Short Research Article

ANTIOXIDANTS ACTIVITIES AND HEAVY METAL PROFIL IN VEGETABLE OILS IN YAOUNDE

Abstract

The main aim of this study was to determine the quality of vegetable oils consumed by the population in Yaoundé.

The study was carried out on 14 vegetable oils sampled following a survey. The antioxidant potentials of these oils were analyzed using the 2,2-diphenyl-1-picrylhydrazyl, FRAP and total antioxidant capacity. The concentrations of some heavy metals (Pb, Cu, and Fe) were determined using flame atomic absorption spectrometry after acid digestion. The acid and peroxide values were assessed using methods described by the Cameroonian standard on vegetable oils.

The sample included 8 brands of which, 5 of refined palm oil, 4 of soybean oil, 1 brand of cottonseed oil, sunflower oil, cold extracted olive oil, red palm oil and bleached palm oil each. The antioxidant activity showed a good correlation, with red palm oil having the greatest antioxidant potential and bleached palm oil having the least antioxidant potential. The Pb, Cu, and Fe contents had the following conformities: 71.4%, 100% and 0%, respectively. For the acid and peroxide values, we found 50% and 21.4%, respectively. Six of the fourteen (42.9%) analyzed oils contained less than 33 IU/g vitamin A.

These results highlight the poor quality of the oils consumed in Yaoundé.

Key words: Vegetable oils, Antioxidant, heavy metal, Standards

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INTRODUCTION

Unsafe food can lead to several health issues, including diarrheal diseases, viral diseases, reproductive and developmental illness, and cancers [2-3]. Thus, it is an increasingly important public health issue. Governments worldwide are intensifying efforts to improve food safety in response to an increasing and various food risks [3].

Safer food saves lives [4]. It is not possible to talk about the quality of a product without considering its safety and vice versa. Food quality can be defined as a total of traits and criteria that characterize food regarding its nutritional and sensory values, convenience, and safety for a consumer's [5]. Food safety (hazard-free) is the most important feature of food quality; hence, food law regulates this issue to ensure consumers that the food they purchase meets their expectations in terms of safety [5-6].

In 2011, Ngando et al. reported that the acid and peroxide values of crude palm oil initially increase over storage [8]. As well, in 2013 this same research group report that 50% of crude palm oil sold in Douala did not meet Codex standards with respect to their acid value [9]. Moreover, Kenmogne [12], emphasized that the conformity of refined vegetable oils consumed in Douala is estimated at 41.96%. Hence, few numbers of vegetable oils available on the market meet the recommended requirements. [8-12]. Even if the manufacturer are the same allover the country, and taking in to account the fact that weather and storage condition can change the quality of oil as well as no report on the vegetable oil sold in Yaoundé, this study aimed at assessing the antioxidant activities and the heavy metal profiles of the vegetable oils in Yaoundé markets.

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MATERIALS AND METHODS

This study was carried out at IMPM (Institute of Medical Research and Medicinal Plant studies), at the “Food and Nutrition Research Centre”, where peroxide and acid contents were determined, at the “Phytochemical Laboratory”, where the antioxidant activities were analyzed, at the “Centre Pasteur du Cameroun”, where heavy metals (Fe, Cu and Pb) of various edible oils were determined.

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The samples of vegetable oils analyzed were obtained from two local markets in Yaoundé (Mfoundi and Mokolo), and two supermarkets (Casino and Mahima). A sample of all vegetable oils found in the markets/supermarkets was bought. Prior to analysis, each sample were aliquoted in four 100 mL translucent plastic bottle and stored away from sunlight and humidity.

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Analysis of the antioxidant activity

Evaluation of radical scavenging activity of oil samples

- **DPPH scavenging test**

Principle: Antioxidants react with DPPH, which is a stable free radical and is reduced to DPPH-H; therefore, the absorbance is decreased from the DPPH radical to the DPPH-H form. The degree of discoloration indicates the scavenging potential of the antioxidant compounds extracts in terms of hydrogen donating ability and is monitored at 517 nm [34].

