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Proximate Analysis of the Paste of Three Varieties of Peanuts (Arachis Hypogaea) Consumed in Côte D'ivoire

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Abstract **Original Research Article**

Peanuts (Arachis hypogaea) since colonization have been an obligatory crop in Ivory Coast. It is currently the culture of women par excellence in the North of Côte d'Ivoire and especially in Korhogo. Almost the entire production is consumed on site and mainly in the form of peanut paste. The objective of this study is to determine the nutritional composition of peanut pastes of three varieties produced in Côte d'Ivoire. To achieve this, three varieties of peanut were studied and named according to their morphological characteristics (large striated shell (Gcs), medium striated shell (Mcs) and small smooth shell (Pcl). These grains were transformed into paste then subjected to analyzes to know their physicochemical characteristics. The results of statistical analysis showed significant differences at P ± 0.05. The variety that contains the least water is (Pcl), it will better resist microbial proliferation. Gcs peanut paste was much richer in fat with a value of 45.088 ± 0.19% and also contained myristic acid (2.976 ± 0.008%) and linolenic acid (0.263 ± 0.002%). As for the Pcl variety, the linoleic and oleic acid contents were dominant compared to the other varieties respectively with values of 1.139 ± 0.006 and 0.412 ± 0.002%. Furthermore, regarding proteins, the Pcl variety presented a high level of proteins (29.00 ± 1.75%), however, arginine, methionine, cysteine and glutamic acid are absent.

Keyword: Peanut paste, analyses, physicochemical, shell, smooth, striated.

INTRODUCTION

Man has consumed fatty substances since ancient times. They are present in animals, frequently in the form of fats while in plants in the form of oils in oilseed fruits and seeds such as the peanut (Arachis hypogaea). Arachis hypogaea, like most oilseeds, occupies an important place in the human diet. It is a good source of lipids (50%), proteins (25 to 30%) and mineral salts. In addition, its seeds contain 5 to 12% carbohydrates and 3% fiber. Studies carried out in the United States have shown that twice-weekly consumption of peanuts and/or peanut products improved the quality of diets (Griel *et al.*, 2004). Produced mainly in the northern and central regions of Côte d'Ivoire (ANADER, 2009), peanut production was estimated at 88,000 tonnes (FAOSTAT, 2008). However, all of this production is consumed on site and mainly in the form of peanut paste (Diakité *et al.*, 2017). The preparation of peanut paste in our households is done under certain conditions which call into question its nutritional and microbiological quality. In addition, they claim that the peanut paste does not deteriorate regardless of the weather. Thus, they produce it in large quantities for long-term use. In order to evaluate the nutritional and microbiological quality of peanut paste stored over a long period, we set ourselves the objective in this study of determining the nutritional value of peanut pastes of three varieties consumed in Côte d'Ivoire.

I- MATERIALS AND METHODS

The material used for this work consists of peanut grains (Figure 1). We used three varieties of peanut which we named the large striped shell variety 'Gcl', the medium striped shell variety 'Mcl' and the small smooth shell variety 'Pcl'.

A: Peanut grain of the 'Pcl' variety, **B:** Peanut kernel of the 'Mcs' variety, **C:** Peanut kernel of the 'Gcs' variety

Figure 1: Photograph of the grains of the three varieties of peanuts

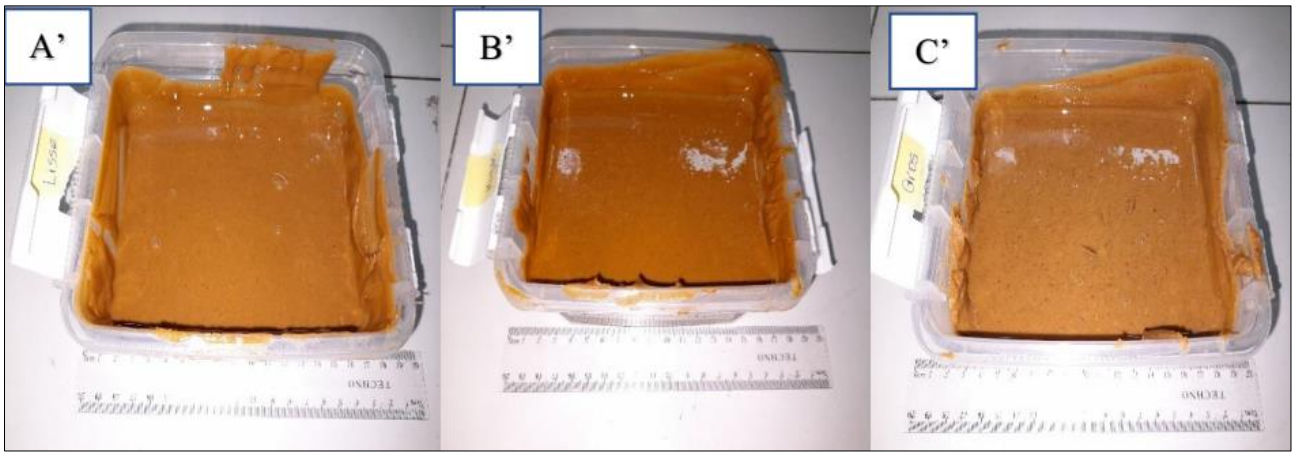
II. METHODS

1. Sampling

The three varieties (large, medium and smooth) were all harvested at physiological maturity in different plantations in Korhogo, a town located in the Pôrô region and 569 km from Abidjan, part of the large Savanes district in the North of the Coast, of ivory. They were then dried in the sun (35□C) for 10 days before being transported in jute bags to the Biocatalysis and Bioprocesses Laboratory of the Food Science and Technology Training and Research Unit of the Nangui Abrogoua University (Abidjan, Ivory Coast) for studies. Once at the Laboratory, each variety was shelled and subjected to the process of transformation into paste.

