means of triplicates (n=3) and the standard deviations (SD)

Table 3.6 shows the zinc levels of plantains that were variously processed from Madina and Dzorwulu. The zinc levels increased in all of the samples after cooking. Reasons given for this in earlier discussion apply to this.

The zinc contents of cooked and raw plantains from Tafo (Old & New) do not show any particular trend. While boiling of Apentu plantains increased zinc in Old Tafo, it decreased it in samples from New Tafo even though marginally. In contrast, frying resulted in an increase in zinc in New Tafo while for those from Old Tafo, there was a decrease. Boiled Apem showed increased zinc in New Tafo but a reduction was observed for the samples from Old Tafo.

Table 3.7:
Zinc content (mg/kg) of cooked plantains from Old and New Tafo (Eastern Region-Ghana)

Plantain	Processing type	Zinc (in mg/kg)	
		Old Tafo	New Tafo
Apentu	Raw	3.5467 ± 0.3691	4.6433 ± 0.4272
Apentu	Boiled	13.4467 ± 0.1387	3.4233 ± 0.4620
Apentu (ripe)	Raw	6.5967 ± 0.4234	3.7 ± 0.4176
Apentu (ripe)	Fried	3.44 ± 0.3274	12.5 ± 0.3209
Apem	Raw	5.36 ± 0.3672	4.1933 ± 0.1701
Apem	Boiled	2.7767 ± 0.2021	12.5267 ± 0.1914

The values represent the means of triplicates (n=3) and the standard deviations (SD)

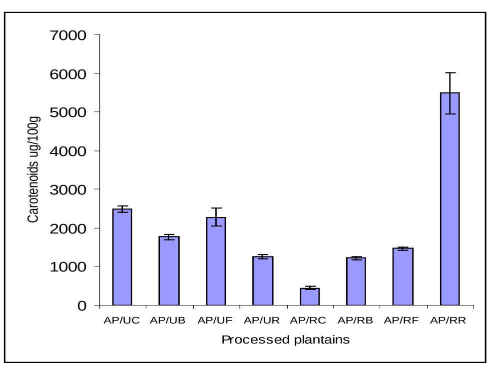

Fig. 3.9 Carotenoids concentration µg/100g in processed plantains
Error bars represent standard deviations of nine reading from three replicates (n=3)

The carotenoid concentration on processed (boiled, fried and roasted) Apentu plantains for the ripe and the unripe is shown in Fig. 3.9. A comparison of the carotenoid level for the unripe and the ripe uncooked plantains (AP/UC and AP/RC) shows a reduction in pulp content of plantain. The reason for such reduction is not quiet clear. This is because, the ripe plantain has the peel changed from green to yellow which colour change is also observable in the pulp. It is therefore expected that the ripe plantain will show high carotenoid content. One possible reason will be the break down or lost of other carotenes so that the carotene that codes for yellow became significant and thus the overall decrease in carotenoid concentration. It is also interesting to note all the ripe processed plantains (boiled, fried and roasted) showed higher carotenoid content than the ripe unprocessed. The increased carotenoid concentration is conspicuously evident in ripe roasted plantain.

It is possible that the vegetable oil used in frying contributed to such high carotenoids observed in the fried plantains. For instance, in the unripe fried plantain, the value recorded for carotenoid was almost equal to the level obtained for the unripe and unprocessed while in the ripe, the level was high the in the unprocessed. However, it is expected that the high temperature treatment of boiling and roasting will result in a decrease in carotenoids. From Fig. 3.8, it is clear that for maximum retention of carotenoids in unripe plantain, frying should be chosen over the others followed by boiling while in the ripe, roasting results in the highest carotenoid concentration. The high carotenoid in the roasted ripe plantains indeed is an observation that cannot be easily explained. It is possible that in roasted ripe, the roasting process led to concomitant production of other substances (organic in nature e.g. Maillard reaction products) that have chemical properties close to the carotenoids that were extracted along the carotenoid.

4.0 CONCLUSIONS & RECOMMENDATIONS

From the results presented and discussed above, the following conclusions could be drawn on the processing effect on the iron, zinc and carotenoid content of plantains.

- Boiling and roasting resulted in loses in iron in both the Apentu and Apem. However, frying resulted in increases in iron concentration in the ripe and the unripe plantains.
- Generally the zinc content in all the processed plantains was higher than the unprocessed. The highest concentrations were seen in those boiled for the Apentu plantain while in the Apem the unripe roasted and the ripe boiled had the highest zinc concentrations.
- There was a general decrease in carotenoids in the unripe Apentu due to processing while in the ripe the opposite was true, with the highest occurring in ripe fried plantain.

In general, processing results in changes in plantains. However such changes may be influenced by the processing conditions or type (boiling, frying or roasting), the ingredients (oil) and the utensils.

The moisture content increased in the boiled plantains while it reduced in both the fried and the roasted plantains, with frying showing the greater reduction. The moisture content of Apem (French) plantains was higher than the Apentu (False Horn) plantains.

A few recommended follow up studies are:

- An in-depth study of the real effect of the cooking methods on the zinc contents in the two varieties plantain. What has been obtained in this present study is unclear.
- Secondly, there will be the need to use more advanced methods, like use of High Performance Liquid Chromatography (HPLC) to in-depth study on the real effect on the micronutrients studied.
- There may be the need to vary slightly the cooking methods used. For example instead of peeling before processing, cooking could done with the peel on (i.e. in the jacket as its done for some foods like potato) especially for ripe plantain and

investigate how this could compare with the traditional methods of processing plantain in Ghana.

