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*RESEARCH ARTICLE*

# EVALUATION OF THE PHYSICOCHEMICAL AND BACTERIOLOGICAL QUALITY OF ARTISANAL EXTRACTION OF PEANUT OILS IN MOUNDOU CITY CHAD

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## *Abstract*

This work was carried out in the city of Moundou, the economic capital of Chad. It focused on the evaluation of the physicochemical and bacteriological quality of artisanal extraction peanut oils. The study involved fourteen samples including two samples of peanut seeds, four samples of oil, four samples of fresh cakes and four samples of dry cakes. The fat, water, total ash and protein contents were analyzed on peanut seeds and cakes; the iodine, saponification, acid and peroxide value of oils. Four bacteriological parameters including Staphylococcus aureus, *Escherichia coli*, coliforms and *Salmonella* spp. were highlighted on each of these fourteen samples. These analyzes were carried out at CECOQDA. The results of physicochemical parameters of the oils obtained meet, for the majority, the standards of the food codex. These results are respectively from 12.120±0.010 to 12.963±0.035 g/100g for the iodine index, from 0.566±0.011 to 1.010±0.010 mg KOH/g for the acidity index, from 121.290±0.350 to 248.623± 2.921 mg KOH/g for the saponification index and from 5.356±0.495 to 14.60±0.200 mEq O2/Kg for the saponification index. Regarding the bacteriological results, the samples analyzed contain more or less germs. However, the seeds of both types of peanuts, the oils and the fresh cakes contain germs at values slightly higher than the decision criteria for total coliforms ($4.7.10^3$ to $1.5.10^5$ CFU) and *Staphylococci aureus* ($7.7.10^3$ at $1.5.10^5$ CFU). In view of these results, artisanal extraction peanut oils could be considered good quality oils from a physicochemical point of view. On a bacteriological level, fresh cakes are a source of contamination.



## Introduction:-

Peanut, the twelfth largest crop production in the world, is a major crop in most tropical and subtropical regions. It is cultivated on all continents, in approximately 120 countries, over a total area of 24.6 million hectares for a production of 38.2 million tonnes (Fonceka, 2010). The African continent, with its 10 million hectares of surface area occupied by peanut cultivation and its 10 million tonnes, occupies second place ahead of the American continent with only 2.3 million tonnes (Revoredo et Fletcher, 2002).

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The peanut produced in the world is mainly transformed into oil, flour and derivatives which are used in the composition of food products such as confectionery, peanut butter, peanut paste, etc. During the period 1996 to 2000, 49.2% of global peanut production was used to produce oil and flour and 41.1% was used in the composition of food products (Revoredo et Fletcher, 2002). In Chad, the artisanal agri-food sector is therefore a source of income for 1 in 5 households in Moundou, 1 in 2 households in Pala and Sarh (Mbayhoudel, 1999).

Many previous works concerning the production of peanut oil (Gillier et Silvestre, 1980), the marketing of cakes and the physicochemical quality of peanut meals have been carried out (Diomande et al., 2017). Due to the limited availability of information on the physicochemical and bacteriological parameters of peanut oils sold on local markets, the study of these different parameters is necessary to enrich existing knowledge. The objective of this investigation is to evaluate the physicochemical and bacteriological quality of peanut oils from artisanal extraction in the town of Moundou in Chad.

## Material and Methods:-

### Presentation of the study area

The study was carried out in the town of Moundou, capital of the Lac Wey Department and the Logone Occidental Province. Moundou is the second largest city in Chad. It is described as the economic capital of the country and the gateway to the southern zone. The town of Moundou (fig. 1) is located between 8° 30'' to 8° 40'' North latitude and 16° 00'' to 16° 10'' East longitude (Djangrang et al., 2011). It is more than 400 km away from the capital Ndjamena and 100 km from Doba. It is located 500 km from the Central African capital Bangui and approximately 400 km from the Ngaoundéré bus station in Cameroon (Ngaoubourandi, 2012). Extending over 7 km from south to north, Moundou has thirty-one (31) neighborhoods divided into 4 districts (Mbaihadjim, 2018).

