

*Full Length Research Paper*

# Losses in $\beta$ -carotene and vitamin C due to frying of plantain (*Musa paradisiaca*) chips

Demasse Mawamba Adelaide<sup>1</sup>, Gouado Inocent<sup>1\*</sup>, Leng Marlyse<sup>1</sup>, Ejoh Aba Richard<sup>2</sup>,  
Njinkoue Jean Michel<sup>1</sup> and Tchouanguiep Mbiapo Felicite<sup>3</sup>

<sup>1</sup>Department of Biochemistry, Faculty of Science, PO Box 24157, Douala, Cameroon.

<sup>2</sup>Department of Food Sciences and Nutrition, PO Box 455, University of Ngaoundéré, Cameroon.

<sup>3</sup>Department of Biochemistry, University of Dschang, PO Box 67, Dschang, Cameroon.

Accepted 17 June, 2006

**Slices of plantain (unripe and ripe) of 0.5, 1 and 2 mm thickness were fried at  $130 \pm 5$ ,  $150 \pm 5$  and  $170 \pm 5^\circ\text{C}$  for 1 to 10 min in refined palm oil. The results obtained showed that  $\beta$ -carotene and vitamin C contents decreased significantly with the elevation of the temperature and duration of frying ( $p < 0.05$ ). The decrease is more important when the thickness of the slices is reduced. Water losses and lipids absorption depend also on the temperature, duration of frying, thickness of plantain and the maturation stage of the plantains. Optimum frying conditions were plantain slices thickness of 1 mm, frying temperature of  $150^\circ\text{C}$  for 5 to 7 min.**

**Key words:** Plantain, frying, chips,  $\beta$ -carotene, vitamin C.

## INTRODUCTION

Vitamin A deficiency still remains a primordial cause of morbidity and mortality mostly in developing countries. In Cameroon, it is a public health problem with high severity in all parts of the country (Kollo et al., 2000). Considering the different available food sources in the country, several sources of vitamin and provitamin A can be identified, but vitamin A deficiency persists due to low availability of micronutrients in the diet. The amount of micronutrients ingested from the diet is often low compared with the unprocessed raw food items. It has been shown that provitamin A levels in foods could be reduced by up to 90% by processing (Penelope and Ritu, 2003). In addition to supplementation, the use of dietary sources is one of the principal means of fighting micronutrients deficiencies. The improvement of the food processing methods for micronutrient rich staples is therefore highly essential.

Processing of plantain into chips is one of the ways to reduced post harvest losses of this crop. These chips are highly consumed in Cameroon (Dury et al., 1998). It is well known that processing of foods modifies their nutrients contents. Micronutrients like  $\beta$ -carotene and vitamin

C play a vital role in the stimulation of immunity, and are active against cardiovascular diseases and some forms of cancers.  $\beta$ -Carotene supply 70 to 90% of dietary vitamin A (Donald and Martin, 2002).

Researches on chips are limited to the determination of some physicochemical parameters. In view of the role of  $\beta$ -carotene and vitamin C in human nutrition, this study is aimed at determining the effect of frying on the  $\beta$ -carotene and vitamin C levels of plantain chips. The effects of temperature, duration of frying, plantain slices thickness, stage of maturation of the plantain and water and total lipids contents of the chips obtained were evaluated to provide data on the best conditions for frying that will minimise losses of these nutrients.