2. Process for Obtaining Peanut Paste

The peanut shells are washed in tap water and dried for 2 to 3 days. Subsequently, they are broken to remove the seeds and sort to remove rotten seeds and foreign bodies. Then the seeds are roasted and then cooled. All the seeds being cold, the next step is to remove their skins, then we move on to winnowing. The final step was the grinding which allowed us to obtain the paste which we kept in plastic bowls (Figure 2).



A: Peanut paste of the 'Pcl' variety**, B:** Peanut paste of the 'Mcs' variety, **C:** Peanut paste of the 'Gcs' variety

Figure 2: Photograph of peanut pastes obtained from the grains of three peanut varieties

3. Physico-Chemical Analyzes of Foods

3.1. Water and Dry Matter Contents

The determination of humidity and dry matter was carried out according to the AOAC method (1990). Ten (5) g of each sample contained in the crucible were then placed in a BIOBASE brand oven (Shandong, China) at 105°C until constant mass. The dried sample crucible assembly was cooled in a desiccator for 30 min. Then the mass of the crucible containing the dried peanut paste sample was determined. The dry matter (% DM) and humidity were calculated according to the following formulas:

$$\%\mathbf{Humidity} = \frac{\mathbf{M1} - \mathbf{M2}}{\mathbf{M2}} \times \mathbf{100}$$

$$\%\mathbf{MS} = \mathbf{100} - \%\mathbf{Humidity}$$

Me: mass (g) of the fresh sample; **M1**: mass (g) of the whole (crucible+sample) before steaming; **M2**: mass (g) of the whole (crucible + sample) after baking; **MS**: dry matter

3.2. Fiber Content

The crude fiber content of the peanut paste was determined according to the method of (AOAC, 1990). Two (6) g of each dried and crushed sample were homogenized in 50 mL of sulfuric acid (0.25 N). The mixture was boiled for 30 min under reflux condenser. Then, 50 mL of sodium hydroxide (0.31 N) was added to the contents of the flask and boiled once again for 30 min under reflux condenser. The extract obtained after boiling was filtered through WHATMAN No. 4 filter paper and the residue was washed several times with boiling water (100 °C) until the alkalis were completely eliminated. The residue was dried in an oven at 105°C for 8 h. It is cooled in a desiccator then weighed. The residue obtained was incinerated in an oven at 550°C for 3 h, cooled in a desiccator, then the ash was weighed. The crude fiber rate was given by the following formula:

$$\textbf{Crude fiber}\ (\%) = \frac{(\mathbf{m_1} - \mathbf{m_2})}{\mathbf{m_e}} \times \mathbf{100}$$

$\mathbf{m_1}$: masse (g) du résidu séché ; $\mathbf{m_2}$: masse (g) des cendres obtenues ; $\mathbf{m_e}$: masse (g) de l'échantillon.

3.3. Lipid content

The lipids were extracted with hexane (organic solvent) from the peanut paste according to the method (AOAC, 1990) using SOXHLET. Sixty (60) g of dried and crushed sample were introduced into a previously tared WHATMAN cartridge. A volume of 300 mL of hexane was poured into an extraction flask previously weighed empty. The flask containing hexane (m0) was placed on the cap and heated to reflux at 110°C for 7 h. After this extraction time, the flask was removed from the SOXHLET apparatus and placed in an oven at 100°C for 20 min for total evaporation of the solvent using a rotary evaporator (HEILDOLPH Laborata 4003 Control, Schwabach, Germany). Once evaporation was complete, the flask was reweighed (mL). The lipid content was determined from the following equation:

$$\textbf{Lipids}(\%) = \frac{(\mathbf{m_0} - \mathbf{m_1})}{\mathbf{m_e}} \times \mathbf{100}$$

$\mathbf{m_0}$: mass (g) of the empty balloon; me: mass (g) of the sample;
$\mathbf{m_1}$: mass (g) of the whole (flask + lipids) after evaporation of the hexane.