Method:

An aliquot of oil solution (50 µL) was added to 2.95 mL of a methanolic solution of DPPH (5 mg/100 mL) and the mixture was read at 517 nm after 15 minutes against a blank tube made of 50 µL of oil solution and 2.95 mL of chloroform.

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A control test was made of 50 µL of chloroform and 2.95 mL of a methanolic solution of DPPH (5 mg/100 mL) and the reading was taken at 517 nm after 15 min against a blank tube containing chloroform.

Expression of results: The radical scavenging activity of extracts was calculated using the formula;

$$= \frac{\text{Absorbance of control} - \text{Absorbance of sample}}{\text{Absorbance of control}} *$$

Evaluation of ferric reducing antioxidant power (FRAP) of oil samples

Principle: In this assay, the yellow color of the test solution changes to green depending on the reducing power of the sample. The presence of reductions (antioxidants) in the sample causes the reduction of the Fe3+/ferricyanide complex to the ferrous form. Therefore, Fe2+ can be monitored by measuring the absorbance at 700 nm [35].

Fe^{3}+ + e- Fe^{2}+

Evaluation of the total antioxidant capacity of oil samples

Principle: The assay is based on the reduction of Mo (VI) to Mo(V) and subsequent formation of a green phosphate/Mo(V) complex at acidic pH.

Heavy metals (Fe, Cu, Pb) profile

Principle: The mineralized oil samples are subjected (sprayed into the flame of an atomic absorption spectrometer) to an energy supplied by a flame (air, acetylene). This energy excites atoms, giving rise to excited atoms. During excitation of these atoms, light rays at a specific wavelength that are emitted from a specific hollow cathode lamp are absorbed by these atoms, and the corresponding absorbance is registered by the detector.

Peroxide and Acid Values by titration

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Principle: The acid value is determined by directly titrating the oil/fat in an alcoholic medium against standard potassium hydroxide/sodium hydroxide solution.

Analytical Importance: The value is a measure of the amount of fatty acids that have been liberated by hydrolysis from glycerides due to the action of moisture, temperature and/or lipolytic enzyme lipase.

Method: A volume of 1 mL of oil solution (oil is dissolved in chloroform) was mixed with 2.5 mL of a 0.2 M sodium phosphate buffer (pH 6.6), 2.5 mL of 1% potassium ferrocyanide and incubated in a water bath at 50 °C for 20 minutes. Then, 2.5 mL of 10% trichloroacetic acid was added to the mixture that was centrifuged for 10 minutes. The supernatant (2.5 mL) was then mixed with 2.5 mL distilled water and 0.5 mL of 0.1% ferric chloride solution. The intensity of the blue-green colour was measured at 700 nm.

Ascorbic acid was used as positive control at concentration ranging from 0 to 0.30 mg/mL. Tests were carried out in triplicate.

Expression of results: The ferric reducing antioxidant power was expressed as µg ascorbic acid equivalents /100 g of dry weight (µg AAE % DW). All samples were analysed in three replications.

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RESULTS

Results obtained from survey

For our survey, 300 women of different homes from 10 different neighbourhoods (30 households per neighbourhood) in Yaounde were interviewed and the following results were obtained.

- ***Mean ages***

Table I: Mean ages encountered in the 10 neighbourhoods where survey was carried out.

Place	Mean ± SE
Bonamoussadi	23.60 ± 0.54
Simbock	27.77 ± 2.33
Nsimeyong	34.63 ± 1.71

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Jouvence	37.20 ± 2.74
Essos	34.90 ±1.71
Biyem Assi	35.33 ± 2.12
Biteng	28.67 ± 3.08
Emana	31.47 ± 3.11
Odza	39.93 ± 1.78
Manguier	33.16 ± 2.32
Area of Study	32.64 ± 0.76

The mean age range of sample population was between 23.60 ± 0.54 to 39.93 ± 1.78.

