Influence of Frying Practices on the Physico-Chemical Parameters of a Palm Oil Refined at DALOA (Côte d'Ivoire)

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Abstract: *Palm oils are widely used in food and in particular for commercial frying. However, given the cost of this oil and to reduce expenses, people very frequently use cooking oil heated repeatedly, without taking into account the health effects. The aim of this study was to assess the influence of frying practices on the physico-chemical parameters of refined palm oil among traders in Daloa. Parameters such as iodine index, impurity, peroxide index, humidity, acid index and saponification index have been determined. The humidity of the oils after frying increases compared to the control oil. This humidity is between 0.26 and 0.36% against 0.15% for the witness. The peroxide index of frying oils varies between 11.63 and 30.35 meq of O_2 / kg of oil and is higher than that of the control oil which is 8.94 meq of O_2 / kg of oil. The acid index of frying oils increases with values ranging from 4.95 to 6.52 mg KOH / g of oil compared to a value of 0.50 mg KOH / g of oil for the control. The oil saponification index dropped after frying with values ranging from 143.24 - 200.49 mg KOH / g of oil compared to 201 mg KOH / g of oil for the control. The iodine value ranges from 28.14 - 62.62 mg KOH / g of oil for frying oils and is 76.62 mg KOH / g of oil for control oil. The impurity of frying oils is high and is between 0.14 and 1.28% compared to 0.04% for the control oil. Frying palm oil has caused changes in the Physico-chemical parameters of the oils. These different changes depend on the type of frying used. For our health, it would be good not to consume oil that has been used for several frying.*

Keywords: Palm oil, Frying palm oil, Peroxide, index, acidity index, impurity

1. Introduction

Oils and fats have always been an important part of the human diet (Prior, 2003). Vegetable oils offer a wide choice in terms of taste, use, price and quality. They also constitute a very important natural source of vitamins A and vitamin E known for its antioxidant properties (Frénot & Vierling, 2001). Palm oil comes from the fruits of the African palm, *Elaeis guineensis* (Family of Arecaceae). The yellow or red color of palm oil depends on its carotenoid content (Grundmann, 2013). In Côte d'Ivoire, palm oil production is estimated at 1,800,000 tonnes per year and represents 3.13% of Gross Domestic Product (GDP). According to Lefèvre (2015), almost all of the primary production is locally processed industrially (table oil, margarines, soaps, etc.). Refined palm oils are used more in food and especially for frying.

Frying is one of the oldest practices for food preparation. It consists in exposing the oil continuously or in using it repeatedly at high temperature (160-190 ° C) in the presence of air and humidity (Moihet, 2017). This leads to many chemical reactions in the oil, such as oxidation, hydrolysis and polymerization. These chemical reactions can alter the quality of the oil, thus leading to the production of various types of oxidative products (Bouchon, 2009). Hydro peroxides and aldehydes are the primary products formed in the early stages of oxidation and absorbed by fried foods (Choe & Min, 2009). This degree of oxidation can be measured using the value of the oil's peroxide index (Bourdet, 2011).

Given the cost of oil and to reduce cooking expenses, people very frequently use cooking oil that is heated repeatedly, without taking into account the health effects (Daniel *et al.*, 2005). Indeed, repeated heating can cause changes in the physical appearance of the oil, such as increased viscosity, darkening of the color, an increase in foam and a decrease in the smoke point (Fauziah *et al.*, 2000; Sharoba *et al.*, 2012). These chemical and physical changes in the oil used in frying can have negative consequences on the health of the consumer (Daniel *et al.,* 2005).

According to the *Codex Alimentarius* (1993), the quality of the oil when frying is determined by many factors, such as the type of frying and the type of oils used. Thus, the study of the influence of frying practices on the physicochemical parameters of refined palm oil therefore makes sense, with the general objective of defining the impact of types of frying on the deterioration of palm oil.