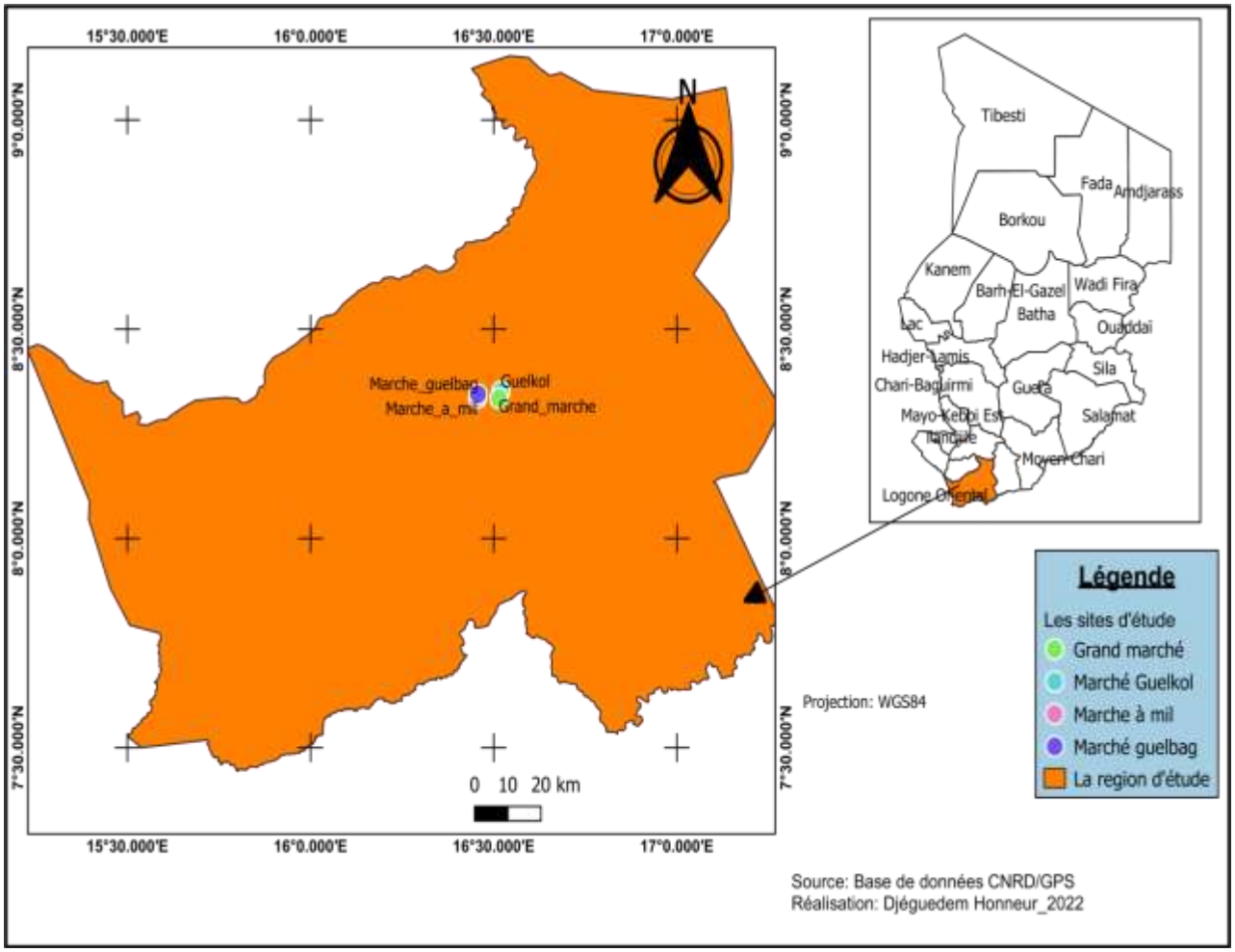


**Figure 1:-** Presentation of the study area.

## Methodology:-

### Biological material

The biological material (fig. 2) of the study consisted of two types of peanut seeds (early and striped), their oils extracted in an artisanal manner and sold by women in the different markets of the town of Moundou Fresh oil extraction cakes called "tougoussa" and dry oil cakes called "bacourou" were also taken into account in the study.

Early peanut seeds Striped peanut seeds

Peanut oil Fresh residue "tougoussa" Dry residue "bacourou"

**Figure 2:-** Biological material.

### Artisanal extraction method of peanut oils in the town of Moundou

The artisanal extraction of peanut oils is carried out in several stages (fig. 3). The harvested inshell peanuts are dried and then shelled. The seeds are sorted by hand to remove spoiled seeds, stones, hulls and other debris. Small impurities are removed by sifting through a sieve. The sorted seeds are then roasted over low heat in a pan in which they are stirred continuously for about an hour.

Roasting allows the aromas to develop. In addition, it facilitates peeling and conditions the yield of oils during extraction. It helps destroy the bonds between the cellular components of the oil (hydrated proteins and starches) which are responsible for oil retention (FAO, 1991).

The roasted seeds are winnowed then subjected to manual sorting to eliminate the last impurities. They are then transformed into paste using a mill. The dough obtained is kneaded in the presence of water and salt for approximately 30 min. Mixing promotes the coagulation of hydrophilic materials which gather into lumps, between which oil appears (FAO, 1991). The extracted oil is heated in a pan over low heat to decrease the water content and improve the shelf life of the product.

