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Determination of Physico-Chemical Indices of Frying Oils Used by Attieké-Fish Sellers in Daloa (Mid-West of Côte d'Ivoire)

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Abstract

The purpose of this article is to compare the quality of three edible oils derived from palm oil in Daloa's city. The methodological approach of the article includes, on the one hand, a field survey determining the most used oils and the number of frying carried out by the attieké-fish sellers. On the other hand, the physico-chemical parameters (refractive index, iodine index, saponification index, acid index and peroxide index) of these oils were determined. As a result, the most used oils are A, B and C and are heated at least 3 times by the attieké-fish sellers. After repeated heating, the values of the peroxide, saponification, refraction, iodine indices of oils A and B do not match those of the codex with the exception of the acid value. For oil C, only the acid and iodine indices correspond to the codex standards. Overall, the results of the study clearly show that the repeated heating of these oils has an influence on the different physico-chemical properties studied.

Keywords

Palm Oil, Frying, Attieké-Fish

1. Introduction

Palm oil is derived from the fruits of an African palm tree, *Elaeis guineensis* (Arecaceae family). It is currently grown on a large scale for its oil-rich seeds for food and industrial use [1]. It is a very important natural source of vitamin A and the second oil richest in vitamin E (tocopherols). The yellow or red colour of palm oil depends on its carotenoid content [2]. Its world production has increased tenfold in the last 30 years, from 45 million tonnes in 2009 [3], graphics, and tables are not prescribed, although the various table text styles are provided. The formatter will need to create these components, incorporating the applicable criteria that follow.

In Cote d'Ivoire, palm oil production is estimated at 1,800,000 tonnes per year and represents 3.13% of the Gross Domestic Product (GDP) [4]. With a turnover of more than 500 billion CFA francs, the oil palm sector supports 2 million people with 200,000 regular jobs [4].

According to [5], almost all primary production (palm regimes) is processed locally in an industrial way. Two levels of processing are distinguished: the first processing consists of palm oil mills and the second processing that produces the processed products (edible oil, margarines, soaps, etc.). Primary processing makes it possible to obtain various by-products, namely edible oils sold in shops. These oils are more commonly used in food and in particular for frying.

Frying is one of the oldest practices in food preparation. It consists of continuously exposing the oil or using it several times at high temperature (160˚C - 190˚C) in the presence of air and humidity. This leads to a number of chemical reactions in the oil, such as oxidation, hydrolysis and polymerization. These chemical reactions can alter the quality of the oil, leading to the production of various types of oxidative products [6]. Hydroperoxides and aldehydes are the primary products formed in the early stages of oxidation and absorbed by fried foods [7]. The degree of oxidation can be measured using the peroxide value of the oil).

The reuse of cooking oil several times is frequent in Côte d'Ivoire, despite the health effects [8], for economic reasons. Repeated heating can lead to changes in the physical appearance of the oil, such as increased viscosity, darkening of colour, increased foam and reduced smoke point [9] [10]. These chemical and physical changes in the oil used in frying can have or have negative consequences on the health of the consumer. According to the [11], the quality of oil during frying is determined by many factors, such as the type of frying and the type of oil used. In Côte d'Ivoire, the fish that accompanies attieké, a highly prized dish, is commonly fried before being served [12].

Thus, in order to better understand the changes in the physico-chemical aspect of repeatedly heated oils, a study was initiated.

This study compares the quality of certain palm oils repeatedly heated during fish frying in the city of Daloa.

2. Materials and Methods

2.1. Presentation of the Study Area

The study site is the city of Daloa, located in western central of Côte d'Ivoire, 150 km from Yamoussoukro (Policical Capital) and 390 km from Abidjan (Economic Capital). Daloa, the 3rd largest city in the country, is located at 6˚53 north latitude and 6˚27 west longitude in a forest area with an area of 530.5 ha or

5.305 km^2. This city is the capital of the department of the Haut-Sassandra region. It has about 245,366 inhabitants in 2014.

2.2. Materials

The survey was carried out based on a questionnaire in order to determine the most using oils for frying fish, as well as the number of fries carried out by the attieké-fish sellers.

The biological material consisted of fresh fish and various frying oils. The oils were purchased in a supermarket in the city of Daloa and the fresh fish of the "chinchard" type was purchased at the market because it is considered much more suitable for attieké-fish traders and consumers in terms.