3.4. Fatty Acid Contents

The chromatographic profile of the fatty acids was carried out according to the NF ISO 6320 (1978) method. It includes two major stages: sample preparation and dosage by gas chromatography.

a. Preparation of Methyl Esters

Fatty acid methyl esters of food lipids were prepared according to ISO 5509 (1978) using the boron tri-fluoride reagent. One hundred (100) mg of oil sample was dissolved in 3 mL of solvent consisting of 1.5 mL of hexane and 1.5 mL of BF3/Met OH contained in a 10 mL screw test tube. The tube was sealed under vacuum, then shaken vigorously for 2 min at room temperature (28°C) before being heated at 100°C for 1 hour. After cooling to room temperature (28°C), one (1) mL of hexane and 0.5 mL of distilled water were added and then the whole was stirred under vacuum. Two phases separated after standing on the bench at room temperature (28°C). The upper phase was collected in another evacuated tube. Then 5 mL of hexane was added to the methyl ester mixture to adapt it for gas chromatographic analysis.

b. Gas Chromatography Analysis

The analysis of methyl esters was carried out on a gas chromatograph (HP 6890 series GC system, GERMANY) equipped with a flame ionization detector according to Standard ISO 5509 (1978). They were separated on an HP-5 capillary column (30 cm length, 0.32 mm internal diameter, whose film thickness was 0.25µm) in the presence of diphenyl (5%, w/v) and dimethyl-polysiloxane (95%, w/v) with an oven temperature programming increasing from 60 to 325°C at a rate of 1°C/min. The injector temperature was set at 275°C and the detector temperature at 325°C. The inlet pressure of nitrogen, used as a carrier gas, varied from 6.90 to 47.6 pka. The flow rate was maintained at 1 cm/minute and the dead time was 1 minute 15 seconds (hydrogen 40 cm/sec). Peaks were identified using reference fatty acid methyl esters by comparing the retention distances of each peak in the chromatogram with those obtained from the standards.

3.5. Protein Content

The crude protein level was determined according to the method (AOAC, 1990) using Kjeldhal. One (1) gram of each sample was heated at 400 °C for 120 min in the presence of a pinch of the catalyst mixture (selenium + potassium sulfate (K2SO4)) and 20 mL of sulfuric acid (H2SO4) 95 -97% in a digester (BUCHI, France). The mineralization obtained was made up to 60 mL with distilled water. To this volume, 50 mL of soda (40%, w/v) were added before being brought to the boil in a LEGALLAIS type distiller. The ammonia which was released was trapped in a measuring vessel containing ten (10) mL of the acid-base mixture (4%, w/v) mixed indicator (methyl red + bromocresol green) at pH 5.1. The dosage was carried out using a decimolar solution of sulfuric acid. A blank was carried out under the same conditions as the test. The protein level was determined according to the following formula:

$$\textbf{Crude protein}\ (\%) = \frac{(\mathbf{V_1} - \mathbf{V_0}) \times \mathbf{14} \times \mathbf{6,25} \times \mathbf{N}}{\mathbf{m_e}} \times \mathbf{100}$$

$\mathbf{V_0}$: volume (mL) of sulfuric acid solution poured for the blank test;
$\mathbf{V_1}$: volume (mL) of sulfuric acid solution poured for the test (sample);
N: normality of the sulfuric acid solution (0.1N);
me: mass (g) of the sample;

14: atomic mass of nitrogen;
6.25: Conversion coefficient of nitrogen into proteins.

3.6. Amino Acid Content

The total amino acid contents of the foods were determined according to the standardized method ISO 13903 (2005) using ninhydrin. A mass of food of 100 mg was dissolved in 1 mL of hydrochloric acid (6N) contained in a flask. The flask was heated to 110°C in a tank for 23 hours then dried under a flow of nitrogen. The dry residues were taken up in 0.5 mL of citrate buffer and the pH was adjusted to 2.20. The volume was adjusted to 1l with distilled water. A 0.5 mL aliquot was diluted ¼ with this buffer. Forty (40) µL of the test were placed in a mini vial. Each solution was injected into a high-performance liquid chromatograph (Amino Tac JLC-500/V, GERMANY) into an analytical column lined with a cation exchange resin. The identification of the amino acids in the different samples was made by comparing the retention times of the amino acids of the samples to the retention times of the standards. Concentrations were determined using the average of the peak areas of each of the standard amino acids. Thus, the concentration (CE) of each amino acid of each of the samples expressed in mg/Kg of proteins relative to dry matter is given by the following mathematical relationship:

$$\mathbf{CE} = \frac{\mathbf{Area\ E \times CT}}{\mathbf{Area\ T}} \qquad (7)$$

4- Statistical analyzes

All measurements were carried out in triplicate. Analyzes were performed in triplicate. The EXCEL 2013 software was used for the representation of graphs as well as for the calculation of means and standard deviations. Statistical analyzes of the data were carried out using STATISTICA 7.1 software (Addinsoft Sarl, Paris-France). Comparisons between dependent variables were determined using one-way analysis of variance (ANOVA) and the DUNCAN test. Statistical significance was defined at the 5% threshold. The means and standard deviations of all analysis results were processed with STASTICA 7.1 and compared with each other.

II- RESULTS AND DISCUSSION

II-1- Results

1.1. Water Content

The water content of our different peanut pastes differs significantly at P<0.05. The large ribbed shells contain more water than the others, their value being 2.19 ± 0.13 (figure 3).