2. Material and Methods

2.1 Material

The biological material is consisted of palm frying oils collected in various districts of the town of Daloa (Côte d'Ivoire) and palm oil (Witness, without frying). The sampling of frying oils was carried out with traders from *Garba* (Attiéké with fried tuna fish), *Gabi* (Frying with pork meat), *fêh* (Attiéké with fried horse mackerel), from *Pékos* (Chicken frying), *Gbofloto* (Wheat fritters), *Alloco* (Ripe Plantain Fried) (Figure 1).
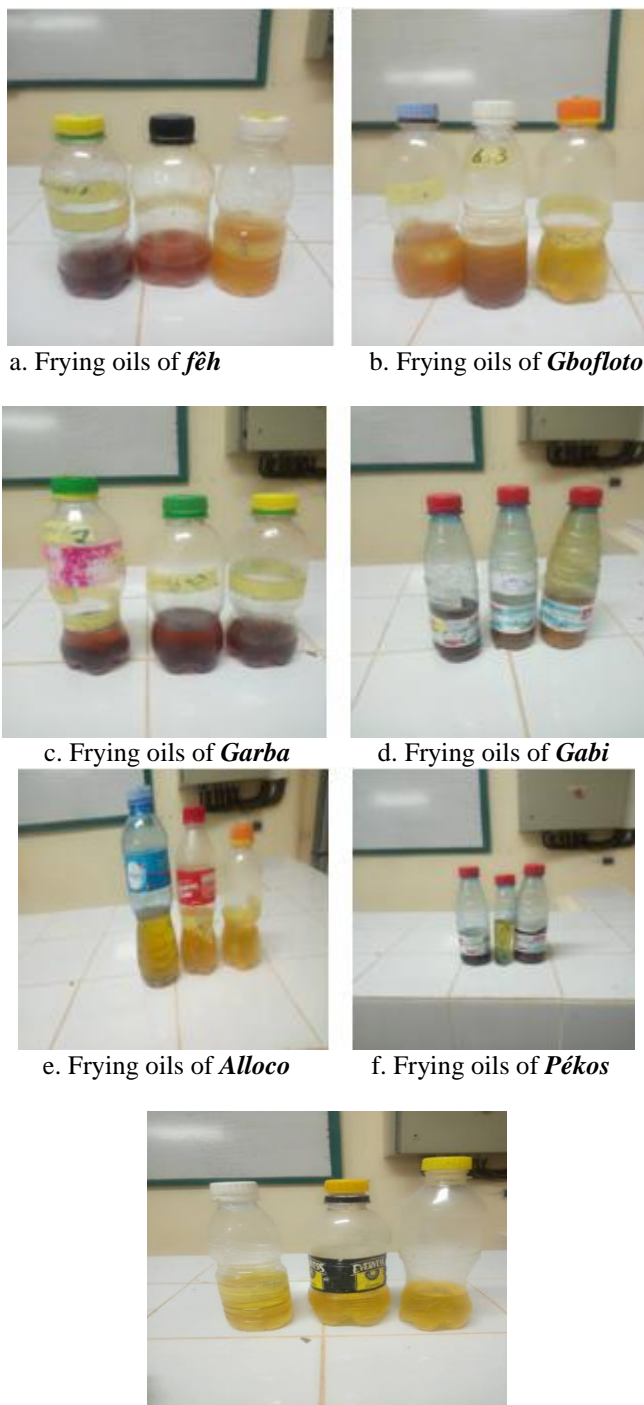
a. Frying oils of *fêh*

b. Frying oils of *Gbofloto*

c. Frying oils of *Garba*

d. Frying oils of *Gabi*

e. Frying oils of *Alloco*

f. Frying oils of *Pékos*

g. Refined Oil without frying (witness)
Figure 1: Different types of frying oils and witness oil

2.2. Methods

2.2.1 Sampling
Three 200 ml oil samples were taken at the end of the day. The samples were taken in the period from January 10, 2020 to January 25, 2020. In total, eighteen samples of frying oil were collected plus three samples of witness oil (no frying) (Figure 1).