Choice of consumption of vegetable oils in homes

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Legend: markets (Mfoundi and Mokolo), and supermarkets (Casino and Mahima)

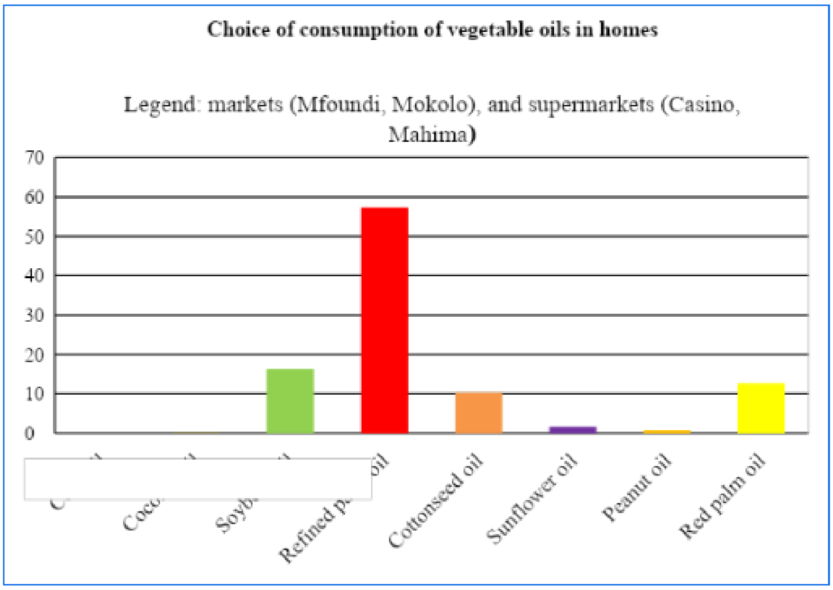

Figure 1: Bar chart showing the primary consumption of vegetable oils in homes

Our survey revealed that refined palm oil is most consumed by the Yaoundé population as their primary choices in their respective homes, followed by soybean oil and then red palm oil, which came in third place.

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Table II: Reason for vegetable oil choices

Reasons for using vegetable oils	Pourcentage
Low cost	40%
Taste	15%

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Refinement	15%
Nutritional value and quality standard	30%

According to the survey, the sampled population decides to use the oil based on low cost (40%), taste (15%) and refinement (15.33%). The remaining 30% uses vegetable oils according to their nutritional value, quality standards, organoleptic properties, and availability.

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Quantitative DPPH analysis

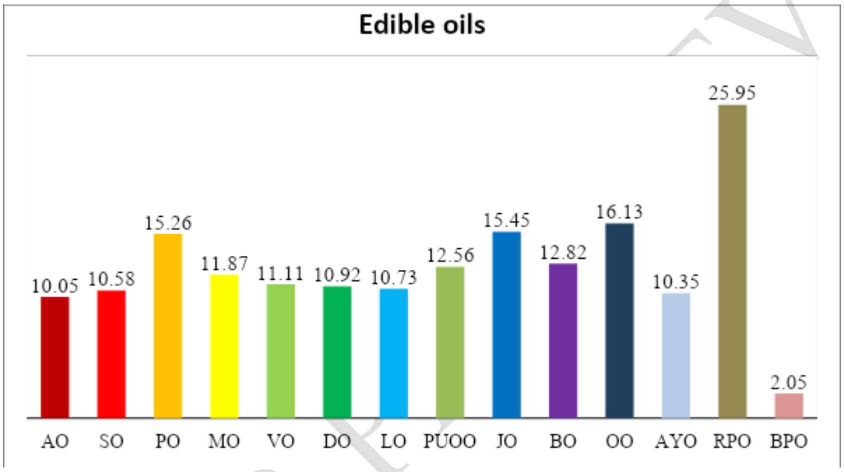

Figure 2: Chart showing the free radical activity of oils using DPPH as a radical.

DPPH analysis revealed that red palm oil had the highest free radical scavenging activity and bleached palm oil had the lowest free radical scavenging activity. Four out of five of the refined palm oils had statistically the same free radical scavenging activity. Three of the soybean oils also showed good free radical scavenging activity, with two being ranked as second highest. However, one of the soybean oils had a significantly different activity (lower) than the other soybean oils. It instead showed the same activity as most of the refined palm oil. Sunflower, cottonseed and olive oil revealed average antioxidant potentials that were comparable to those of the four previously mentioned refined palm oils.