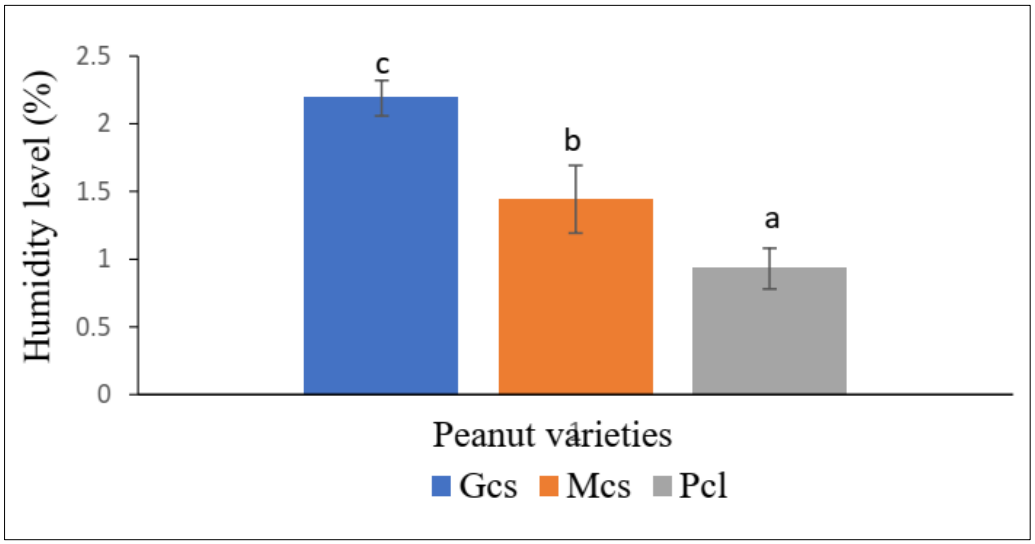


Figure 3: Moisture content of different peanut varieties

The same letters assigned to the averages mean that they are not different at the 5% threshold.
Gcs: large ribbed shell; **Mcs**: medium ribbed shell; **Pcl**: small smooth shell.

1.2. Lipid Content

The lipid contents of the three peanut varieties studied are statistically different at P□0.05. Indeed, the lipid level in peanut 'Gcs' is estimated at 45.088± 0.19 and those of 'Mcs' and 'Pcl' are respectively 24.923±0.61 and 38.419±0.40 (figure 4).

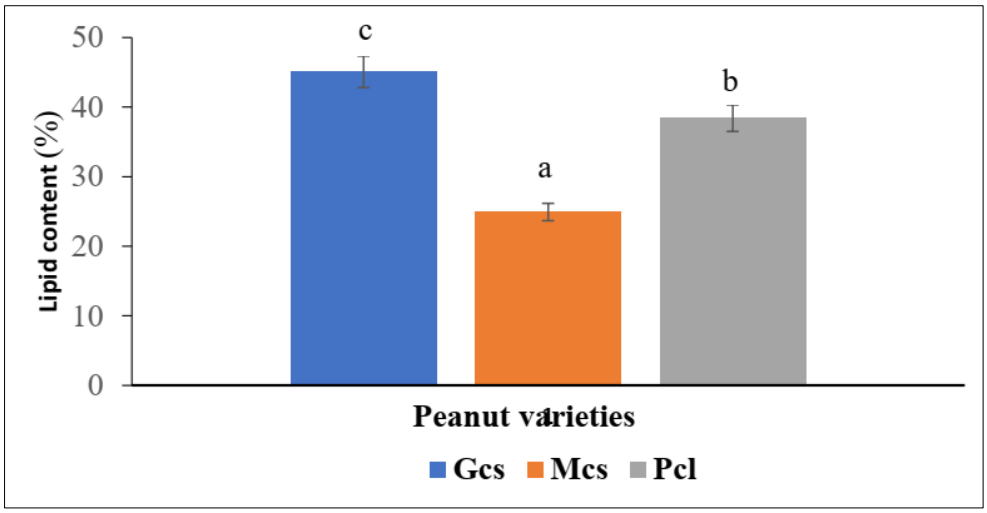


Figure 4: Lipid levels of different varieties of peanuts.

The same letters assigned to the averages mean that they are not different at the 5% threshold.
Gcs: large ribbed shell; **Mcs**: medium ribbed shell; **Pcl**: small smooth shell.

1.3. Fatty Acid Content

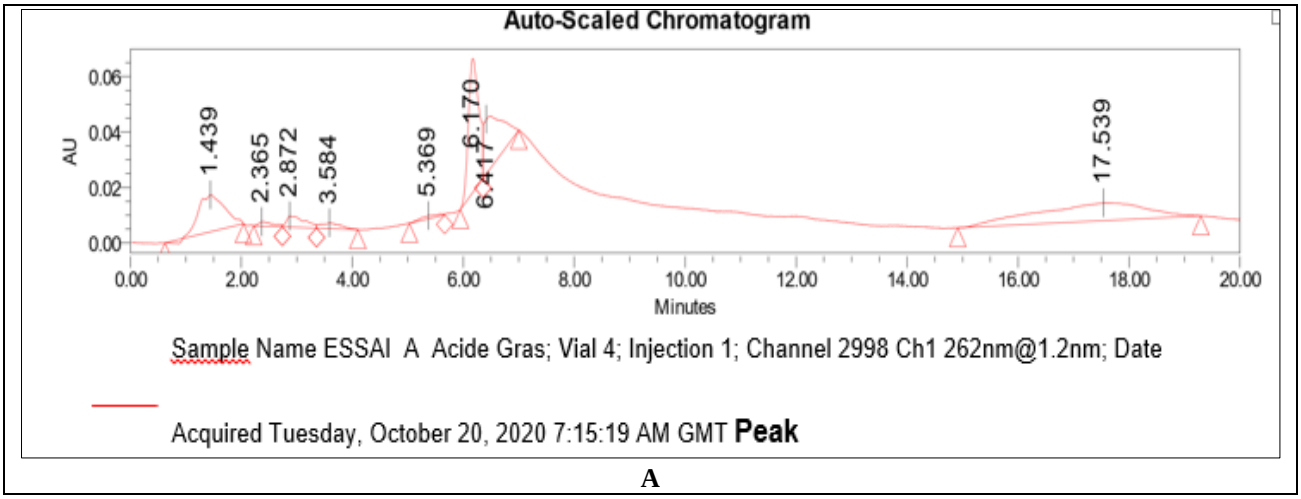
The fatty acid content of different peanut pastes differs significantly at the 5% threshold. Six (6) fatty acids were found in the different varieties of peanut. The "large grain" and "medium grain" varieties are very rich because all the fatty acids are present: myristic, palmitic, oleic, linoleic, linolenic and arachidic acids. On the other hand, in the "smooth grain" variety, palmitic acid and linolenic acid are absent (Table I).