2.2.2 Determination of Physico-chemical parameters

2.2.2.1. Iodine index
The determination of the iodine index of the oil samples is carried out according to the method of Wijs (AOAC, 1997).

This method involves treating the fat with an excess of iodine trichloride in acetic acid (Wijs reagent). The excess reagent is then titrated with a sodium thiosulfate solution after release of the iodine. A mass of 0.5 g of oil is dissolved in 15 ml of chloroform contained in an Erlenmeyer flask. Twenty (20) mL of Wijs reagent is added to it. The Erlenmeyer flask is then closed, slightly agitated and placed in the dark for 1 hour. After this time in the dark, 10 ml of a 10% potassium iodide solution and 150 ml of distilled water are successively added. The mixture obtained is titrated with a solution of sodium thiosulfate (0.1 N) contained in a burette in the presence of starch paste until completely discolored. A blank test is carried out under the same conditions. The tests are carried out in triplicate per oil sample.

The iodine value is given by the mathematical expression below:

$$Ii = \frac{(V_0 - V)}{m} \times 12{,}69 \times N$$

Ii: Iodine index value in g of iodine / 100 g of oil
V_0: Volume in mL of sodium thiosulfate (0.1 N) poured in equivalence for the blank test.
V: Volume in mL of sodium thiosulfate (0.1 N) poured in equivalence for the test portion.
m: Mass in g of the oil sample (test sample).
N: Normality of the sodium thiosulfate solution (0.1 N).
12.69: Mass of iodine corresponding to 1 ml of sodium thiosulfate per 100 g of fatty substance.

2.2.2.2. Impurity (ISO 663, 2007)
The oil sample is placed in an oven at about 50 ° C for one hour in order to homogenize and liquefy it. The GF / D filter is oven-dried at around 103 ° C (+/- 2 ° C) for 1 hour. Then the filter is cooled in a desiccator and weighed.

About 10 g of the oil sample is placed in the conical flask and 250 ml of petroleum ether is added to it. The mixture obtained is stirred at room temperature for approximately 40 minutes and then filtered on the stainless steel ramp (GF / D filter). Rinse is carried out with 200 ml of petroleum ether (or 500 ml if the filter is clogged). Leave most of the solvent still present on the GF / D filter to evaporate under a hood at the end of filtration and complete the operation in the oven at approximately 103 ° C (+/- 2 ° C) for 1 hour by placing the filter in its dish with its lid open. Remove from the oven; allow cooling in the desiccator and weighing.

The content of insoluble impurities, expressed as a percentage by mass, is equal to:

$$Imp = \frac{m2 - m1}{m0} \times 100$$

m2 = Mass, in g, GF / D filter and its dry residue in its dish + lid;
m1 = Mass, in g, of the GF / D filter in its cup + cover;
m0 = Mass, in g, of the test portion.

2.2.2.3. Peroxide index
The peroxide index of the oil samples is determined according to the method described by AOAC (1997). This method consists of treating a test sample of fat dissolved in a

mixture of chloroform and acetic acid, with a saturated solution of potassium iodide, then titrating the released iodine with a solution of sodium thiosulfate. One gram of oil is dissolved in 30 mL of a chloroform-acetic acid mixture in the proportions 3: 2 (v / v). To the content is added 1 mL of saturated potassium iodide solution. The mixture obtained is stirred for 1 min and protected from light for 5 min. After this time in the dark, 30 mL of distilled water is added to the bottle. The mixture thus formed is then titrated with a 0.01 N sodium thiosulfate solution contained in a burette in the presence of starch paste until completely discolored. A blank test is carried out under the same conditions. The tests are carried out in triplicate for each oil sample. The peroxide index is calculated as follows:

$$PI = \frac{V - V_0}{P} \times 10$$

With:

Pi: Peroxide index in meq of O_2 / kg of oil

V_0: Volume (mL) of 0.01 N sodium thiosulfate poured in equivalence for the blank test.

V: Volume (mL) of 0.01 N sodium thiosulfate poured in equivalence for the test portion.

P: Mass (g) of the oil sample (test sample).