2.3. Methods

2.3.1. Data Collection

Overall, the study concerned all the fish attieké sellers (women and men) in the popular districts of the city of Daloa. The sellers were selected according to the regularity of their activity and their importance in terms of influx of customers. Thus, the study was conducted among 100 attiéké fish sellers located in different areas of the city of Daloa (Abattoirs, Lobia, Soleil, Tazibouo, Kennedy and Garage) between November and December 2017. This survey was carried out in order to find out:

- different oils used for frying fish consumed with attieké;
- number of frying made with each quantity of oil.

The fish was fried in a frying pan with 0.15 L of fresh oil from the biochemistry laboratory of the University Jean Lorougnon Guédé. Three pieces of fish were used at each frying step and three fries were made with the same oil. Then, the oil has decreased and blackened, another quantity (0.15 L) is added after the previous frying and 3 other frying operations are carried out. The temperature was taken at each frying step using a culinary thermometer.

Frying oil sampling was carried out in the biochemistry laboratory of the University Jean Lorougnon Guédé. After cooling the oil, the samples were taken in cryotubes with a capacity of 50 mL and then stored in the refrigerator at 6˚C before being analyzed. Frying oil sampling counted 24 samples.

2.3.2. Determination of the Physico-Chemical Indices of Frying Oils

The refractive index of oils has been determined using a refractometer according to method described in [13]. The acid, peroxide, saponification, iodine indices of the oil samples are performed by the methods described by [14].

In order to determine whether differences observed between oils during the frying steps were significantly different, data were subjected to the non-parametric comparison tests (Kruskal-Wallis test and Mann-Whitney test). Differences between oils during the frying steps addition effects were compared with 0.05. All statistical analyses were carried out by the software Paleotological Statistic (PAST) version 3.23 [15].

3. Results and Discussion

3.1. Results

3.1.1. Characteristics of the Frying Oils Used

The survey of attieké-fish sellers revealed that they used 5 brands of oils, namely A, B, C, D and E (Figure 1(a)). Analysis of the data obtained during the survey showed that the most commonly used oils are A (51%), B (19%), C (23%).

With regard to the number of frying carried out, the survey recorded that 62% of the saleswomen used oils for a minimum of 3 fries, 18% for 2 fries and 20% for a single fry (Figure 1(b)).

Before adding fresh oil (F1), Figures 2(a)-(c) show that the temperatures for A oscillate between 114.3˚C and 125.9˚C and then between 121.4˚C and 135.1˚C for B and between 104.7˚C and 111.3˚C for C.

After adding fresh oil (F2), temperatures vary for oil A between 108.7˚C and 123˚C, then between 122.8˚C and 131.4˚C for B, and finally between 115.9˚C and 126.1˚C for oil C (Figures 3(a)-(c)).

3.1.2. Evolution of the Refractive Index

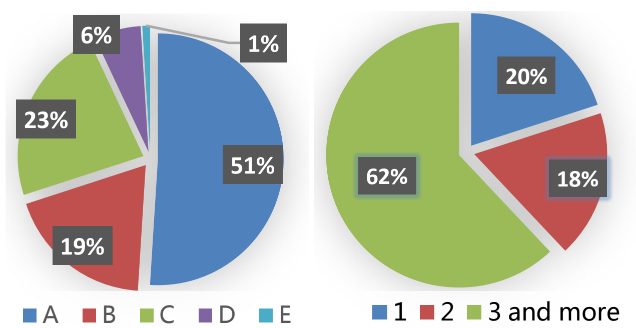
The refractive index increased before the addition of fresh oil, from 1.41 to 1.54 for A, from 1.5 to 1.62 for B and from 1.4 to 1.53 for C (Figure 4(a)). The refractive index after addition of fresh oil increased from 1.49 to 1.87 for A, from 1.58 to 1.77 for B and from 1.52 to 1.75 for C (Figure 4(b)).

The refractive index values recorded in F1 and F2 do not vary significantly ($p < 0.05$) from one oil to another and do not vary from one frying to another.

3.1.3. Acid Index

Before adding fresh oil (F1), the acid index increased from 1.94 to 4.49; 2.07 to 4.88 and 1.56 to 4.89 respectively for samples A; B and C (Figure 5(a)). Increased was also observed after addition (F2). The acid index value rose from 3.76 to 5.15 for A; 4.32 to 6.88 for B, and 4.42 to 6.6 for C (Figure 5(b)).

Overall, there were no significant differences ($p > 0.05$) between oils neither from the same frying and from one frying to another.



(a) (b)

Figure 1. Temperature variation after addition of oils, A (a), B (b) and C (c).