Table I: Fatty acid content of different peanut varieties

Types of fatty acids	Fatty acid content (%)		
	Gcs	**Mcs**	**Pcl**
Myristic acid C14:0	2,976 ± 0,008 [c]	0,373 ± 0,004 [a]	2,723 ± 0,007[b]
Palmitic acid C16:0	0,361 ± 0,002 [b]	0,323 ±0,001 [a]	------
Oleic acid C18:1	0,292 ± 0,004 [b]	0,083 ± 0,001 [a]	0,4122 ± 0,002[c]
Linoleic acide C18:2	0,457 ± 0,003 [b]	0 ,325 ± 0,002 [a]	1,139± 0,006[c]
Linolenic acid C18:3	0,263 ± 0,002 [b]	0,003 ±0,003 [a]	------
Arachidic acid C20:0	1,000 ± 0,002 [b]	1,057 ± 0,002 [c]	0,674 ± 0,001 [a]

The same letters assigned to the averages mean that they are not different at the 5% threshold.

Gcs: large ribbed shell; **Mcs**: medium ribbed shell; **Pcl**: small smooth shell.



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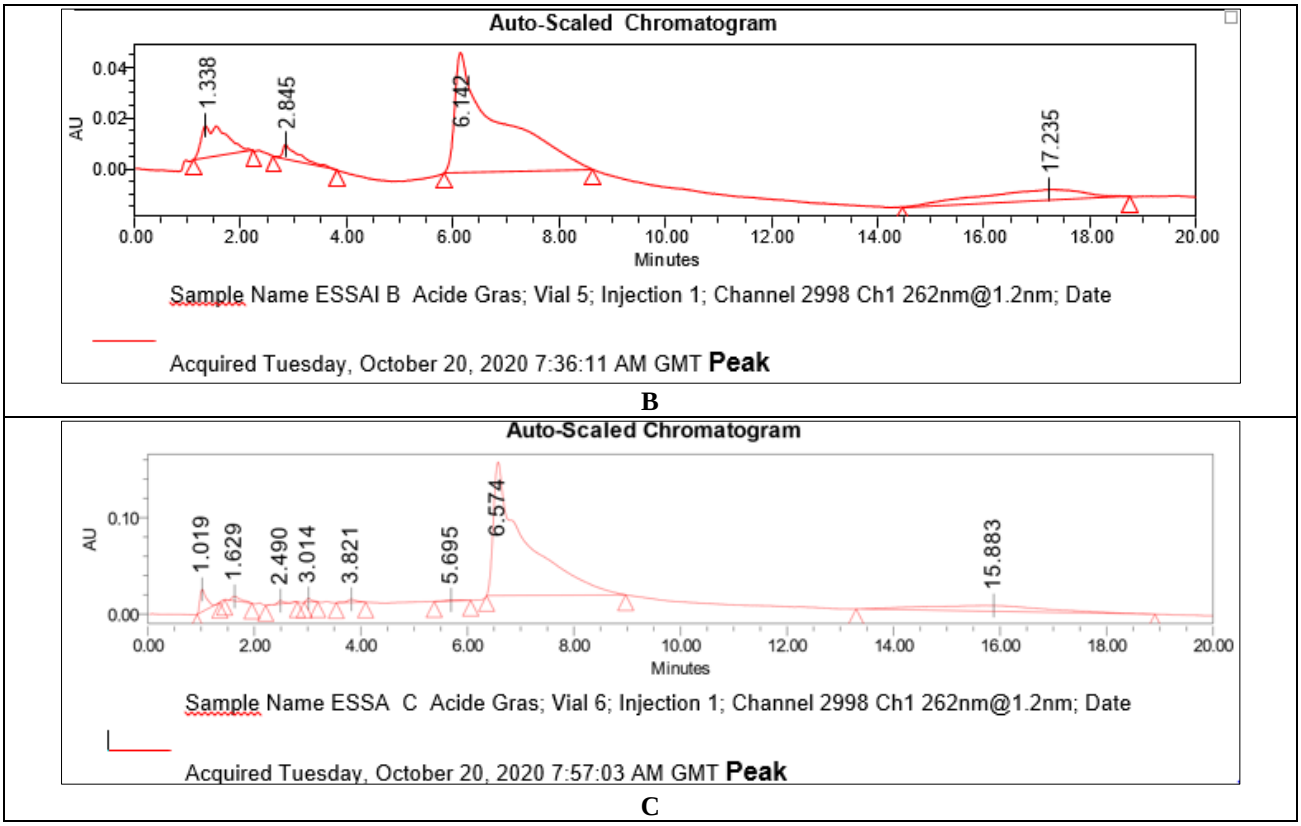