10: number of mill molecules of peroxides / Kg.

2.2.2.4. Water content

The water content is obtained by steaming the sample according to the method described by AOAC (1997). A quantity of 2 g of sample is spread in a crucible previously dried and tared. The whole is placed in an oven (MEMMERT, Germany) at 105 ° C for 24 hours. The removed sample is cooled in a desiccator and weighed. The water content is then determined according to the following formula

$$Humidity\ Rate = \frac{P1 - P2}{P1 - P0} \times 100$$

P_0 : Mass of the empty crucible.

P_1: Mass of empty crucible + sample.

P_2: Mass of the empty crucible + sample after evaporation

2.2.2.5. Acid index

The acid index of the oil samples was determined according to the AOAC method (1997). This method consists in titrating with an alcoholic potassium solution, the acidity of a fat sample initially dissolved in a mixture of solvent in equal parts. Thus 2g of oil are dissolved in 10 mL of an ethanol-diethyl ether mixture in respective proportions 1: 1 (v / v). The mixture is then titrated in the presence of 3 drops of phenolphthalein with a 0.5 N alcoholic potassium hydroxide solution contained in a burette until turning. A blank test is carried out under the same conditions. The tests are carried out in triplicate for each oil sample. The acid number is calculated according to the following formula:

$$AI = \frac{56,1 \times (V - V_0) \times N}{m}$$

Ai: Acid index in mg KOH / g of oil

m: Mass (g) of the oil sample (test sample).

V: Volume (mL) of alcoholic potassium hydroxide poured in equivalence for the test portion

V_0: Volume (mL) of alcoholic potassium hydroxide poured in equivalence for the blank test

N: Normality of the alcoholic potash solution.

56.1: Molar mass (g / moles) of potassium hydroxide.

2.2.2.6. Saponification index

The saponification index is determined according to the AOAC method (1997). The method consists of treating the fat with an excess of alcoholic potassium hydroxide solution hot and then titrating the excess of alcoholic potassium hydroxide with a hydrochloric acid solution. Two grams (2 g) of oil are dissolved in 25 mL of 0.5N alcoholic potash. The mixture is then brought to a boil in a boiling water bath for 1 hour under a reflux condenser. After cooling, the excess alcoholic potassium hydroxide is titrated with a 0.5N hydrochloric acid solution contained in a burette, in the presence of 3 drops of phenolphthalein until it turns colorless. A blank test is carried out under the same conditions. The tests are carried out in triplicate for each oil sample. The saponification index is calculated according to the following formula:

$$SI = \frac{V_0 - V}{m} \times N \times 56,1$$

Si: Saponification index in mg KOH / g of oil

N: Normality of the hydrochloric acid solution

V_0: Volume (mL) of hydrochloric acid poured at the equivalence for the blank test

V: Volume (mL) of hydrochloric acid poured in equivalence for the test portion

m: Mass (g) of the oil sample (test sample).

56.1: Molar mass (g / moles) of potassium hydroxide.

2.3 Statistical analysis

The statistical analysis of the results was carried out using the STATISTICA 7.1 software. An analysis of variance (ANOVA) was carried out to find out if significant differences exist between the different frying oils. The samples are separated using the Duncan's test for its effectiveness, at the confidence level $p \leq 0.05$.