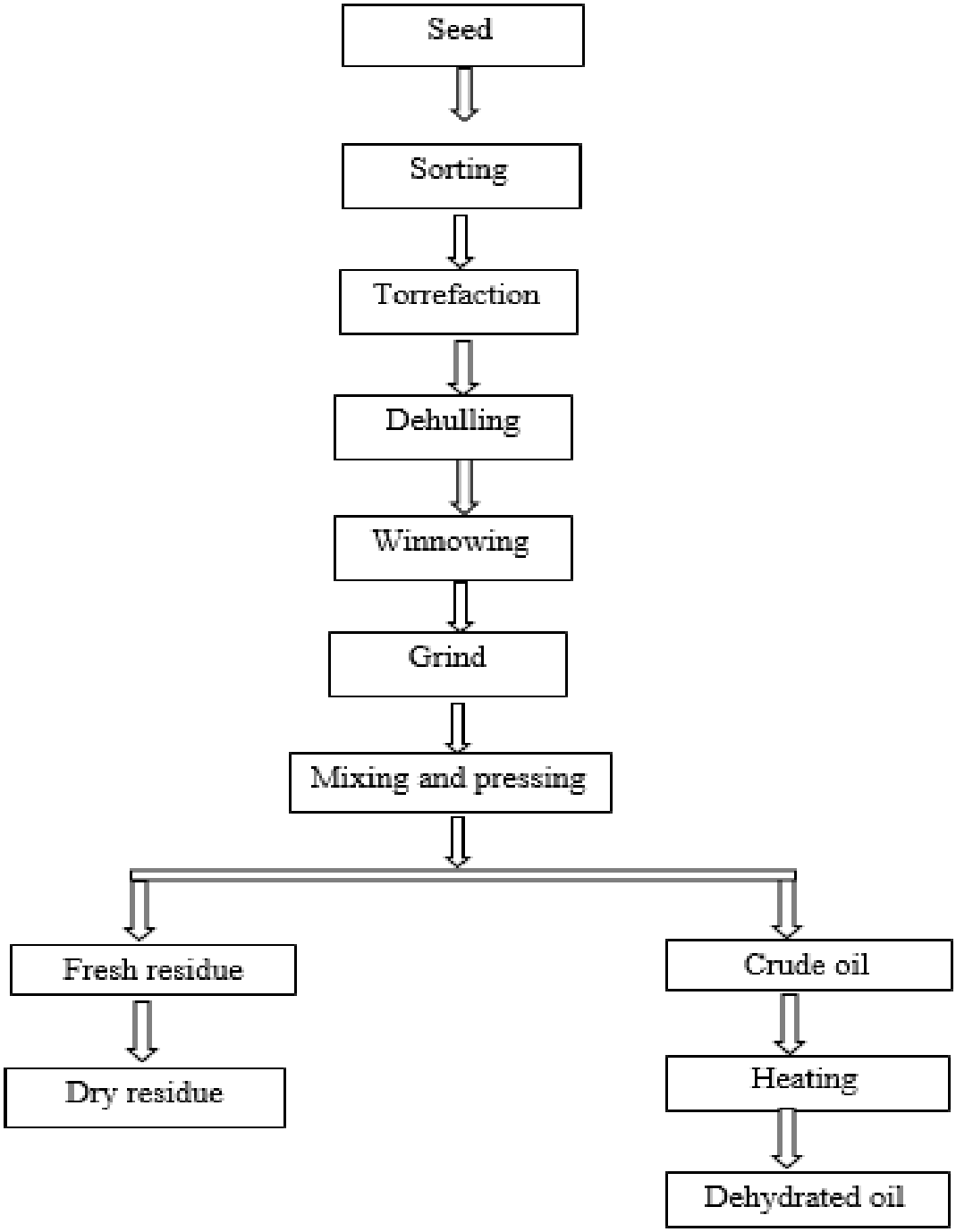


**Figure 3:-** Technological diagram of artisanal peanut oil extraction in Moundou Chad.

**Sample collection**

The sampling involved two types of peanut seeds (early and striped), four samples of oils, four samples of dried "bacourou" cakes and four samples of fresh "tougoussa" cakes. The samples were taken under general asepsis and under natural conditions of sale of these products in the different markets of the city of Moundou from sellers.

The oil samples were taken in sterile plastic bottles while the seeds and cakes were packaged in plastic bags, which were also sterile. These samples were carefully labeled and stored in a cooler at a temperature of around 4°C using ice packs.

**Analysis of physicochemical parameters**

Fat content, iodine, acid, saponification and peroxide indices; the water, total ash and protein contents are the physicochemical parameters which were analyzed on the different samples.

- Determination of fat content using the Soxhlet method (NF EN ISO 13944).
- The iodine index was determined according to the NF ISO 3961 standard.
- The acid number consists of determining the number of milligrams of potassium hydroxide (KOH) necessary for the neutralization of the free acids contained in 1 gram of fatty substances Ezoua et al. (1999).
- The saponification index is determined according to the NF ISO 3657 standard.
- The peroxide index is a measure used to estimate the quantity of peroxides present in a fat (1995).
- The determination of the dry matter content is carried out according to the method described by (Lion**,** 1955).
- The determination of total ash content was made according to (Marty, 2005).
- The determination of the protein content was calculated from the total nitrogen content determined by the Kjeldahl method (NF EN 13342).

**Analysis of bacteriological parameters**

Bacteriological analyzes were carried out on cosmopolitan bacteria such as total coliforms, E. coli, staphylococci aureus and salmonella.

- The enumeration of total coliforms was carried out according to the NF V08-050 standards. - The count of Escherichia coli is carried out according to French standard V08-053 (2002).
- The enumeration of Staphylococcus aureus was carried out on Baird Parker agar which is a selective medium for coagulase-positive Staphylococcus and in particular Staphylococcus aureus (MA. 700 STA 1.0).
- The search for salmonella is carried out according to standard ISO 6579/A1 (2007).