Figure 5: chromatographic profile of fatty acids of the three peanut varieties

A: Chromatographic profile of fatty acids of the 'Gcs' variety
B: chromatographic profile of fatty acids of the 'Pcl' variety
C: chromatographic profile of fatty acids of the 'Mcs' variety

1.4. Protein content

Statistical analysis of protein contents revealed a significant difference between the values at the 5% threshold. Indeed, the 'Pcl' variety is the one with the highest protein content (29.00 ± 1.75) (figure 6).

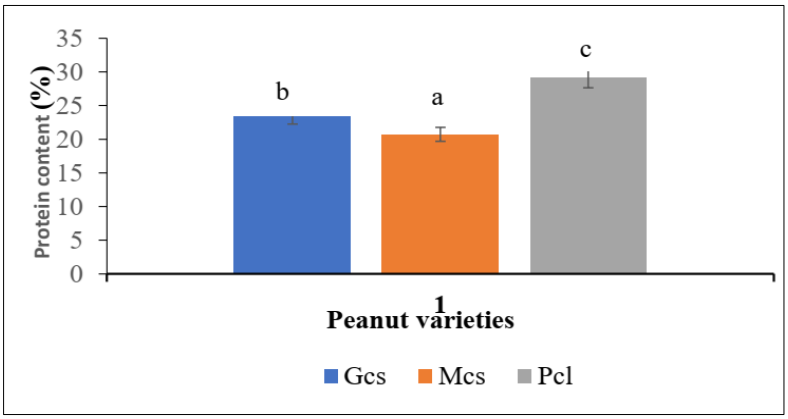

Figure 6: Taux de protéines des différentes variétés d'arachides

The same letters assigned to the averages mean that they are not different at the 5% threshold.
Gcs: large ribbed shell; **Mcs**: medium ribbed shell; **Pcl**: small smooth shell.

1.5. Amino Acid Content

The amino acid contents are significantly different at the 5% threshold. The 'Grain gros' variety is very rich because it contains eight out of nine amino acids: serine, lysine, alanine, leucine, valine, arginine, methionine and cysteine. Only glutamic acid is missing. In the smooth variety four amino acids are absent: arginine, methionine, cysteine and glutamic acid while in the 'medium grain' variety only three are absent: leucine, arginine and methionine (Table II).

Table II: Amino acid content of different peanut varieties

Types of amino acids	Amino acid content (%)		
	Gcs	**Mcs**	**Pcl**
serine	1,856 ± 0,001 [a]	2,330 ± 0,005 [c]	2,072 ± 0,006 [b]
lysine	0,538 ± 0,002 [b]	1,248 ± 0,004 [c]	0,290 ± 0,001 [a]
alanine	0,304 ± 0,003 [b]	0,450 ± 0,002 [c]	0,166 ± 0,001 [a]
leucine	4,377 ± 0,007 [a]	-------	6,222 ± 0,004 [b]
valine	4,749 ± 0,005 [a]	15,124 ± 0,009 [c]	4,896 ± 0,002 [b]
arginine	0,147 ± 0,001[a]	-----	-----
méthionine	0,079 ± 0,001 [a]	-----	-----
cysteine	0,010 ± 0,001 [a]	0,017 ± 0,002 [b]	------
glutamic acid	------	0,141 ± 0,001[a]	------

The same letters assigned to the averages mean that they are not different at the 5% threshold.

Gcs: large ribbed shell; **Mcs**: medium ribbed shell; **Pcl**: small smooth shell.