3. Results and Discussion

3.1. Results

3.1.1. Evolution of Humidity
The control oil without frying has the lowest percentage of humidity with a value of 0.15%. After frying, the humidity increases for all oils compared to the control oil. These values are respectively 0.26%; 0.29%; 0.31%; 0.32%; 0.32% and 0.36% for the oils of fried *garba, pekos, gabi, Alloco, gbofloto* and *fêh* (Figure 2). Statistical analysis showed a significant difference ($p \leq 0.05$) between the value of the control oil and the frying oils.
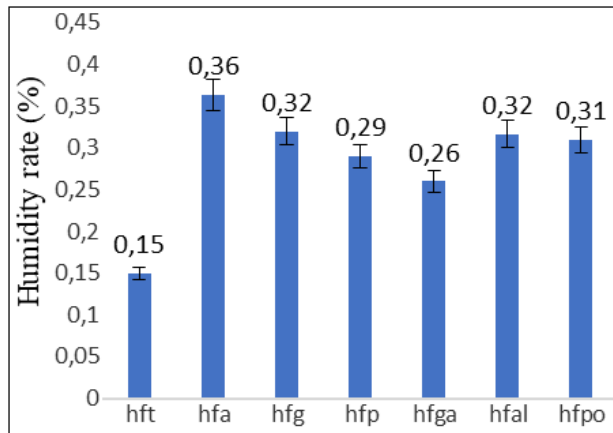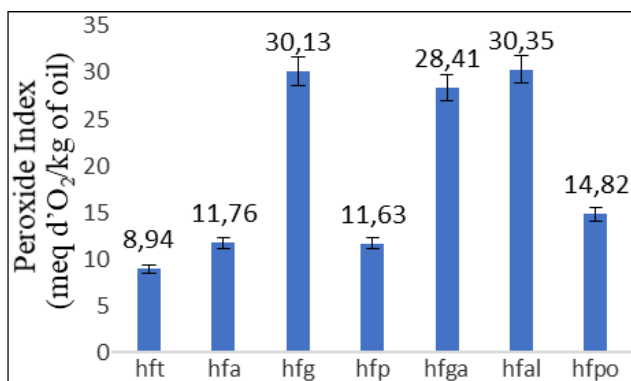
Figure 2: Evolution of Humidity.

Hft : Refined oil without frying (witness) ; Hfa : Frying oils of Fêh ; Hfg : Frying oils of Gbofloto ; Hfp : Frying oils of Pékos ; Hfga : Frying oils of Garba ; Hfal : Frying oils of Alloco ; Hfpo: Frying oils of Gabi

3.1.2. Evolution of Peroxide index

The peroxide index of the control oil is 8.94 meq of O2 / kg of oil. After frying, a general increase in the peroxide index in the different types of oils is observed compared to the control oil with different proportions. Thus the oil of *fêh* and *pekos* fry undergoes a slight increase with respective values of 11.76 meq of O2 / kg of oil and 11.63 meq of O2 / kg of oil. As for the oils from the *Gbofloto, Alloco, Garba* and *Gabi* frying, very high values between 14.82 meq of O2 / kg of oil (Gabi oil) and 30.35 meq of O2 / kg of oil (*Alloco* oil) were obtained (Figure 3). Statistical analysis showed a significant difference (p ≤ 0.05) in the peroxide index from one type of oil to another during frying.
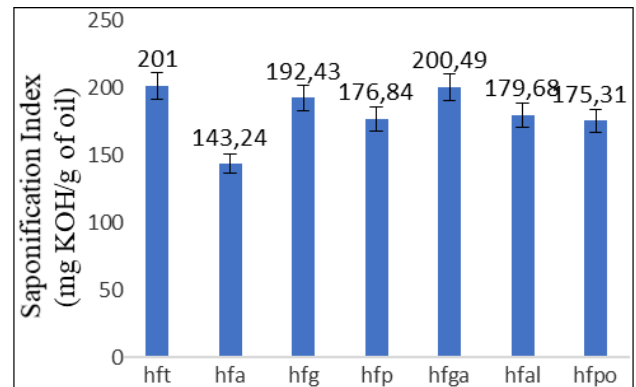

Figure 3: Evolution of Peroxide index

Hft : Refined oil without frying (witness) ; Hfa: Frying oils of Fêh ; Hfg : Frying oils of Gbofloto ; Hfp : Frying oils of Pékos ; Hfga : Frying oils of Garba ; Hfal : Frying oils of Alloco ; Hfpo: Frying oils of Gabi

3.1.3. Evolution of Saponification index

The saponification index before frying is 201 mg KOH / g of oil (witness oil). After frying, a slight decrease in the saponification index is observed overall compared to the control oil. *Garba* oil recorded the smallest decrease with 200.49 mg KOH / g of oil. Respectively *Gbofloto* oil (192.43 mg KOH / g of oil), *Alloco* oil (179.68 mg KOH / g of oil), *Pekos* oil (176.84 mg KOH / g d oil), Gabi oil (175.31 mg KOH / g of oil) and *Fêh* oil which records the greatest decrease with a value of 143.24 mg KOH / g of oil (Figure 4). Statistical analysis showed a significant

difference (p ≤ 0.05) in the saponification index from one type of oil to another during frying.