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6.0 Appendix

The tables below show the results obtained in the preliminary cooking processes for the plantain samples at the different stages of ripeness.

Table 6.1:
Weights, cooking time and temperatures of unripe False Horn plantain (Apentu) during roasting at different time and temperatures

WEIGHTS (g)			
Before Peeling	After peeling	Roasting Temp (ºC)	Roasting Time (min)
326.53	200.89	350	30
311.05	200.04	375	27
331.12	208.51	400	20

Table 6.2:
Weight of unripe French Horn plantain (Apem) during roasting at different time and temperatures

WEIGHTS (g)			
Before peeling	After peeling	Roasting Temp (ºC)	Roasting Time (min)
152.75	95.34	350	30
135.84	89.09	375	26
149.27	94.01	400	18

Table 6.3:
Weights, cooking time and temperatures of ripe False Horn plantain (Apentu) during roasting at different time and temperatures

WEIGHTS (g)			
Before Peeling	After Peeling	Roasting Temp (ºC)	Roasting Time (min)
584.88	366.30	350	30
513.50	310.91	375	26
575.19	370.46	400	22

Table 6.4:
Weights, cooking time and temperatures of unripe French Horn plantain (Apem) during roasting at different time and temperatures

WEIGHTS (g)			
Before peeling	After peeling	Roasting Temp (ºC)	Roasting Time (min)
181.01	127.82	350	30
167.40	110.64	375	27
140.76	1033.55	400	20

Table 6.5:
Weights and cooking times during deep-fat frying of ripe False Horn plantain (Apentu) at 180 ºC

Initial wt (g)	Wt after peel (g)	Wt before frying (g)	Wt after frying (g)	Time (min)
446.74	310.60	241.94	184.91	5
367.60	252.92	191.77	112.54	10
430.90	304.25	216.72	112.62	15

Table 6.6:
Weights and cooking times during deep-fat frying of unripe French Horn plantain (Apem) at 180 ºC

Initial wt (g)	Wt after peel (g)	Wt before frying (g)	Wt after frying (g)	Time (min)
373.95	225.10	164.34	96.74	5
385.08	233.00	158.47	91.15	10
328.02	189.39	131.93	75.75	15

Note: It was from the results in Tables 6.1 to 6.6 that helped to establish the appropriate cooking times and temperatures regimes as below:

Table 6.7:
Weights, colour codes and moisture contents of unripe and ripe boiled plantains.

	Weight (g)				**Colour code**		**Moisture (% wb)**	
	Before Peeling	After Peeling	Wt. before boiling	Wt after boiling	Before	After	Before	After
Unripe *Apentu*	512.67	290.12	241.46	267.97	Near 1	3-4	60.98	65.23
Unripe *Apem*	500.92	280.02	234.08	256.77	2-3	5-6	59.00	63.44
Ripe *Apentu*	527.30	332.51	256.54	280.61	2	3	64.30	68.84
Ripe *Apem*	270.51	181.47	144.02	148.02	4-5	5	63.55	64.14

Table 6.8:
Weights, colour codes and moisture contents of unripe and ripe roasted plantains.

	WEIGHTS (g)				**Colour Code**		**Moisture (% w.b)**	
	Before Peeling	After Peeling	Wt. before Roasting	Wt after Roasting	Before	After	Before	After
Unripe Apentu	791.32	447.03	377.82	253.99	Near 1	<1	60.98	37.88
Unripe Apem	591.79	343.54	308.96	220.62	2-3	<1	59.0	46.81
Ripe Apentu	382.85	252.80	234.58	152.51	2	2-3	64.30	52.64
Ripe Apem	289.77	193.71	185.61	123.92	4-5	2-3	63.55	53.07

Table 6.9:
Weights, colour codes and moisture contents of unripe and ripe deep-fat fried plantains.

	Weight (g)				Colour Code		Moisture (% w.b)	
	Before Peeling	After Peeling	Wt before Frying	Wt after Frying	Before	After	Before	After
Unripe *Apentu*	762.07	405.72	380.28	209.45	Near1	3-4	60.98	20.19
Unripe *Apem*	646.12	346.67	311.79	181.80	2-3	4-5	59.00	12.44
Ripe *Apentu*	308.69	199.08	194.07	124.25	2	9-8	64.30	39.86
Ripe *Apem*	266.47	182.76	156.00	109.58	4-5	9-8	63.55	36.27

Table 6.9
Changes in pulp to peel ratio of plantain as it ripens

Plantain sample	**Pulp to peel ratio of plantains**	
	Ripe	**Unripe**
Apentu	1.67 ± 0.1374	1.70 ± 0.1015
Apem	2.38 ± 0.4173	1.76 ± 0.1313

The pulp to peel ratio is expressed as weight of pulp divided by the weight of the peel. From the above table, the pulp to peel ratios of the two plantain cultivars (Apem and Apentu) showed contrasting trends from the unripe to the ripe. While in the Apentu there was a reduction in the ratio from the unripe to the ripe, the opposite was true in the Apem plantain. The different trends in pulp to peel ratio in the two plantains could not be easily explained.