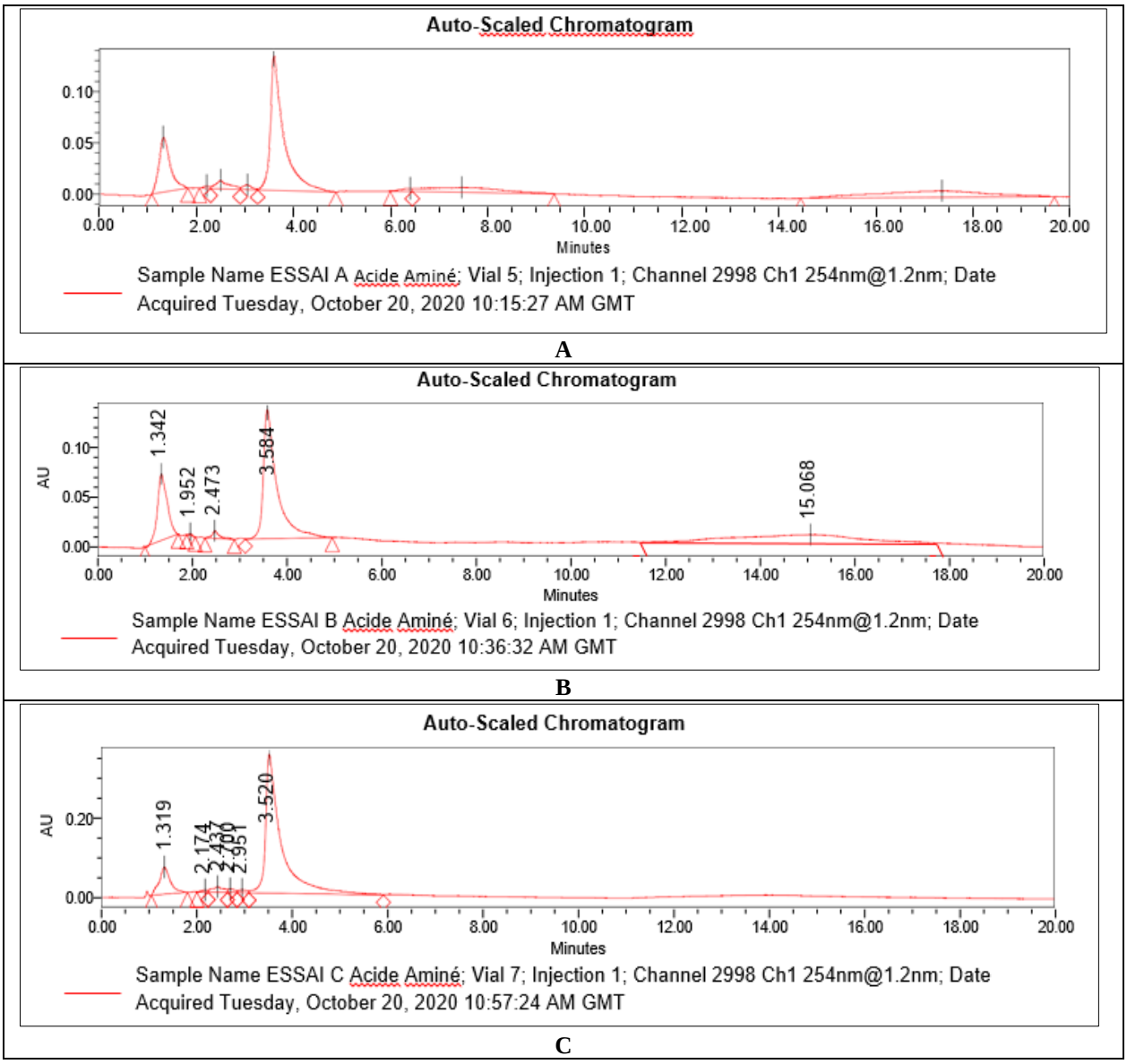

Figure 7: Chromatographic profile of amino acids of three peanut varieties

A: chromatographic profile of the amino acids of the variety 'Gcs'
B: chromatographic profile of the amino acids of the 'Pcl' variety
C: chromatographic profile of the amino acids of the variety 'Mcs'

1.6. Fiber Content

The fiber content is shown in Figure 9. According to statistical tests, there is a significant difference at 5%. The fiber content is low 'Gcs' (1.368± 0.08) then comes the variety 'Mcs' (2.653± 0.03) and 'Pcl' (3.337± 0.01) (figure 8).

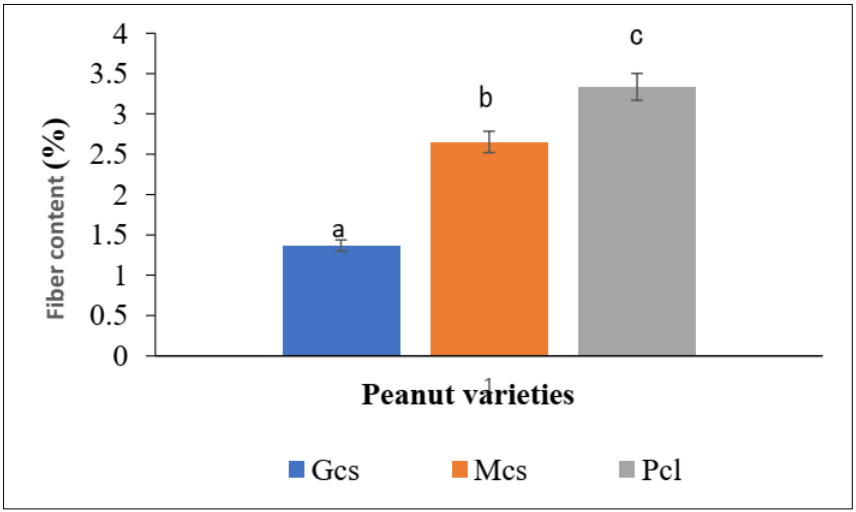

Figure 8: Fiber content of different varieties of peanuts

The same letters assigned to the averages mean that they are not different at the 5% threshold.
Gcs: large ribbed shell; **Mcs**: medium ribbed shell; **Pcl**: small smooth shell.

II-2-DISCUSSION

The moisture content of the peanut pastes of the three varieties is very low because the water content values are much lower than 10%. The results of the analysis revealed a moisture content of 2.19% for the variety (Gcs), 0.93% for the variety (Pcl) and 1.44% for the variety (Mcs). These results would imply that during the storage of peanut pastes, microorganisms could not easily develop there to alter not only their market value but also their nutritional quality (Fellows, 1997). The variety that will keep best for a long time is the (Pcl) variety because it has the lowest water content. Indeed, the water content of a food is a quality criterion used mainly to estimate the degree of humidity and provide information on the stability of the product against the risk of deterioration during storage. According to the work of Paris and Moyse (1965), a water content of less than 10% in a food would ensure good preservation for it. These water contents obtained in our study are lower than those of the peanut seeds studied by Aguieb and Mssais (2015) who obtained 8%.