Figure 4 : Evolution of Saponification index

Hft : Refined oil without frying (witness) ; Hfa : Frying oils of Fêh ; Hfg : Frying oils of Gbofloto ; Hfp : Frying oils of Pékos ; Hfga : Frying oils of Garba ; Hfal : Frying oils of Alloco ; Hfpo: Frying oils of Gabi

3.1.4. Evolution of Acid index

The acid index of the control oil is 0.50 mg KOH / g of oil. A general increase in the acid index of frying oils is observed. This increase is greater for the frying oils of *Gbofloto*, *Fêh* and *Alloco* with respective values of 6.45 mg KOH / g of oil; 6.39 mg KOH / g oil and 6.52 mg KOH / g oil. Frying oils from *Pékos*, *Gabi* and *Garba* with respective acid value of 4.95 mg KOH / g of oil; 5.8 mg KOH / g of oil and 5.4 mg KOH / g of oil record values close to that of the control oil (Figure 5). Statistical analysis shows a significant difference (p ≤ 0.05) in the acid index between the frying oils and the witness oil.
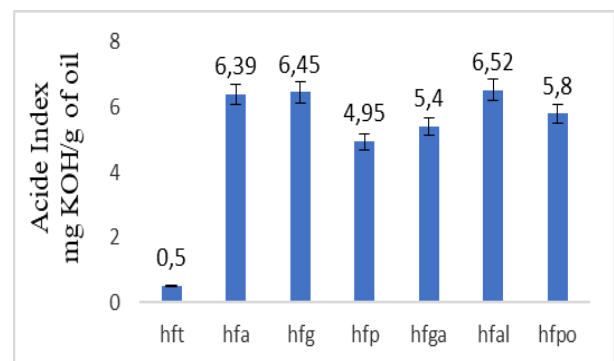
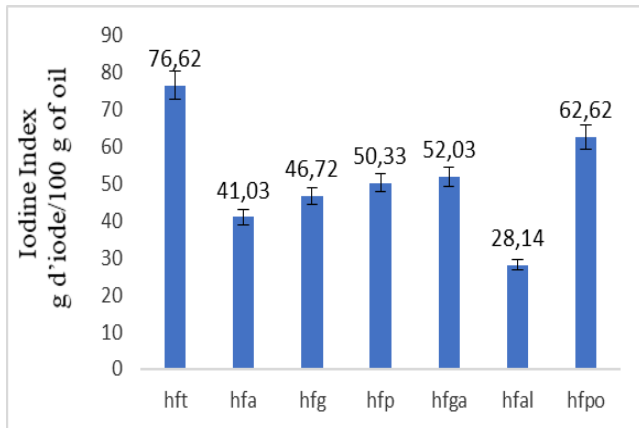**Figure 5:** Evolution of Acid index

Hft : Refined oil without frying (witness) ; Hfa : Frying oils of Fêh ; Hfg : Frying oils of Gbofloto ; Hfp : Frying oils of Pékos ; Hfga : Frying oils of Garba ; Hfal : Frying oils of Alloco ; Hfpo: Frying oils of Gabi

3.1.5. Evolution of Iodine index

The iodine index of the control oil is 76.62 g of iodine / 100 g of oil. After frying, a decrease in the iodine index of the different types of oils is noted. The smallest decrease was recorded for *Gabi* frying oil with a value of 62.62 g of iodine / 100 g of oil, followed by *Garba* frying oil (52.03 g of iodine / 100 g of oil), *Pékos* frying oil (50.33 g of iodine / 100 g of oil), *Gbofloto* frying oil (46.72 g of iodine / 100 g of oil), *Fêh* frying oil (41.02 g of iodine / 100 g of oil). On the other hand, the lowest iodine value is obtained with *Alloco* frying oil (28.14 g of iodine / 100 g of oil) (Figure 6).