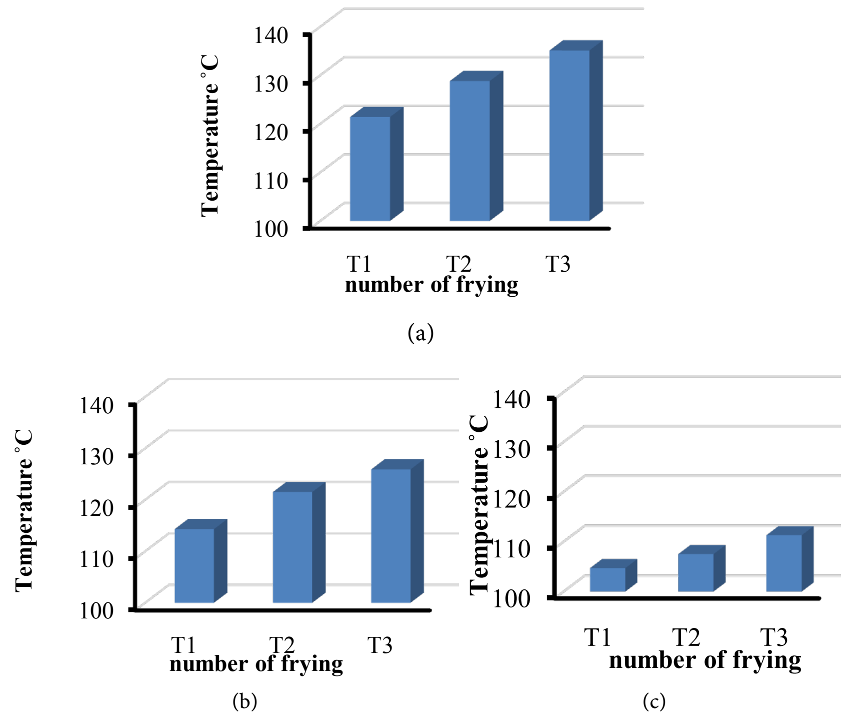


Figure 2. Temperature variation during frying of the different oils before adding fresh oil from oils A (a), B (b) and C (c). With: T1: temperature at first frying; T2: temperature at the second frying; T3: third frying temperature.

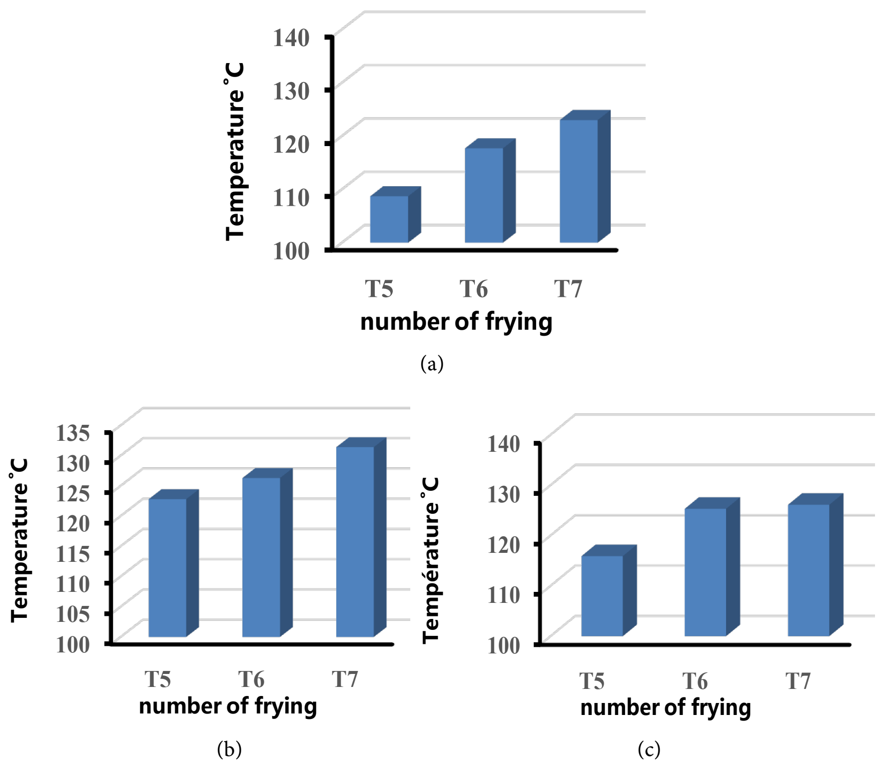
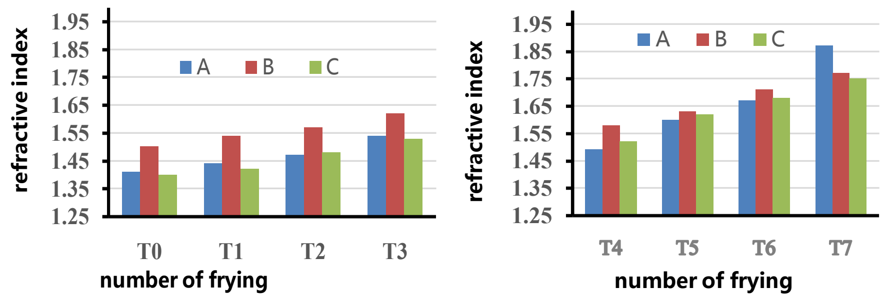
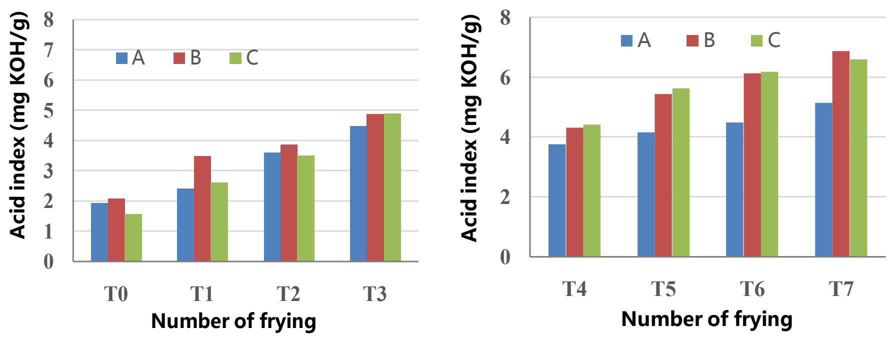