Non-assimilable dietary fibers are structural sugars constituting the wall of all plant cells. They include hemicellusaes, pentosans, pectins, cellulose and lignin. There are actually two types of fiber, insoluble fiber and soluble fiber. Insoluble fibers are represented mainly by cellulose, hemicellulose and lignin. They ensure good intestinal transit by filling with water and thus prevent constipation (Marlett *et al.*, 2002). In addition, they protect against colon or rectal cancer; they reduce the risk of the appearance of stones in the gallbladder; ultimately they intervene, although moderately, in the fight against hypercholesterolemia (Kushi *et al.*, 1999). In our study, the fiber contents of the different peanut varieties (Gcs), (Pcl) and (Mcs) are respectively 1.37; 3.34 and 2.65. These contents are less than 6%. This situation suggests that this pasta cannot be considered high in fiber. Given that fibers are known for their positive actions on intestinal transit and the reduction of the absorption of carbohydrates and lipids, making it possible to regulate blood sugar levels and avoid excess cholesterol (Ponka *et al.*, 2016), known for their prebiotic actions in the colon of the host organism (Ifon *et al.*, 2009), the consumption of formulated pastes, not rich in fiber, would not be recommended in the prevention, reduction and treatment nutritional diseases (constipation, colon cancer, diabetes, obesity and gallstones) (Dakia *et al.*, 2017). These fiber contents are very low compared to those of other legumes such as beans and lentils.

Lipids are important macronutrients in nutrition, because they promote an increase in the energy density of foods (Tenagashaw *et al.*, 2017). Furthermore, they help to increase the nutritional composition of fat-soluble vitamins (A, E) of foods by facilitating their availability in the body (Levitsky and Patapoud, 2015). The lipid contents of the peanut pastes determined are between 24 and 45%. The peanut paste with the highest lipid content is that of the variety (Gcs) with 45.09. Our results agree with those found by Davis *et al.*, (2008) who obtained between 40 and 50% oil by the Soxhlet method. These results make it possible to classify these varieties among the most interesting oilseeds to exploit. In addition six fatty acids were determined in the doughs (Gcs) and (Mcs) and four fatty acids in the doughs (Pcl). These are myristic acid, palmitic acid, oleic acid,

arachidic acid, linoleic acid and linolenic acid. Palmitic and linolenic acids are absent in the variety (Pcl). The presence of linoleic fatty acids (C18: 2 ω 6) and linolenic acid (C18: 3ω3) in pasta is very beneficial because these lipid substances play essential roles in the body. Indeed, they will help strengthen the immune system, affect mood, brain health and reduce inflammation. All of this will therefore support heart health, protect the brain, fight depression, relieve inflammation and reduce joint pain in consumers (Kriss, 1999). They also have an influence on blood cholesterol levels. They are considered protective elements against cardiovascular diseases. Indeed, they are known to lower bad cholesterol (LDL cholesterol) and to increase good cholesterol (HDL cholesterol).

Concerning proteins, they are essential macronutrients for the body because they are involved in several biological functions such as the establishment of muscle tissues, the production of enzymes and hormones, and growth (Ponka *et al*., 2016). The protein levels obtained in peanut pastes show that they are also real protein sources. The dough richest in protein is that obtained with the variety (Pcl) which has a content of 29.101%. Indeed, according to Ali's research. (2009), edible plants whose proteins provide more than 12% of the caloric value, constitute good sources of protein. The protein contents obtained nevertheless remain lower than that of soya (40%), but they are higher than that of most cereals such as corn (10%), sorghum (11%), wheat (8-11%), rice (8%) (Anegbeh *et al.,* 2005).

In addition, the amino acid profile of the paste of the three peanut varieties in this study revealed the presence of nine amino acids which are: serine, lysine, alanine, leucine, valine, arginine, methionine, cysteine and glutamic acid, four of which are essential and play important physiological roles in child growth (Kafuti *et al.,* 2015). Indeed, the quality of proteins in foods depends on their content of amino acids and particularly essential amino acids. The presence of leucine is beneficial because it increases the production of growth hormones (Mero, 1999). This shows that formulated pastes are a source of essential amino acids to ensure good growth of children (Jaovelo, 2007).

CONCLUSION

In short, the three varieties of peanuts studied have very interesting nutritional characteristics. They have a lipid and protein quality which makes them foods of choice for human nutrition with a view to overcoming nutritional deficiencies. Furthermore, the study was able to reveal specificities at the level of each variety. The variety that contains the least water is (Pcl), it will better resist microbial proliferation. Also, the best variety for oil production is (Gcs) because it gives us the highest oil yield by the Soxhlet method. The best quality oil is that extracted from the variety (Mcs) because it contains the highest level of Omega 3 and 6 and which has good resistance to oxidation. It would therefore be favorable for making mayonnaise and pastry products. Finally, the variety (Pcs) could be used to make infant dishes because it is very rich in protein.

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