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FRAP Activity

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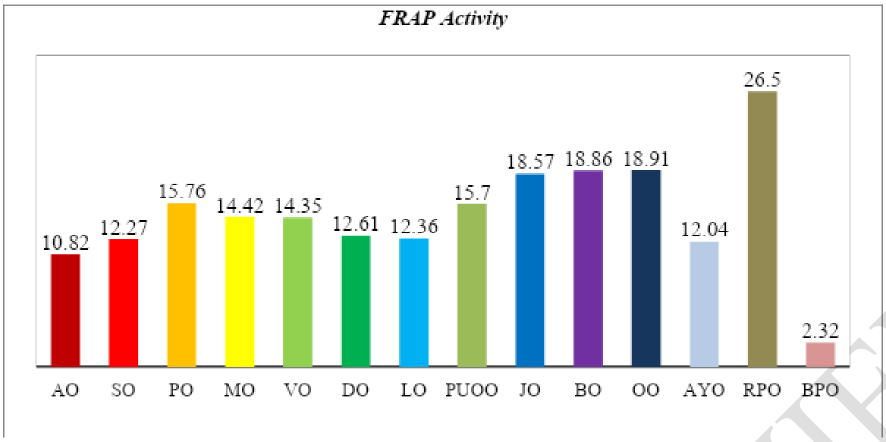

Figure 3: Chart showing FRAP activity of oils.

The FRAP activity revealed that red palm oil had the highest antioxidant activity and that bleached palm oil had the least antioxidant activity. The second ranked were soybean oils, with the exception of one, which was instead comparable to the antioxidant potential of the refined palm oils.

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Notably, there was one refined palm oil whose activity was not significantly different from the soybean oils that were ranked second.

Total antioxidant activity

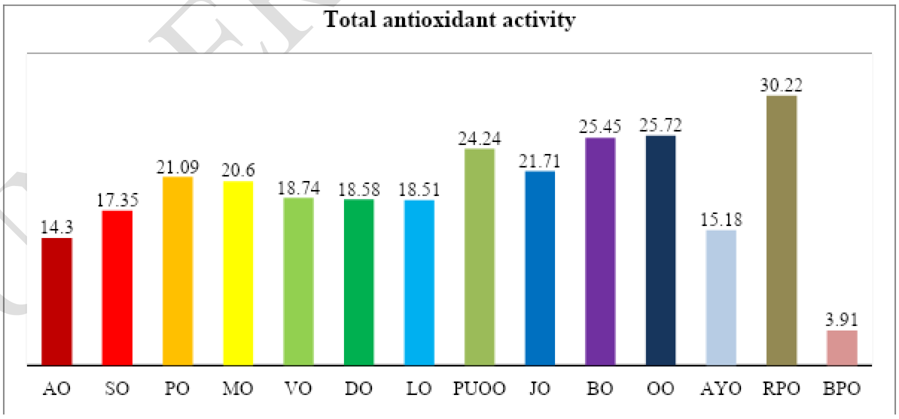

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Figure 4: Bar chart showing total antioxidant activity

The total antioxidant activity revealed that red palm oil had the highest antioxidant potential and bleached palm oil had the lowest antioxidant potential. Red palm oil was followed by three of the soybean oils and olive oil, which showed no significant difference in antioxidant potential. However, one of the soybean oils still showed a low antioxidant potential with respect to the others.

Results for the analysis of heavy metals

Lead content

Table III: Lead content of oil samples

Samples	**Lead content** (mg/kg)	**Standard value**	**Student t test**	**p-value**
AO	0.38 ± 0.12[a]	0.1	2.447	0.247
SO	1.19 ± 0.13[a]	0.1	8.003	0.015*
PO	0.85 ± 0.12[a]	0.1	5.961	0.027*
VO	0.48 ± 0.24[a]	0.1	1.627	0.245
DO	0.73 ± 0.20[a]	0.1	3.188	0.086
LO	0.38 ± 0.30[a]	0.1	0.923	0.525
PUOO	1,05 ± 0.23[a]	0.1	4.183	0.053
JO	0.73 ± 0.18[a]	0.1	3.458	0.074
BO	0.85 ± 0.31[a]	0.1	2.407	0.251
OO	0.00 ± 0.00[a]	0.1	-34.463	0.001*
RPO	12.50 ± 0.64[b]	0.1	19.434	0.003*
BPO	13.55 ± 0.78[b]	0.1	17.243	0.003*

