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Effect of Different Temperatures and Exposure Times on Acrylamide Formation in Banana Chips. (*Musa paradisiaca*)

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Abstract

Acrylamide (AA) is known as a probably carcinogenic to humans and its detection in common heated starch-rich foodstuffs has attracted public attention and worldwide monitoring of this substance in various food products. This study investigates the effect of temperature and exposure times on AA formation in banana chips (*Musa paradisiaca).* A High Performed Liquid Chromatography (HPLC) method was employed to analyze the acrylamide content. All cassava samples had significant concentrations of AA, while in the control sample (without treatment) AA was not detected. The highest acrylamide content (840 $\mu g.kg^{-1}$) was found when banana chips were subjected to 160°C for 7 minutes, while the lowest value 90,60 $\mu g.kg^{-1}$ was obtained when exposed to 120°C during 3 minutes. However, when the temperature was set at 180 °C, the concentration of A.A the level increased to 920 $\mu g.kg^{-1}$, when the exposure time was 7 minutes. The results found can contribute to improving the adjustment processes and being able to predict the concentrations of AA in the banana chips subjected to different temperatures and cooking times.

Keywords: Acrylamide, HPLC, *Musa paradisiaca.*

1 Introduction

Banana is the fourth most important crop in the world, it is considered a commodity and export, source of employment and income in many developing countries. The product that enters international trade is from Latin American and Caribbean countries, among which is Colombia. It belongs to the traditional sector of peasant production and occupies little significant areas in family farms for domestic consumption. It is a fundamental part of the diet of Colombians [1].

The chemical composition of the banana in different physiological states per 100 grams of fresh fruit is presented in the following table 1.

Table 1. Chemical composition of banana.

Component	Unit	Banana Endocarp	
		Immature	Mature
Energy	Kcal	99	122
Wáter	G	63	65
Proteín	G	0,8	1,3
Total lípidstotales	G	0,1	0,37
Carbohydrates	G	24,3	32
Dietary fiber	G	5,4	2-3.4
Na^{+}	Mg	-	4
K^{+}	Mg	-	500
Ca^{++}	Mg	7	3
Mg^{++}	Mg	33	35
P	Mg	35	30
Fe	Mg	0,5	0,6
Cu	Mg	0,16	-
Zn	Mg	0,1	-
Mn	Mg	15	-
Eq. β-Carotenes	Mg	0,03-1,2	390-1095
Vitamin C	Mg	20	20
Thiamine	Mg	0,05	0,08
Riboflavin	Mg	0,05	0,04
Niacin	Mg	0,7	0,6

Source: Aurore et al., 2009 [2].

It should be highlighted that during food processing (heating) many chemical contaminants could be formed [3]. The impact of these contaminants on consumer health is evident only after many years of ingestion. An example of such chemical contamination of food is AA. It is believed that AA has the potential to increase the risk of cancer. AA is a crystalline toxic compound that could be formed in foods, especially in foods with high levels of starch [4, 5, 6]. Additionally, chronic exposure to AA, even at low levels can result in neurotoxicity in both animals and humans.

Although there have been many studies about the presence of AA in foods such as pre-prepared croquettes [3], fried plantain chips [7] baked cookies [8]. There is almost no information regarding the formation of AA in Colombian cassava. Therefore, this study focuses on determining the content AA by HPLC in green banana subjected to both different temperatures and exposure times.

2 Materials and methods

Samples

As a study sample, banana slices were used, cut in a shaped way. Was carried out in a 2L commercial deep-fat fryer in sunflower oil at different temperatures (100, 120, 140, 160 and 180°C). The temperature of the heating medium was measured by an automatic temperature control system. Each frying temperature was maintained during varying durations (3, 5 and 7 minutes). Finally, the excess of oil was removed with paper after samples' removal from the fryer.