## Results and Discusion:-

**Physicochemical parameters**

**Physicochemical parameters of peanut seeds**

It appears from Table I that the fat content of striped peanut seeds (45.436±0.577 g/100gDM) is substantially identical to that of early peanut seeds (44.903±0.765 g/100gDM). These results are similar to those reported by (Multon, 1982) and (Gnanwa and al., 2021) who revealed that the lipid content of peanut seeds varies between 44 and 56 g/100g. The results obtained are much higher than that obtained by (Diomande and al., 2017) which is 28.26±0.08 g/100g in Ivory Coast. This difference in results is due to the extraction method, but also to the origin of the seeds because seasonal variations influence the results of the physicochemical composition of plant organs (Comelade, 1990).

Striped peanut seeds have a higher water content (6.760±0.090 g/100gDM) than early seeds (4.820±0.050 g/100gDM). These results comply with CODEX STAN 200-1995 standards which limit the humidity value less than or equal to 9. In foods, there are two kinds of water: free water and bound water. It is mainly the constitutional water or bound water which should remain after drying while the free water evaporates during the maturation of the seeds (Multon, 1982). The low moisture levels of peanut seeds have great advantages (Comelade, 1990).

The ash content of early peanut seeds (2.310±0.020%) is slightly higher than that of striped seeds (2.270±2.270%). The peanut seed has an ash content similar to that of Irvingia gabonensis seeds (2.9%) and lower than that of Ricinodendron heudelotii seeds (7.5%) (Kouamé and al., 2015). This difference between ash contents could be explained by the texture and composition of the soils which would have an effect on the mineral absorption of plants and varietal differences (Osorio-Dıaz and Bello-Perez, 2002).

## Results of Translation:-

The protein content of early peanut seeds (29.123±0.085 g/100g) is also higher than that of striped seeds (22.430±0.301 g/100g). These results are similar to those obtained by (Misra, 2001) who reported that the peanut seed is composed of approximately 24 g/100g of proteins. The results obtained are also in agreement with those obtained by (Kouamé and al., 2015) which vary from 26.4 to 27.5%. In view of the high protein contents, peanut seeds could be used to alleviate the problems of protein-energy malnutrition (Aberoumand, 2008).

**Table I:-** Physicochemical parameters of peanut seeds.

| **Samples** | **Fat (g/100gMS)** | **Humidity** | **Total ashes (%)** | Proteins |
|---|---|---|---|---|

| | | (g/100gMS) | | (g/100gMS) |
|---|---|---|---|---|
| **Early peanut** | 44.903±0.765 | 4.820±0.050 | 2.310±0.020 | 29.123±0.085 |
| **Striped peanut** | 45.436±0.577 | 6.760±0.090 | 2.270±2.270 | 22.430±0.301 |

**Physicochemical parameters of peanut oil**

The peanut oils collected are subjected to a physicochemical examination in order to identify their quality indices in comparison with the official standard (Codex Alimentarius, 1983). Thus, the results obtained for the physicochemical parameters are recorded in Table II.

**Table II:-** Physicochemical parameters of peanut oils.

| Samples | Iodine index (g/100g) | Acid index (mg KOH/g) | Saponification index (mg KOH/g) | Peroxide index (mEq $O_2$/Kg) |
|---|---|---|---|---|
| **Oil 1** | 12.403±0.005 | 0.943±0.055 | 243.066±3.576 | 7.290±0.710 |
| **Oil 2** | 12.120±0.010 | 1.010±0.010 | 121.290±0.350 | 14.600±0.200 |
| **Oil 3** | 12.160±0.010 | 0.566±0.011 | 248.623±2.921 | 8.356±0.205 |
| **Oil 4** | 12.963±0.035 | 1.010±0.010 | 130.103±1.395 | 5.483±0.495 |

**Iodine index**

The iodine index provides information on the degree of establishment of fatty acids contained in a given oil. It is directly related to the degree of oxidation of an oil: the more unsaturated an oil is, the higher its iodine index (Wolff, 1968). The results obtained for the iodine index of peanut oil are of the order of 12.120±0.010 to 12.963±0.035 g/100g of oil. These values are much lower than those provided by the Codex Alimentarius standard (86-107).

**Acid index**

The acid number is the number of mg of KOH necessary to neutralize the free fatty acids contained in 1 g of fat. The acid number, which measures the quantity of free fatty acids resulting from the hydrolytic reactions of triglycerides, is a quality criterion making it possible to report the state of conservation of an oil; a good quality oil should have a low or no acid number (FAO, 1999).

The acid number values obtained from peanut oil range from 0.566±0.011 to 1.010±0.010 mg KOH/g. These values are much lower than that obtained (3.34) by (Karoui and al., 2021) in Algeria and comply with the standards of CODEX STAND 210-1999. According to the Codex Alimentarius, a good quality oil must have a low acid number (≤ 4 mg KOH/g) because it helps give it strong stability against oxidation.

**Saponification index**

The saponification index provides information on the length of the carbon chain of the acids constituting the oil. The saponification index of an oil is higher when the carbon chain of the fatty acids is short (Lion, 1955).