Figure 3. Temperature variation during frying of the different oils after adding fresh oil from oils A (a), B (b) and C (c). With: T5: temperature at the fifth frying; T6: temperature at the sixth frying; T7: temperature at the seventh frying.



(a) (b)

Figure 4. Evolution of the refractive index as a function of the number of fries of the various oils before addition (a) and after addition (b) of fresh oil. With: T0: initial value of the oil; T1: value before first frying; T2: value before second frying; T3: value before third frying; T4: initial value after adding fresh oil; T5: value after first frying; T6: value after second frying; T7: value after third frying.



(a) (b)

Figure 5. Evolution of the acid index according to the number of frying of the different oils before adding (a) and after adding (b) fresh oil. With: T4: initial value after adding fresh oil; T5: value after first frying; T6: value after second frying; T7: value after third frying; T4: initial value after adding fresh oil; T5: value after first frying; T6: value after second frying; T7: value after third frying.

3.1.4. Peroxide Index

Before adding fresh oil (F1), the peroxide value increased from 9.86 to 11.58; 3.11 to 12.33 and 7.98 to 10.33 respectively for A; B and C (**Figure 6(a)**).

After adding fresh oil, the values increased from 11.24 to 14.06 for A, from 22.52 to 29.5 for B, and from 10.15 to 12.18 for C (**Figure 6(b)**).

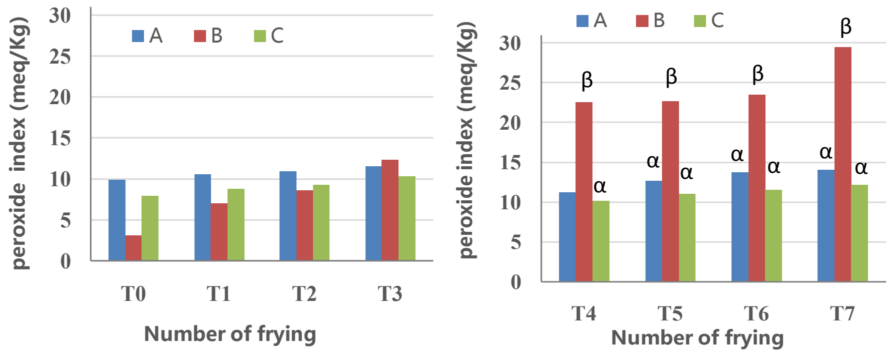
Overall, there was no significant difference ($p > 0.05$) between F1 oils. However, significant variation ($p < 0.05$) occurred between F2 oils and between the two types of frying.