HPLC-analysis

The AA content in banana chips was analyzed in triplicate using an Agilent 1200 Series HPLC system (Agilent Technologies Inc., CA, USA). The sample preparation procedure involved the AA extraction with 80% methanol in water defatting with hexane. A Zorbax XDB C-18 column (4.6mm x 150mm, 5µm) and a UV detector were employed. Five different levels (50, 100, 200, 400, 600 and 800, 1000 µg.kg-1) were studied in order to build the calibration curve, where 20 µg/L was the limit of quantification. The column temperature was set at 24ºC, the sample injection volume was 20µL and the mode of elution used was isocratic with the mobile phase consisting of (1:24 v/v) acetonitrile/water with a flow rate of 0.5 mL/min.

Statistical analysis

Data were analyzed using SPSS software (ver 17.0 for windows). Analysis of Variance (ANOVA) and Tukey test was performed in order to establish differences of mean values. Significant difference was determined at $p < 0{,}05$.

3 Results

Acrylamide was found in all Cassava samples analyzed except the control sample (without thermal treatment). Significant differences ($p < 0.05$) in AA content were found between the banana chips at different temperatures and different exposure times as can be shown in table 2. These differences could be explained by the fact that AA is mainly formed in the outer layer exposed to heat and it should be considered that heat transfer is efficient during deep-frying process.

Table 2: Acrylamide concentration ($\mu g.kg^{-1}$) in banana chips at different temperatures and exposure times.

Temperature (°C)	Time (minutes)	Mean ±SD ($\mu g.kg^{-1}$)
100	1	Nd
120	3	90,60±0.44^{a}
120	5	110,00±0.2^{a}
120	7	121,0±0.47^{b}
140	3	146,0±0.10^{c}
140	5	270,1±0.12^{d}
140	7	390,8± 0.20^{e}
160	3	576,20±0.1^{f}
160	5	710,40±0.1^{g}
160	7	840,0± 0.3^{h}

*The values of columns with the same superscripts indicate no significant statistical difference. Nd: not detected. --: control sample (not treated)

Levels between 90,60 and 840($\mu g.kg^{-1}$) were found at the end of the thermal treatment (Table 1). The highest AA 920±0,61) was obtained when the green banana was subjected at 180 °C during 7 minutes.

It should be noted there was an increase in AA concentration when the temperature increased from 120 to 180°C. Thus suggesting a directly proportional relationship between temperature and exposure time with resulting

4 Discussion

In this study, the levels of AA encountered were compared with others food matrixes because there is a lack of literature data on the AA content in banana. The findings showed in this paper are in disagreement with those reported by Pedreschi et al., [9] who found acrylamide content at the level of 370 mg/kg in pre-prepared French fries. These discrepancies were probably due to different sugar reducing contents. The amount of AA found within the foods is related to the quantities of precursors as reducing sugars and amino acids (asparagine). Michalak et al., [3] reported high amounts of acrylamide in croquettes treated with pan-frying and deep-frying (285 and 298 mg/kg, respectively).

The highest AA obtained at 180° C could mean a reduction in AA levels when there is an increase in frying time from 5 to 7 minutes. A possible explanation for this reduction is due to degradation of AA or incomplete pyrolysis. It should be highlighted that the presence of AA in food is generated from the Maillard reaction, which involves the interaction between the free amino group of amino acids or proteins and the carbonyl group of sugars or carbohydrates [10]. The decarboxylation and deamination of asparagine have also been suggested .possible pathway for the formation of acrylamide. Although various mechanisms have been proposed for the formation of AA, the level of asparagine and reducing sugars are the main factors [8].

The AA concentrations reported in the present study (90,60 – 840 $\mu g.kg^{-1}$) are greater than those published by Bent et al., [10].

5 Conclusion

The lowest value (7.07 mg/kg) was obtained at 120°C during 3 minutes. These findings can contribute to possible industrial applications of cassava chips in the development of new alimentary products. Furthermore, this study could help to formulate strategies and guidelines for reducing acrylamide in a variety of high temperature processed food products that can bring down the exposure of this toxicant to the population.

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