The saponification index values obtained for the peanut oils analyzed range from 121.290±0.350 to 248.623±2.921 mg KOH/g oil. These values fall outside the Codex Alimentarius range, which recommends 170 to 200 mg KOH/g oil, the limit value for the saponification value of an oil. Some saponification index values, such as 172.640 mg KOH/g oil (Table II), are similar to that obtained by (Diomande and al., 2017), which is 173.98 mg KOH/g oil in Côte d'Ivoire.

**Peroxide index**

The peroxide index is a quality criterion which makes it possible to see the oxidation state of oils and to control the first stages of oxidative alteration (Chimi, 2005). To this end, an oil with a peroxide index lower than 15 mEq $O_2$/kg, the limit value recommended by FAO for vegetable oils intended for human consumption, is poorly exposed to oxidation (Adebisi and Olagunju, 2011).

The values obtained (Table II) range from 5.483±0.495 to 14,600±0.200 mEq $O_2$/Kg of oil. These results show that the peroxide index of peanut oil is lower than the value required by the Codex Alimentarius standard (Max 15 mEq of active oxygen/Kg of oil), which means that this oil is oxidizes little, it can be kept for a long time. This confirms the oxidation stability of peanut oil at room temperature and more resistant to rancidity according to (Tchiegang and al., 2005).

**Statistical analysis of physicochemical parameters**

Statistical analysis of the physicochemical parameters of peanut oils by the PCA (Principal Component Analysis) method under the R software version 4.3.0 (2023-04-21 ucrt) was carried out on Table II: Oils 1, 2 , 3 and 4 represent the "Individuals" and the physicochemical parameters, the iodine number, the acid number, the saponification number and the peroxide number represent the "variables".

**Representation of Individuals (Oils)**

Figure 4 brings together four individuals who are represented by the types of peanut oils. It appears from this figure that the individual Oil 2 is positively correlated with the second axis while the individuals Oil 1, Oil 3 and Oil 4 are negatively correlated with the first factorial axis. It should also be noted that the individuals are not grouped together, which means that there is not a very strong link between them.

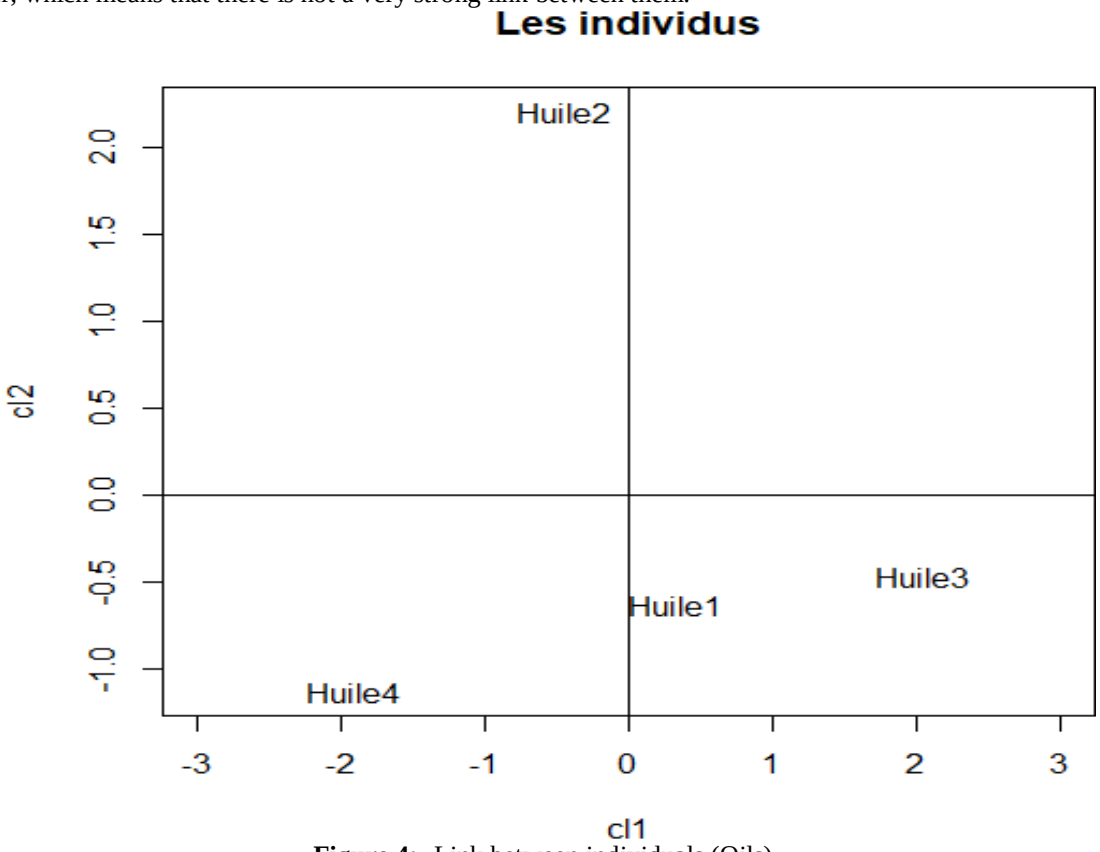


**Figure 4:-** Link between individuals (Oils).

**Representation of Variables (Parameters)**

Figure 5 highlights the correlations between the different physicochemical parameters of oils which were analyzed which are the iodine index, the peroxide index, the acidity index and the saponification index. The representation of the variables shows that the variables "acid index", "peroxide index" and "iodine index" are positively correlated with respect to the second axis. They are opposed to the "saponification index" variable which is negatively correlated with the second axis.