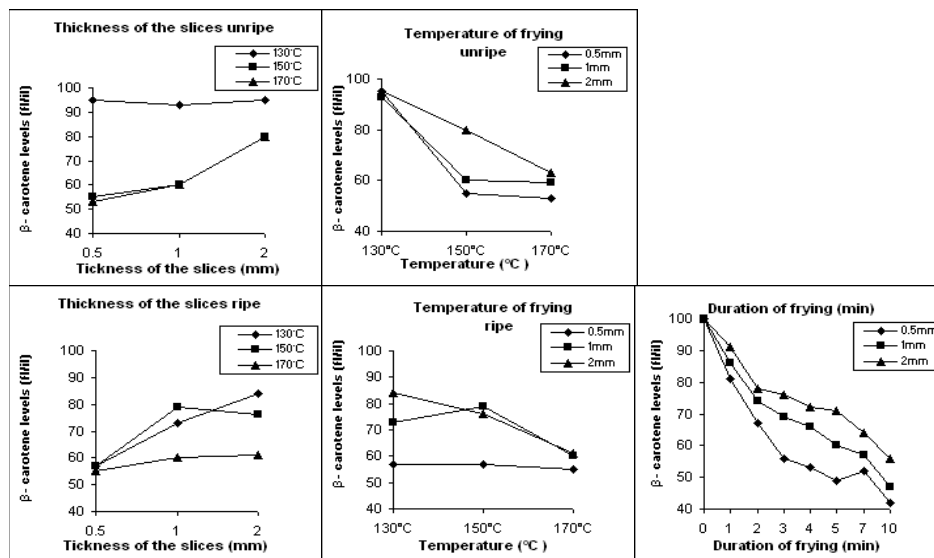
## MATERIALS AND METHODS

### Plantain chips production

The *Big Ebanga* variety of plantain and refined CDC (Cameroon development cooperation) palm oil obtained from the Douala main Market were used in the study. The plantain variety has a yellow pulp and in Cameroon, it is used regularly to make chips.

Unripened Plantains (green stage) collected from the market were divided in two parts. The first part was used immediately and the second part stored in the laboratory until they were ripe (green with yellow spots stage) and ready for the production of chips. The

\*Corresponding author. E-mail: [gouadoi@yahoo.fr](mailto:gouadoi@yahoo.fr).



**Figure 1.** Levels of  $\beta$ -carotene in plantain chips due to temperature, duration of frying and thickness of the slices.

unripe and ripe plantains were washed, peeled and the pulp was sliced into 0.5, 1, and 2 mm thicknesses. The sliced plantains were immediately fried in oil heated previously at 130, 150 and 170°C with the ratio of 20 g/l (plantains/oil). The sliced plantains were fried for 1, 2, 3, 4, 5, 7, and 10 min and divided into 4 portions. The different portions were then stored in dark hermetic small bottles. Two portions were immediately used for the evaluation of water and vitamin C contents respectively by AOAC method (1980) and titration with 2,6 dichlorophenol indophenol (Harris and Ray, 1935). The two other portions were frozen at -16°C for 24 h before analysis of total lipids (Bergeret, 1955) and  $\beta$ -carotene by open column chromatography (Simpson et al., 1987).

### Statistical analysis

Data were expressed as mean and standard deviation. Analysis of variance (ANOVA) was used to determine the effect of different parameters (temperature and duration of frying, thickness of the slices and stage of maturation). The Pearson's linear correlation was used to determine the relationship between the different parameters. The least significant difference was also done using the DUNCAN multiple range tests. All statistical analyses were done using the SigmaStat program, version 2.03 (SPSS, 1995).

## RESULTS

### Effect of frying on vitamin C and $\beta$ -carotene contents

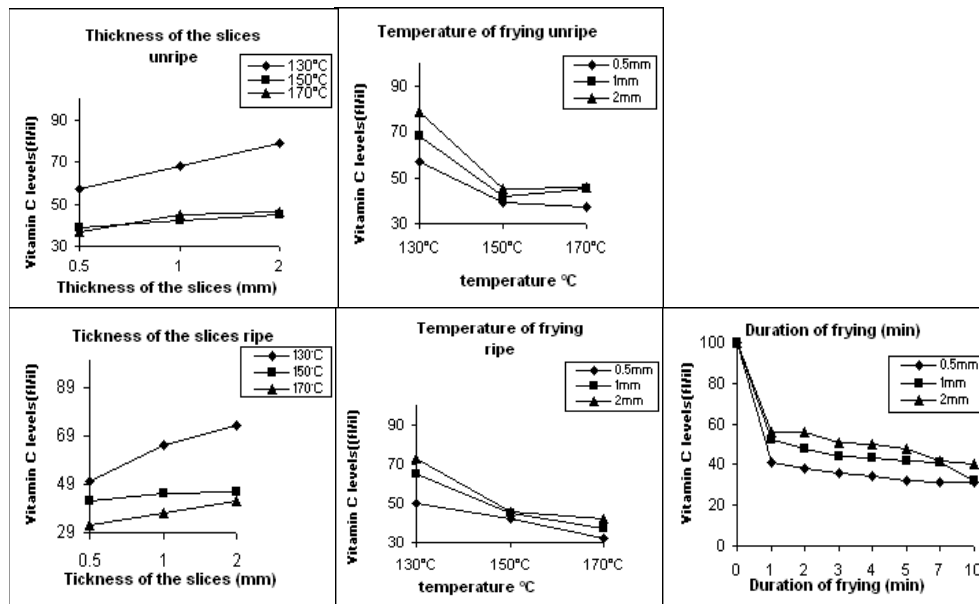
The levels of  $\beta$ -carotene and vitamin C of chips remaining after frying are dependent on the temperature of frying, the duration of frying and the thickness of the slices.  $\beta$ -carotene losses are significantly higher ( $p < 0.05$ ) for the slices of 0.5 mm compared with the other slices (Figure 1). About 40, 30 and 20% of  $\beta$ -carotene are lost from the slices of 0.5, 1 and 2 mm, respectively, when fried at 150 and 170°C. Similarly,  $\beta$ -carotene losses are significantly higher ( $p < 0.05$ ) when the slices are fried at