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Lead content of oil samples

The values carrying the different letters in the same column are significantly different ($p < 0.05$) the samples are different from the standard value ($p < 0.05$)

ND: not detected

Five (35.71%) oils showed a significant difference from the standard value. This revealed that the lead content in four (28.57%) of these oils was higher than the maximum standard value and that one was far lower. Among these four oils that were higher, we had two refined palm oils and two crude oils. The crude oils (red palm oil and bleached palm oil) showed a significant difference from the refined palm oils, with their Pb concentrations being much higher. The others showed no significant difference from the standard value.

Table IV: Iron content

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Samples	**Iron content** (mg/kg)	**Standard value**	**Student t test**	**p-value**
AO	4.51 ± 0.07[a]	1.5	42.270	0.001*
SO	3.39 ± 0.03[a]	1.5	67.177	0.000*
PO	3.18 ± 0.20[a]	1.5	8.489	0.014*
MO	9.44 ± 0.12[a]	1.5	67.314	0.000*
VO	9.93 ± 0.18[a]	1.5	47.321	0.000*
DO	4.61 ± 0.21[a]	1.5	15.104	0.004*
LO	7.05 ± 0.11[a]	1.5	51.820	0.000*
PUOO	3.03 ± 0.15[a]	1.5	10.399	0.009*
JO	6.21 ± 0.14[a]	1.5	33.371	0.001*
BO	7.51 ± 0.15[a]	1.5	40.185	0.001*
OO	21.33 ± 0.36[a]	1.5	54.986	0.000*
AYO	7.18 ± 0.09[a]	1.5	62.443	0.000*
RPO	33.83 ± 0.14[a]	5	203.076	0.000*
BPO	29.62 ± 0.22[a]	5	113.779	0.000*

Iron content of oil samples

The values carrying the different letters in the same column are significantly different ($p < 0.05$)

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The samples are different from the standard value ($p < 0.05$)

The iron content in all (100%) analysed oil samples was significantly higher than the standard value. The highest mean of 33.83 ± 0.14 was obtained from red palm oil, and the lowest was obtained from olive oil.

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Acid Value and Peroxide Value

Table V: Acid value

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Samples	**Acid value (**mg KOH/g oil)	**Standard value**	**Student t test**	**p-value**
AO	0.85 ± 0.01^{c}	0.2	48.417	0.013*
SO	1.42 ± 0.01^{d}	0.2	78.098	0.008*
PO	0.63 ± 0.03^{bc}	0.2	15.277	0.042*
MO	0.59 ± 0.03^{bc}	0.2	13.846	0.046*
VO	2.55 ± 0.03^{e}	0.2	78.408	0.008*
DO	0.24 ± 0.04^{ab}	0.2	1.046	0.486
LO	0.02 ± 0.02^{a}	0.2	-9.255	0.069
PUOO	0.80 ± 0.00^{c}	4	-7241.841	0.000*
JO	0.59 ± 0.00^{bc}	0.2	492.631	0.001*
BO	0.06 ± 0.02^{a}	0.2	-6.821	0.093
OO	0.95 ± 0.09^{cd}	0.2	8.678	0.073
AYO	0.80 ± 0.00^{c}	0.2	956.251	0.001*
RPO	9.34 ± 0.29^{f}	10	-2.212	0.270
BPO	10.37 ± 0.15^{g}	10	2.471	0.245

Acid value of oils

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The values carrying the different letters in the same column are significantly different ($p < 0.05$)

The samples are different from the standard value ($p < 0.05$)

Seven (50%) oils were proven to have acid values significantly higher than the standard values, while the other seven had acid values lower than the standard maximum level. The lowest acid value was observed in sunflower oil, while the highest acid value was observed in bulk oil, commonly known as 'vrac'.