3.1.5. Saponification Index

Figure 7(a) shows a decrease in the index from 199.01 to 187.59 for A, then from 200.01 to 188.75 for oil B and from 196.81 to 182.62 for C.

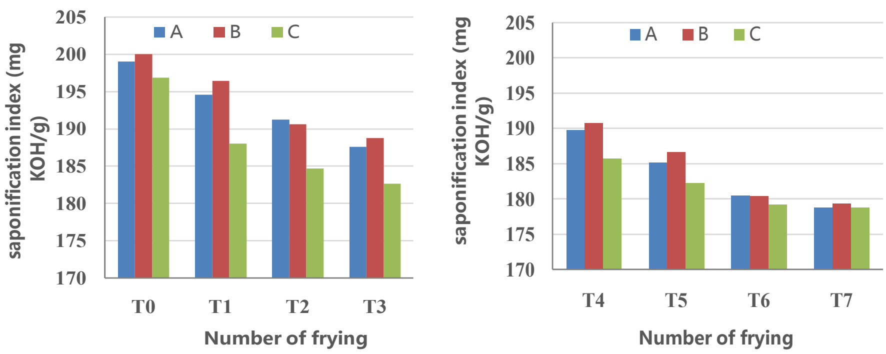
The saponification index after addition of fresh oil fell from 189.8 to 178.81 for A, from 190.72 to 179.37 for B; and from 185.73 to 178.73 for C (**Figure 7(b)**).

The saponification index values recorded for F1 and F2 oils did not vary



(a) (b)

Figure 6. Evolution of the peroxide index according to the number of frying of the various oils before addition F1 (a) and after addition F2 (b) of fresh oil. Histograms with the same letter of the Greek alphabet do not differ significantly.



(a) (b)

Figure 7. Evolution of the saponification index according to the number of frying of the various oils before addition F1 (a) and after addition F2(b) of fresh oil.

significantly ($p < 0.05$) from one oil to another and neither from one type of frying to another.

3.1.6. Iodine Index

The iodine value before addition of fresh oil (F1) decreased from 75.02 to 50.42 for A, from 36.35 to 26.43 for B and from 75.62 to 61.61 for C (Figure 8(a)) then from 51.68 to 40.71; 29.55 to 15.45 and 65.83 to 50.39 respectively for A; B and C after adding fresh oil (F2) was added (Figure 8(b)).

Overall, there was no significant difference ($p > 0.05$) between the oils of the two types of frying. For F1 and F2 oils, a significant variation ($p < 0.05$) was found between B and the other two oils (A and C).

3.2. Discussion

This study revealed that oils such as A, B and C have been used much more for frying by attieké-fish sellers. Indeed, according to these sellers, these oils are prized for their good flavours and odours. These oils are therefore more suitable for frying because they do not blacken and do not spontaneously produce smoke. In addition, the survey generally showed that the saleswomen carried out

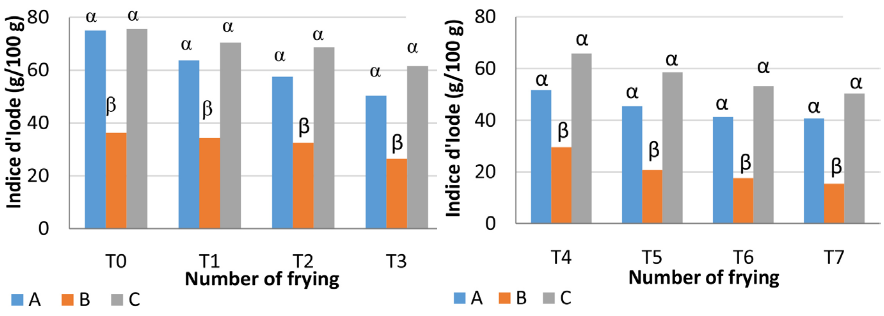


Figure 8. Evolution of iodine index according to the number of frying of the various oils before addition (a) and after addition (b) of fresh oil. Histograms with the same letter of the Greek alphabet do not differ significantly.

a minimum number of 3 fries with the oils and went further while increasing the quantity of oil just after the third fry because according to them the oil became much too black but especially out of concern to have a profit because the permanent purchase of the oil was quite expensive for them.