170°C (about 50% loss) as compared to those fried at 130°C (10% loss). However, the effect of the temperature tends to decrease with the ripening. The loss of  $\beta$ -carotene is significantly different for the different frying temperatures except in 0.5 mm slices where no significant variations were observed when they were fried using different temperatures.

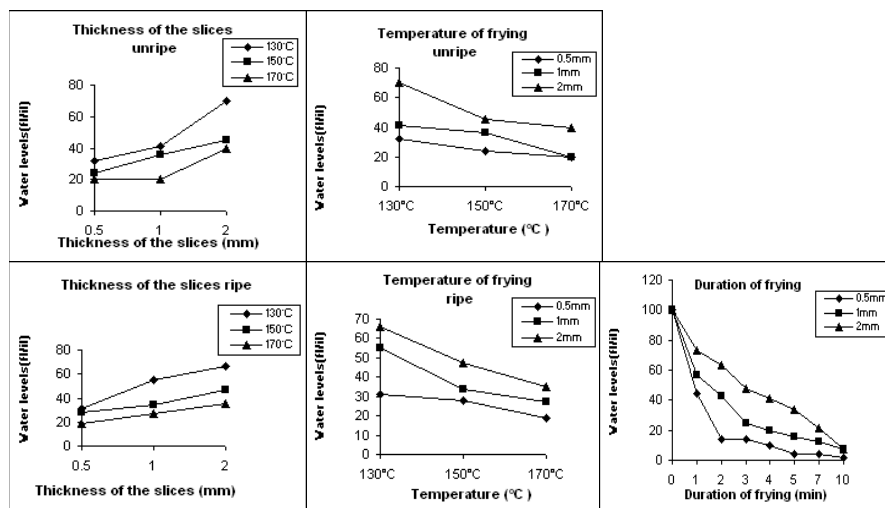
Vitamin C losses at the start of frying are high (Figure 2) especially when the temperature is highest at 170°C (about 50% loss). Vitamin C losses increase as the thickness of the slices is reduced. Losses of vitamin C are significantly higher ( $P < 0.05$ ) for the slices of 0.5 mm thickness (about 43 to 70% of loss). The rate of vitamin C losses increases significantly ( $P < 0.05$ ) with increase in temperature (54 to 70% losses for the slices fried at 150 and 170°C against 20 to 43% for those fried at 130°C).

### Effects of frying on the total lipids and water contents

Water losses are higher during the three first minutes of frying (Figure 3). The extent of losses depends on the temperature of frying and the thickness of the slices. Slices of 0.5 mm thickness loose ( $p < 0.05$ ) higher quantities of water (68 to 81%) than 2 mm slices (30 to 65%). However, the effect of the thickness of the slices decreases with the ripeness. Moreover, slices fried at 170°C loose significantly higher quantities of their water ( $p < 0.05$ ) (about 60 to 80%) compared with those fried at 130°C (30 to 70%). The total lipids content of the chips depend also on the duration and the temperature of frying and the thickness of the slices (Figure 4). Lipids absorption is at the maximum during the first minute of frying and this is independent of the temperature of frying and the thickness of the slices. The quantity absorbed is sig-