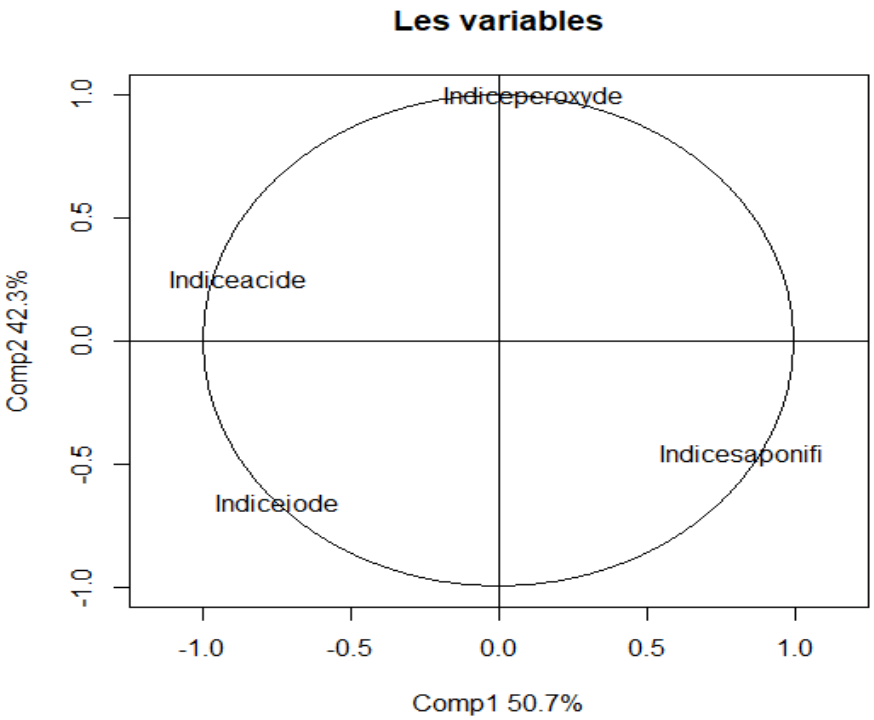


**Figure 5**:- Correlation circle between peanut oil variables.

**Representation of individuals and variables**

The simultaneous representation of individuals and variables shows that there is no link between the physicochemical parameters (variables) of the oils. Individuals "Oil 1, Oil 3, Oil 4" have a higher saponification and iodine index than individual "Oil 2".

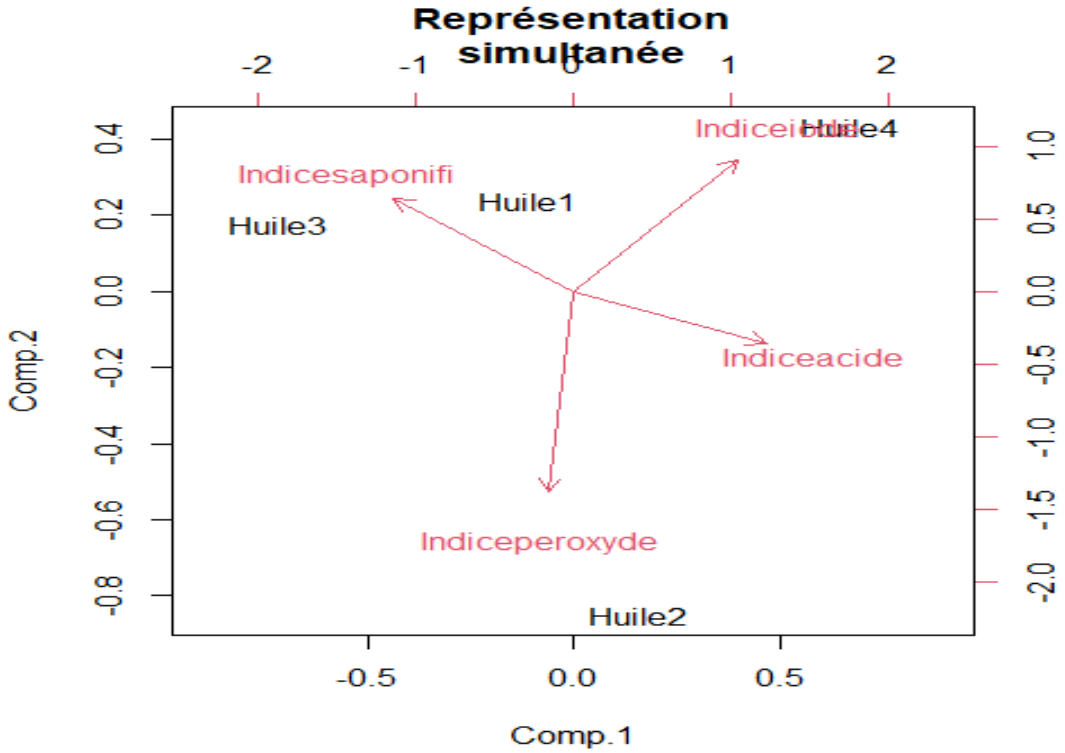


**Figure 6**:- Link between Oils and parameters.

**Physico-chemical parameters of fresh cakes**

The analysis of Table III shows that the fat contents of fresh cakes vary from 22.883±0.185 to 29.903±0.175g/100gMS. To be suitable for the manufacture of dry cakes, fresh cake must contain at least 26% of its mass in oil (FAO, 1985). The results obtained show that the fresh cakes taken are appropriate.