Statistical analysis showed a significant difference (p ≤ 0.05) in the iodine value from oil to another during frying.

Figure 6: Evolution of Iodine index

Hft : Refined oil without frying (witness) ; Hfa : Frying oils of Fêh ; Hfg : Frying oils of Gbofloto ; Hfp : Frying oils of Pékos ; Hfga : Frying oils of Garba ; Hfal : Frying oils of Alloco ; Hfpo: Frying oils of Gabi

3.1.6. Evolution of Impurity

The impurity of the control oil is 0.04%. After frying, an increase in the impurity of the different types of frying oil is observed. The most important are obtained with the fries of *Garba, Fêh* and *Gabi* with respective values of 1.28%; 1.03% and 0.92%. The oils from *Gbofloto, Alloco* and *Pékos* fry register respective impurity values of 0.14%; 0.25% and 0.76%. Statistical analysis showed a significant difference (p ≤ 0.05) in the impurity of oil to another during frying.
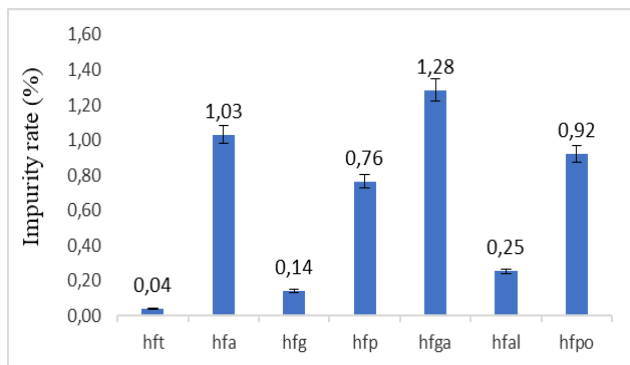
Figure 7 : Evolution of Impurity

Hft : Refined oil without frying (witness) ; Hfa : Frying oils of Fêh ; Hfg : Frying oils of Gbofloto ; Hfp : Frying oils of Pékos ; Hfga : Frying oils of Garba ; Hfal : Frying oils of Alloco ; Hfpo: Frying oils of Gabi

3.2 Discussion

The frying of the oils studied showed changes in the Physico-chemical parameters. Concerning the humidity level, that of the control palm oil remained within the acceptable limits concerning refined oils which are 0.2% according to the codex alimentarius (2003). All frying oils have their humidity level which exceeds the standard of the Codex Alimentarius. This increase could be explained by a transfer of water from food (fish, chicken, banana and others) to oil during frying. Indeed, frying is considered as a

partial (Adedeji *et al.*, 2009) or total dehydration method. This dehydration takes place thanks to the mass transfers (loss of water) and energy (heat supply) which occur simultaneously during frying (Krokida *et al.*, 2000; Farinu and Baik, 2008; Debnath *et al.*, 2009). Mass transfer is characterized by two phenomena mentioned by many authors (Dobraszczyk *et al.*, 2006; Gazmuri and Bouchon, 2009; Adedeji *et al.*, 2009). This is the loss of water from food and the absorption of oil in it. The heat of the oil bath provided by the fryer is conveyed to the food slices by convection and conduction respectively on the surface and inside the product. This heat provided in the form of energy is responsible for eliminating water in the form of vapor which results in bubbling around the food (Duran *et al.*, 2007; Debnath *et al.*, 2009; Sothornvit, 2011).