Samples	**Peroxide value (**milli equivalents of active oxygen/kg oil)	**Standard value**	**Student t test**	**p-value**
AO	7.59 ± 0.29^{a}	5	8.906	0.071
SO	9.79 ± 0.09^{abc}	5	54.978	0.012*
PO	15.12 ± 0.03^{ef}	5	354.100	0.002*
MO	11.99 ± 0.36^{cde}	5	19.171	0.033*
VO	15.78 ± 0.10^{f}	5	105.123	0.006*
DO	11.16 ± 0.23^{bcd}	5	26.991	0.024*
LO	8.34 ± 0.07^{ab}	5	45.489	0.014
PUOO	20.13 ± 0.03^{g}	15	158.232	0.004*
JO	9.71 ± 0.27^{abc}	5	17.692	0.036*
BO	12.66 ± 0.04^{cdef}	5	191.181	0.003*
OO	13.62 ± 0.26^{def}	5	32.536	0.020*
AYO	15.47 ± 0.40^{f}	5	26.112	0.024*
RPO	21.05 ± 0.33^{g}	15	18.086	0.035*
BPO	21.64 ± 2.13^{g}	15	3.119	0.198

Table VI: Peroxide value of oils

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The values carrying the different letters in the same column are significantly different ($p < 0.05$), the samples are different from the standard value ($p < 0.05$)

Eleven (78.57%) peroxide values were significantly higher than the standard values, but 3 values showed no significant difference from the standard values.

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DISCUSSION

The first aim of this study was to identify the edible oils consumed by the Yaoundé population. The second aim was to determine the quality of these edible oils by analysing the antioxidant activity, content of heavy metals (Pb, Cu, Fe), acid value, and peroxide value

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Refined palm oil was the most consumed edible oil in Yaoundé based on our study. This result is line with the report by the Ministry of Trade in Cameroon (2016) [8]. This could be explained primarily by the comparatively low cost of refined palm oils.

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However, most traditional dishes require cooking with red palm oil; thus, red palm oil was ranked second in consumption. Moreover, red palm oil is relatively cheap and readily available.

Soybean oil and cottonseed oil are averagely consumed. Soybean oil is believed to be very healthy due to its fatty acid composition consisting mainly of polyunsaturated fatty acids. On the other hand, cottonseed oil is loved due to its great taste and because it resists further processing at high temperatures.

Some oils are barely consumed due to high cost (sunflower oil) and unavailability (peanut oil and corn oil) in the market.

Some people bleach palm oil and use it in place of refined oils, most likely due to socioeconomic reasons. This not only leads to the deterioration of the sensory qualities of oils but also their nutritional quality. Beta carotene, which gives the characteristic colour of red palm oil, is lost during bleaching.

Each vegetable oil has its own nutritional properties. For example, some are rich in omega 3 fatty acids, while others are rich in omega 6 fatty acids. Vegetable oils have to be consumed every day. Knowing that vegetable oils are the main source of essential fatty acids, it is recommended, as emphasised by Fediol (2015), to vary the source of vegetable oils or to use various vegetable oils to reach the appropriate balance of essential fatty acids [8-9].

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Finally, the survey revealed the increased need of consumers to know the quality of vegetable oils they consume.

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For the DPPH qualitative assay, all the oils except one bleached DPPH solution purple colour in the thin layer chromatographic qualitative assay, showing that all of them except bleached palm oil are potential antioxidants.

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There was a positive correlation between the three quantitative assays used for determining the antioxidant potential of oil samples. Quantitative assays revealed varying degrees of antioxidant activity of the oils.

The DPPH, FRAP and total antioxidant activities all revealed that red palm oil had the highest antioxidant potential, while bleached palm oil had the lowest antioxidant potential. Red palm oil is very rich in carotenoids and tocopherol, which are natural antioxidants [7].

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Soybean oil also showed a relatively high antioxidant potential except for one soybean oil, which showed an average low antioxidant potential. This could be due to its position in the supermarket; it was displayed at the entrance and hence directly exposed to light. The high antioxidant activity of these soybean oils is in agreement with the study carried out by Castelo-Branco et al. in Brazil in 2015 [11].