These temperatures are in accordance with Codex Alimentarius standards. Indeed, according to the Codex Alimentarius (2017) [16], the maximum temperature of a frying must not exceed 180˚C. In addition, frying at too high a temperature can produce a "thermo cracking" (Barka (2016) [17]).

Concerning the refractive index, the results showed an increase before and after the addition of the three types of oils. Conferring to Karleskind and Wolff (1992) [18], this increase is linked to the degree of unsaturation of the oil during frying. These results are not consistent with those of Barka (2016) [17] in a study on frying with soybean oil and sunflower oil. This increase is believed to be related to the high saturated fatty acid content and the non-hydrogenation of palm oil, making it less resistant to heat. The refractive indices of A, B, and C in their initial state do not comply with the requirements of the Codex Alimentarius. Indeed, the Codex Alimentarius (2017) [16] stipulates indices between 1.453 and 1.456. This discrepancy could be explained, on the one hand, by the refining process and, on the other hand, by the deodorization process of oils A, B and C.

For the acidity index, the initial values of oils A, B, and C are perfectly in line with the Codex Alimentarius (2017) [16] standards which stipulate that the acidity index of a virgin palm oil must be less than 10 mg KOH/g oil. According to Kandji (2001) [19], an oil of good quality must have little or no acidity. No samples analysed showed zero acidity, but the values of the acidity index remain in compliance with Codex Alimentarius standards. Overall, the acidity index increased during the various frying operations. Conferring to Ahounou *et al.* (2008) [20], the increase in the acidity index of oils is certainly due to chemical reactions occurring in the oil in contact with water under the effect of heat.

In terms of peroxide value, the values recorded increased during frying before and after the addition of fresh oil. This increase is largely due to temperature, oil contact with air and the introduction of condiment (fish) according to Erum *et al.* (2014) [21]. According to Lamboni *et al.* (2000) [22], the rancidity of the oil results in the destruction of the fatty acids in the oil and the production of highly toxic compounds. Moreover, rancidity could be explained by the transformation of other substances present in the oil such as carotenoids, vitamins A, E and squalene (into peroxides) (Appelbaum *et al.* (1989) [23]). Similar results were obtained by M'baye *et al.* (2012) [24] on the determination of the peroxide value during frying. Indeed, these results showed that the values of the peroxide value increased from 8.1 to 24.12 milliequivalents of oxygen per kilogram.

The saponification index provides information on the length of fatty acid chains. It decreases with the increase in the length of these chains and is related to the length of the fatty acids that make up the oil. A decrease in the contents is observed before and after the addition of fresh oil from the different oils. This decrease could be justified by the sensitivity of the oil to heat treatment. According to Barka (2016) [17], heating causes splits in the double bonds of acids with the formation of other acid compounds. The initial values of the saponification index of A, B and C correspond to the range 190 - 209 set by the Codex Alimentarius (2017) [16]. Indeed, a low saponification index corresponds to fatty acids with a longer carbon chain. A high saponification index results in a high level of short-chain fatty acids and a higher glycerol content (Ferhat *et al.* (2014) [25]).

Concerning the iodine index, the decrease observed before and after the addition of fresh oil during the study of the three types of oils is due to the breaking of double bonds following oxidation and polymerization (Sharoba and Mohamed (2012) [10]). According to Vinaixa *et al.* (2005) [26], the index provides information on the degree of oxidation of oils and their oxidative stability. In addition, Le Floch *et al.* (1968) [27] estimated that chemicals resulting from the polymerization and cyclisation of fatty acids remain in the oil and become toxic to consumers. These observations were also reported by Chebet *et al.* (2016) [28] in their study on the use of vegetable oils in frying different types of food.

4. Conclusion

This study was conducted to compare the quality of certain palm oils repeatedly heated in fish frying in the city of Daloa. It appears that oils A, B, and C are the most commonly used by women selling attieké-fish for frying fish. These oils are heated at least three times at each frying by these saleswomen. The determination of physico-chemical parameters has made it possible to better assess the nutritional quality of frying oils. With the exception of the refractive and iodine indices of oils used before frying, the saponification, peroxide and acidity indices show values in accordance with Codex Alimentarius standards. In addition to the increase in refractive, peroxide and acidity indices of frying oils before and after the addition of fresh oil, the values of iodine and saponification indices have decreased. After a cycle of six fries for A and B, the values of the peroxide, saponification, refraction and iodine indices did not correspond to those set by the Codex Alimentarius. However, the iodine index values of oil B were in Codex standards. The three types of oils studied generally degraded much faster after the third frying despite the addition of fresh oil.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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