The humidity levels of fresh cakes are around 23.940±0.450 to 29.503±0.265%. Fresh peanut meals have water contents that do not comply with CODEX STAN 200-1995 standards which limit the humidity value to less than or equal to 9. These results suggest that fresh peanut meals cannot be stored for a long time.

The total ash rates of fresh cakes vary from 3.043±0.035 to 3.160±0.020%. These rates are similar to those of cowpea powder which were 3.62% (Carnovale and al., 1989).

Regarding protein content, fresh cakes presented values ranging from 32.873±0.125 to 43.153±0.345g/100g. From this result, it appears that fresh cakes such as peanut seeds are sources of vegetable proteins.

**Table III:-** Physico-chemical parameters of fresh cakes.

| Samples | Fat (g/100gMS) | Humidity (g/100gMS) | Total ashes (%) | Protéins (g/100gMS) |
|---|---|---|---|---|
| **Fresh residue 1** | 29.903±0.175 | 28.393±0.275 | 3.060±0.040 | 37.713±0.095 |
| **Fresh residue 2** | 22.883±0.185 | 23.940±0.450 | 3.160±0.020 | 32.873±0.125 |
| **Fresh residue 3** | 29.893±0.215 | 29.013±0.635 | 3.043±0.035 | 36.370±0.060 |
| **Fresh residue 4** | 26.020±0.100 | 29.503±0.265 | 3.080±0.060 | 43.153±0.345 |

**Physico-chemical parameters of dry cakes**

The fat contents of dry cakes range from 21.323±0.155 to 29.490±0.220 g/100gMS. They are slightly lower compared to the values found by (Diomande and al., 2017) on peanut cake (31.14±0.10 g/100gMS) and cashew cake (31.91±0.09 g/100gMS). Dried cakes could be used in the diet of people who are advised not to eat foods that are too fatty (Seerley, 1991).

The results obtained for the humidity of the dry cakes are of the order of 3.923±0.035 to 4.513±0.075 g/100gMS (table IV). They are slightly higher than the value found by (Diomande and al., 2017) which is 2.79±0.01 g/100gMS. It should also be emphasized that these values are well below the upper limit allowed by the AFNOR standard for efficient food packaging, which is 8%. This means that dried cakes can be stored for a long time with little risk of microbial contamination.

The total ash rates of the dry cakes range from 4.033±0.020 to 4.963±0.025 g/100gDM (Table IV). It appears from the results obtained that the consumption of dry peanut cakes would then be recommended for the prevention of certain diseases by strengthening the immune system thanks to their minerals (Rosique-Esteban and al., 2018).

The protein levels of the dry cakes obtained range from 30.630±0.949 to 51.120±0.190 g/100gDM (Table IV). These results are similar to that reported by (Mongodin and Tacher, 1979) and (Larbier and Leclercq, 1992) which is 47 g/100gMS. These high protein contents in dry cakes could help prevent protein-energy malnutrition in children (Hsairi Mand al., 2021) and also be used in livestock feed.

**Table IV:-** Physico-chemical parameters of dry cakes.

| Samples | Fat (g/100gMS) | Humidity (g/100gMS) | Total ashes (%) | Protéins (g/100gMS) |
|---|---|---|---|---|
| **Dry residue 1** | 29.490±0.220 | 3.923±0.035 | 4.173±0.005 | 30.630±0.949 |
| **Dry residue 2** | 21.323±0.155 | 4.313±0.015 | 4.963±0.025 | 51.120±0.190 |
| **Dry residue 3** | 21.540±0.810 | 4.200±0.070 | 4.033±0.020 | 44.243±0.185 |
| **Dry residue 4** | 25.140±0.160 | 4.513±0.095 | 4.840±0.060 | 34.370±0.190 |

**Bacteriological parameters**

**Bacteriological parameters of peanut seeds**

The analysis of Table V shows that the two (2) peanut seeds highlighted are largely contaminated by total coliforms. The results obtained are higher than the limit set by the Food Codex standards (10 CFU/g). Studies carried out in Africa (Euloge and al., 2012), analyzing samples of peanut-based cake, showed a very high number of microbiological contaminants which exceed the limits set by regulations.

Peanut seeds are also contaminated by Staphylococcus aureus. The enumeration results obtained vary from $7.7.10^3$ to $1.5.10^5$ CFU/g. These values are higher than the Food Codex standards ($< 10^2$ CFU/g).

Escherichia coli and salmonella, the two samples analyzed do not contain bacterial germs. The results obtained comply with Food Codex standards.