Refined palm oils had an average antioxidant potential, but there was one refined palm oil with potential similar to soybean oil with high potential. This again will be explained based on its lack of exposure to light. This oil was stored in a carton that was arranged on the inner shelves in a store.

However, the overall antioxidant potential of the oil samples in this study was lower than that seen in the literature, which might be due to our solvent choice. In 2011, Sagar B proved that the solvent used affects the antioxidant potential [12].

Oxidative stability and antioxidant activity are two parameters that explain the resistance of oils against oxidative deterioration by oxygen during heating and storage.

Mari S, Urszula and Sanja et al. observed that the antioxidant effectiveness of oil is dependent on the extent to which the antioxidant participates in side reactions, such as reactions with species other than peroxyl radicals [10-13].

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Four oil samples showed a mean concentration higher than the standard maximum level (0.1 mg/kg), as defined by the Cameroonian standards and the Codex Alimentarius. Two refined oils had mean concentrations of 1.19 ± 0.13 and 0.85 ± 0.12, which are above the maximum level in refined oils [6; 17].

Two virgin oils, red palm oil and bleached palm oil, had much higher concentrations of 12.5 ± 0.64 and 13.55 ± 0.78, respectively.

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The results obtained for Pb content for these four oils were significantly greater than results obtained in the literature. However, the values obtained for the ten other oil samples were tied with the studies carried out by Llorent Martinez et al. in Spain (2011), Fangkun et al. in China (2011), and Nnorom et al. in Nigeria (2014) [14-15].

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The copper metal was not detected in any analysed oil sample. This is in agreement with standards that state that the maximum copper level is 0.1 mg/kg for refined oils and 0.4 mg/kg for virgin oils [6; 17].

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Our results obtained for Cu content are similar to those obtained by Llorent-Martinez et al. (Spain, 2011), Fangkun et al. (China, 2011) and Nnorom et al. (Nigeria, 2015) [14-15].

Notably, the FAAS used had a limit of detection of 0.1 mg/kg. This explains why we could not obtain precise values for any concentration less than 0.1 mg/kg.

In our study, the highest mean Fe concentration was 33.83 ± 0.14, which corresponded to the mean red palm oil, while the lowest was 3.03 ± 0.15, which corresponded to the mean olive oil. This gave us a mean range of 3.03 – 33.83 mg/kg.

The mean concentrations of Fe in all analysed vegetable oils were much higher than the standard maximum level. The standard and quality agency (ANOR) in Cameroon had set standard maximum levels that are technically equivalent to the CODEX STAN 201- 1999 (Rev. 1-1999). These standard maximum levels for Fe content are 1.5 mg/kg for refined oils and 5 mg/kg for virgin oils [9].

The mean Fe content obtained in our study was lower than that observed by Nnorom et al. in Nigeria (2015), who obtained a range of 50 – 425 mg/kg in imported oils and 125 – 413 mg/kg for local oils. Our results were also lower than those obtained by Nnorom et al. in 2014 in Nigeria [15].

The presence of metals in vegetable oils depends on several factors. They might come from the soil, environment, and genotype of plants, fertilisers and/or metal-containing pesticides introduced during their production process or by contamination from metal processing equipment [16].

Furthermore, long-term water irrigation may lead to the accumulation of heavy metals in edible plants. Singh et al. Prieto P, Pineda M, Aguilar M. observed that vegetables accumulate heavy metals in the edible and nonedible parts; thus, this could be the reason for the very high Pb concentration in red palm oil and bleached palm oil given that they do not go through the refining process, hence retaining most of the metals [11].

Although some heavy metals, such as Fe and Cu, act as micronutrients at lower concentrations, they become toxic at higher concentrations. Health risks due to heavy metal contamination of soils have been widely reported [18].

It is common knowledge that lead is very toxic and can be very harmful even at low concentrations when ingested over a long time period. However, iron and copper are similar to oxygen; they have to be handled

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properly because they have the potential to catalyse damaging free radical reactions, as portrayed by Halliwell B. in Britian (1997) [16].