**Figure 2.** Levels of vitamin C in plantain chips due to temperature, duration of frying and thickness of the slices.



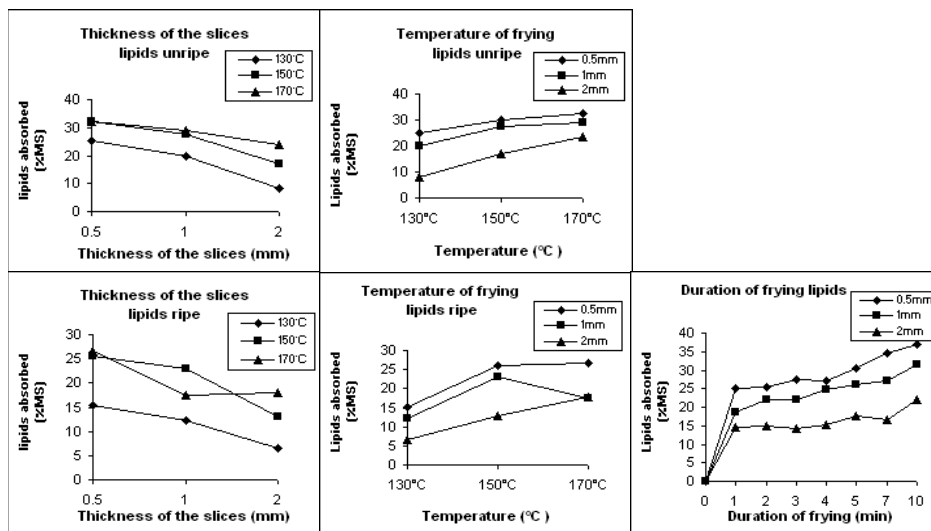
**Figure 3.** Levels of water in plantain chips due to temperature, duration of frying and thickness of the slices.

nificantly higher ( $p < 0.05$ ) when the thickness of the slices is reduced. Slices of 0.5 mm thickness absorbed 15 to 32% of lipids as against 26 to 23.7% for 1 and 2 mm slices. Furthermore, lipids content of slices fried at 170°C is higher ( $p < 5\%$ ) (17.4 to 32.4%) than those fried at 130°C (8.7 to 26%).

## DISCUSSION

During frying, the thinner the slices, the higher the water loss and the lipids absorbed. These results are similar to those obtained in potato by Gamble and Rice (1987) and

Leng et al. (1997). These authors revealed that the increase in thickness of the slices causes resistance to the loss of water and absorption of the lipids. This resistance is eliminated by the softening of the pulp due to ripening especially when the thickness of the slices is reduced. This explains why the difference between  $\beta$ -carotene losses of ripe chips of 0.5 mm is not significantly different. The exchange between water and lipids during frying were also noted by Guillaumin (1988), Lamberg et al. (1990) and Raoult-Wack (1994). This confirms the significant correlation between water losses and lipids absorption. This correlation explains why slices fried at



**Figure 4:** Levels of total lipids in plantain chips due to temperature, duration of frying and thickness of the slices.

**Table 1.** Correlations between losses of vitamin C,  $\beta$ -carotene, water and oil absorption in plantain chips during frying at different temperatures.

Parameters	T°C thickness	Total lipids			$\beta$ -carotene			Vitamin C		
		130°C	150°C	170°C	130°C	150°C	170°C	130°C	150°C	170°C
Water	0.5 mm	-0.98 <sup>a*</sup>	-0.97*	-0.89*	0.76*	0.86*	0.98*	0.97*	0.98*	0.95*
		-0.83 <sup>b*</sup>	-0.91*	-0.88*	0.89*	0.93*	0.94*	0.91*	0.82*	0.94*
	1 mm	-0.98*	-0.95*	-0.95*	0.76*	0.98*	0.96*	0.97*	0.86*	0.97*
		-0.86*	-0.77*	-0.92*	0.95*	0.79*	0.94*	0.99*	0.82*	0.86*
	2 mm	-0.91*	-0.84*	-0.89*	0.76*	0.91*	0.89*	0.99*	0.87*	0.81*
		-0.86*	-0.76*	-0.73*	0.86*	0.93*	0.93*	0.98*	0.85*	0.76*
Total lipids	0.5 mm				-0.56	-0.9*	-0.86*	-0.95*	-0.97*	-0.98*
					-0.56	-0.77*	-0.97*	-0.79*	-0.94*	-0.76*
	1 mm				-0.67	-0.97*	-0.87*	-0.95*	-0.93*	-0.99*
					-0.71*	-0.52	-0.96*	-0.87*	-0.84*	-0.87*
2 mm				-0.47	-0.78*	-0.95*	-0.87*	-0.92*	-0.90*	
				-0.72*	-0.46	-0.88*	-0.94*	-0.88*	-0.88*	
$\beta$ - carotene	0.5 mm							0.76*	0.94*	0.77*
								0.77*	0.76*	0.82*
	1 mm							0.79*	0.87*	0.79*
								0.91*	0.76*	0.79*
	2 mm							0.70*	0.91*	0.89*
								0.82*	0.79*	0.89*

\*5 % significant.

a: Ripe chips.

b: Unripe chips.