The control palm oil peroxide index with a value of 8.94 meq of O2 / kg of oil complies with the standard of the *Codex Alimentarius* (2003) which fixes the limit value at 10 meq of O2 / kg of oil for refined oils. However, the peroxide index of frying oils increases and is higher than the value of the *Codex alimentarius*. The peroxide index is considered to be a good indicator for primary oil oxidation (Frankel, 2005; Romano *et al.*, 2012). This increase in frying oils is due, in large part, to the temperature, contact of the oil with air and the introduction of food (Erum *et al.*, 2014). For Oke et al. (2017), the frying conditions, i.e. intense heating and repeated cooling alternately with traditional fryers, favor the alteration of oils by the formation of unwanted newly formed compounds, resulting in the formation of peroxides during the cooling. The consumption of rancid oils has the effect of inducing certain cancers and increasing the risks of coronary heart disease and has unpleasant aftertaste and odors (Doborganes *et al.*, 2000).

The acid index or percentage of free fatty acid is considered by many authors (Bhattacharya *et al.*, 2008; Enriquez-Fernandez *et al.*, 2011) as a parameter indicating the hydrolytic deterioration of a fat. Refined oils must have an acid number of less than 0.6 mg KOH / g of oil (*Codex Alimentarius*, 2003). The acid index values of frying oils are important and above the codex standard. This could be explained by the hydrolysis of triacylglycerols due to contact with water and enzymes contained in the food during frying. These frying oils consist of altered fats rich in free fatty acids (Ahounou *et al.*, 2013) which could easily expose this oil to oxidation (Kandji, 2001).

The saponification index provides information on the length of the fatty acid chains. It decreases with the increase in length of these chains and is related to the length of the fatty acids that make up the oil. A slight decrease in the saponification index was observed in almost all of the samples. The differences in variation observed between frying oils could be explained by the food used for each frying. This decrease could also be justified by the sensitivity of the oil to heat treatment. According to Barka (2016), heating generates splits at the level of acid bonds with the formation of other acid compounds. The initial value of the saponification index of the witness oil is in the range (190-209) set by the *Codex Alimentarius* (2017). Indeed, a low saponification index corresponds to fatty acids having a longer carbon chain. A high saponification index

results in a high level of short-chain fatty acids and higher glycerol content (Ndeye, 2001).

Regarding the iodine value, after frying a decrease in the content is observed. These results show that our oils have undergone self-oxidation catalyzed by a high temperature of the medium (Ndzouli, 2011) and that the drop in the iodine index would be the consequence of the destruction of the double bonds by oxidation and polymerization (Abdulkarim *et al.*, 2007) or modification of fatty acids during frying (Tynek *et al.*, 2001; Manral *et al.*, 2008; Sharoba & Mohamed, 2012). Indeed, according to Vinaixa *et al.* (2005), the iodine index provides information on the degree of oxidation of oils and their oxidative stability. In addition, Floch *et al.* (1968) estimated that the chemicals that result from the polymerization and cyclization of fatty acids remain in the oil and become toxic to consumers. These observations have also been reported by Chebet *et al.* (2016) in their study on the use of vegetable oils in frying different types of food.

After frying, a general increase in the impurity rate is observed and all the values are higher than the standard prescribed by the *Codex alimentarius* (2003) which is 0.05%. This could be explained for cooking debris from food and oil oxidation products (Ahounou *et al.*, 2013). Indeed, repeated heating can cause changes in the physical appearance of the oil, such as increased viscosity, darkening of the color, an increase in foam and a decrease in the smoke point (Fauziah *et al.*, 2000). The values obtained in this study are lower than those of Barka *et al.* (2016) in their experiments on the evolution of the physicochemical nature indices of some frying edible oils and impacts on consumer health (1.54-3.34%).

4. Conclusion

This study was conducted to determine the influence of frying practices on the Physico-chemical parameters of a refined palm oil used in the city of Daloa. The determination of the Physico-chemical parameters made it possible to better appreciate the nutritional quality of the frying oils of each type of food. The results showed that frying the oil causes changes in the Physico-chemical parameters of the oils. These different changes depend on the type of frying carried out. For our health, it would be good not to consume oil that has been used for several frying.

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