**Table V:-** Bacteriological parameters of peanut seeds.

| **Echantillons** | **total coliforms (**CFU **/g)** | ***Escherichia coli*(**CFU **/g)** | ***Staphylococcus aureus*(**CFU **/g)** | **Salmonella (**CFU **/g)** |
|---|---|---|---|---|
| **Peanut 1** | **4.7.** $10^3$ | < 10 | **7.7.** $10^3$ | Absence in 25 g |
| **Peanut 2** | $1.5.10^5$ | < 10 | 1.5. $10^5$ | Absence in 25 g |

**Bacteriological parameters of peanut oils**

The values obtained from the counts of total coliforms and Staphylocoques aureusare respectively of the order of $1.1.10^3$ to $9.2.10^4$ (CFU/g) and $1.4.10^3$ to $4.9.10^4$ (CFU/g). Concerning *E. coli* and salmonella, the various samples tested were negative.

These results are consistent with those of (Sebei and al., 2011) and (Aguieb and Mssais, 2015) which revealed that the oils of the four (4) peanut varieties showed no antibacterial activity for all the strains studied. This is likely due to the fact that the oils are composed almost entirely of triacylglycerols (TAG) which are structurally made up of aliphatic carbon and hydrogen chains which do not induce antibacterial activity (Aguieb and Mssais, 2015).

**Table VI:-** Bacteriological parameters of peanut oils.

| **Samples** | **total coliforms (**CFU/**g)** | ***Escherichiacoli* (**CFU/**g)** | ***Staphylococcus aureus*(**CFU/**g)** | **Salmonella(**CFU/**g)** |
|---|---|---|---|---|
| **oil 1** | $9.2.10^4$ | $5.10^1$ | $4.9.10^4$ | Absence in 25 g |
| **oil 2** | $3.8.10^3$ | < 10 | $2.10^3$ | Absence in 25 g |
| **oil 3** | < 10 | < 10 | $1.4.10^3$ | Absence in 25 g |
| **oil 4** | $1.1.10^3$ | < 10 | $7.10^3$ | Absence in 25 g |

**Bacteriological parameters of fresh peanut meals**

The results obtained show that fresh peanut cakes are largely contaminated by total coliforms, *E. coli* (cakes 3 and 4) and Staphylocoques aureus. The values obtained (Table VII) are above the Food Codex standards which limit a value below $10^2$ for total coliforms and staphylococci. Consumption of fresh meal would be a source of contamination of gastroenteric E. coli and nosocomial infections 'Odu and Okonko, 2012). These results can be explained by non-compliance with hygiene measures during processing or contamination of the cakes during exposure to sale or consumption. However, there was a total absence of salmonella in all the samples analyzed.

**Table VII:-** Bacteriological parameters of fresh cakes.

| **Samples** | **total coliforms (**CFU/**g)** | ***Escherichiacoli*(**CFU/**g)** | ***Staphylococcus aureus*(**CFU/**g)** | **Salmonella (**CFU/**g)** |
|---|---|---|---|---|
| **Fresh residue 1** | 2.2. $10^4$ | < 10 | 1.5. $10^5$ | Absence in 25 g |
| **Fresh residue 2** | $2.6.10^4$ | < 10 | $2.6.10^4$ | Absence in 25 g |
| **Fresh residue 3** | $6.9.10^4$ | 6.10 | $7.5.10^4$ | Absence in 25 g |
| **Fresh residue 4** | $4.9.10^4$ | $2.6.10^2$ | $1.5.10^5$ | Absence in 25 g |

**Bacteriological parameters of dried peanut cakes**

Dried peanut meals did not show bacterial activity. The results obtained from the enumeration of total coliforms, *Escherichia coli* and *Staphylococcus aureus* comply with Food Codex standards. There is also an absence of

salmonella. These results were not surprising, since there are few data in the literature that mention bacterial activities on dry cakes. Dried cakes can be considered pathogen free.

**Table VIII:-** Bacteriological parameters of dried cakes.

| Echantillons | total coliforms (CFU/g) | *Escherichiacoli*(CFU/g) | *Staphylococcus aureus*(CFU/g) | Salmonella (CFU/g) |
|---|---|---|---|---|
| **Dry residue 1** | < 10 | < 10 | $< 10^2$ | Absence in 25 g |
| **Dry residue 2** | < 10 | < 10 | $< 10^2$ | Absence in 25 g |
| **Dry residue 3** | < 10 | < 10 | $< 10^2$ | Absence in 25 g |
| **Dry residue 4** | < 10 | < 10 | $< 10^2$ | Absence in 25 g |

## Conclusion:-

The extraction of peanut oils is a traditional, purely feminine activity. It has recently become an income-generating activity for women processors. This extraction is accompanied by fresh waste or tougoussa which, when heated, produces dry waste or bacourou. Fresh and dry waste is, given its protein concentrations, protein concentrates. The protein levels contained in these two types of waste vary from 32.873±0.125 to 43.153±0.345g/100g for fresh cakes and from 30.630±0.949 to 51.120±0.190 g/100gMS for dry cakes. These cakes also contain significant quantities of total ash ranging from 3.043±0.035 to 3.160±0.020% for fresh and from 4.033±0.020 to 4.963±0.025 g/100gDM for dry ones. Therefore, they could be considered as sources of mineral substances and proteins to prevent protein-energy malnutrition.

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