130°C which has the high content of water absorbs a lesser quantity of lipids.

$\beta$ -carotene losses observing during frying may be due to the heat brought in when oil gets into the slices. This hypothesis may be true for the moment where the corre-

lation is significant for the slices fried at 170°C as compared with those fried at 130°C. It has been showed that heat brings about cis-trans isomerisation of some double bonds and the consequence is the modification of the colour and the nutritional value of the diet (Simpson et al.,

1987). These results obtained for  $\beta$ -carotene is in conformity with the observations of Penelope and Ritu (2003) who showed that high temperature and chopping lead to  $\beta$ -carotene losses. The positive and significant correlation between the losses of  $\beta$ -carotene and water (Table 1) may confirm the exchange occurring during frying where oil replaces the holes left by water after diffusion. Similarly, the negative and significant correlation between oil absorption and vitamin C losses may be also due to the heat brought in by the oil during absorption. Furthermore, since vitamin C is water soluble, it could diffuse simultaneously with the water. This diffusion may contribute to the losses during frying as shown by the positive and significant correlation between water and vitamin C losses.

Frying at 150°C for 5 to 7 minutes was also found to be optimum. A simple regression model was determined only for the variation of the vitamin C losses of ripe chips with the equation:

$$Y = 0.41 - 0.08t - 0.149T + 0.074e$$

Where t, T and e are the duration of frying, temperature of frying and the thickness of the slices, respectively.

In conclusion,  $\beta$ -carotene and vitamin C losses during frying are link to the behaviour of physicochemical parameters during the water/lipids exchange.

## ACKNOWLEDGEMENT

We thank the international Foundation for Sciences (IFS) and Nutrition Third World (NTW) for the financial support offered to the second author through the research grants n° - 35841.

## REFERENCES

- AOAC (1980). Official methods of analysis, 11<sup>th</sup> ed., WILLIAM HORWITZ edv., Washington D.C.
- Bergeret B (1955). La chimie analytique dans un laboratoire d'outre mer. Organisation du laboratoire : Etude des techniques d'analyses employées au laboratoire de la section l'IECAM- ORSTOM. IRCAM, pp: 56.
- Donald McL.S, Martin F (2002). Troubles dus à la carence en vitamine A (TCVA). Sigh life. pp: 172.
- Dury S, Bricas N, Tchango Tchango J, Biko A (1998). La consommation et les critères de qualité du plantain à Douala et Yaoundé In : Bananas and food security. International Symposium. Douala-Cameroun.10-14 November 1998: 507-523.
- Gamble MH, Rice P (1987). Effect of pre-fry drying oil uptake and distribution in potato crisp manufacture. Int. J. Food Sci. Technol. 22(5): 535-542.
- Guillaumin R (1988). Kinetics of fat penetration in food. In: Frying of food; principles, changes, new approaches. Ellis Horwood, Chichester, UK. pp: 82 – 92.
- Harris IJ, Ray SN (1935). Determination of ascobic acid in urine. Method: using titration with dichlonophenol indophenol. Lancet 1(76): 4862.
- Kollo B, De Bernadi R, Sibetcheu D, Nankap M, Tata Ngoh J, Gimpou MM, hakoua A, haselow NJ (2000). Enquête nationale sur la carence en vitamine A et l'anémie au Cameroun. pp : 60.
- Lamberg I, Hallostrom B, Oisson H (1990). Fat uptake in potato drying/frying process. *Lebensm. Wiss. Technol.* 23: 295-300
- Leng MS, Ndjouenkeu R, Etoa FX, Raoult-Wack AL (1997). Influence de quelques conditions de prétraitement sur la cinétique de friture des chips de patate douce. Récent progrès en génie des procédés.11. 9(59) : 131 – 138.
- Penelope N, Ritu N (2003). Food preparation practices can affect provitamin A carotenoid content and bioavailability. ILSI. Human Nutr. Insti. pp: 3.
- Raoult-Wack AL (1994). Recent advance in the osmotic dehydration of foods. *Trend Food Sci. Technol.* 5(8): 50 255 – 260.
- Simpson KL, Tsou STC, Chichester CO (1987). Biochemical methodology for assessment of carotenes. Monograph published by IVACG, Washington. pp: 47.
- SPSS (1995). SigmaStat for Windows version 2.03 Copyright, 1992-1997, SPSS Inc.