In Brazil, Castelo-Branco et al. (2015) observed that acid and peroxide values are the most commonly used quality indices because they are mandated by legislatures and reflect appropriate processing conditions, including extraction and refining processes as well as storage [11]. In Cameroon, Ngando et al. (2011) also stated that peroxide and acid values are useful indices to control dietary oil safety and quality [10].

The acid value is an indicator of hydrolytic rancidity in oils, i.e... It measures the extent to which the constituent glycerides have been decomposed by lipase action, thus forming free fatty acids (hydrolysis). AV is expressed as the amount of KOH (in milligrams) necessary to neutralise free fatty acids contained in 1.0 g of oil, as stated by Fakhri et al. (2011) [14].

Our results were also similar to those obtained by Kenmogne in his research work in Douala, Cameroon [12]. In contrast, all samples initially assayed by Ngando et al. in Cameroon (2011) complied with recognised standards [10], and the samples assayed by Fakhri et al. in Romania (2011) [14].

Most peroxide values of oils from the different oil varieties showed values higher than the maximum standard levels, which are fixed at 5 mEq of oxygen per kg for refined vegetable oils and 15 mEq of oxygen per kg for virgin vegetable oils [6].

This was an indication that the oils were not freshly extracted and that they are liable to oxidative rancidity at room temperature. This high level of lipid oxidation expressed in the form of peroxide can also be explained by the high level of Fe (confirmed by the measurement of the Fe content using the FAAS) in these oils, which increases the rate of oxidation.

The high acid values of some of these oils also indicate the presence of free fatty acids in the oils. As stated Brand-Williams W, Cuvelier M, Berset C et al (2005) and Singh A, Rajesh k, Madhoolika A, Marshall and Jin R. (2014) these free fatty acids are also capable of being autoxidised and thus can increase the PV of the oil. This explains why the bulk oil, which had the highest acid value (free fatty acids), also had a relatively higher peroxide value. The same relationship was observed with sunflower oil, which had the smallest acid value and one of the smallest acid values. [17-19]

Our results were comparable to those obtained by Kenmogne in 2015, who had a range of 2.5 – 35.9 [9]. However, our results were slightly lower than those obtained by Kenmogne. In contrast, samples assayed by Ngando et al. in 2011 and 2013 all conformed to recognised standards [8; 9].

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CONCLUSION

Based on the survey, 12 different brands of edible oils as well as red palm oil and bleached oils were seen to be mostly consumed by the Yaounde population with respect to the other edible oils. Among the 12 different oil brands we had, 5 brands of refined palm oil, 4 brands of soybean oil, 1 cottonseed oil, 1 sunflower oil and 1 olive oil.

Overall, quality control of vegetable oils sold in Yaounde was the aim of our study with emphasis on their nutritional quality and safety. To attain this goal, a survey and the evaluation of the following quality parameters were carried out: antioxidant potential, heavy metal (Pb, Cu, and Fe) content, peroxide value, acid value and vitamin A content. Using the chosen methods, we can say our objectives were met.

From these analyses, we can conclude that vegetable oils consumed by the Yaounde population are substandard. However, the refined vegetable oils were of better quality than the red palm oil. Although the analysed red palm oil had the highest and antioxidant activity, it had a relatively high lead content. In summary, sunflower oil was of the best quality based on the parameters evaluated in this study.

On this note, further studies must be done on vegetable oils to detect possible adulterations. This can be done by assessing the fatty acid composition of these oils. Furthermore, studies must be done too to determine if the oils we consume here are free of pesticide residues and last but not the least the impact of heat on physicochemical characteristics as well as the nutritional factors should be brought to light.

Vegetable oil safety in particular and food safety in general is a theme of high relevance to all people on the planet and multiple stakeholders, including government, civil society, the private sector, and intergovernmental agencies. Thus, we must all treat food safety as a top priority.

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REFERENCES

1. Food Safety and Standards Authority of India. Manual of methods of analysis of foods: oils and fats. Fssai. 2012

2. Sikora T, Strada A. Safety and Quality Assurance and Management systems in food industry: An overview. The food industry in Europe: 2003; Chapter 6: 85 – 95

3. Fezeu L, Balkau B, Sobngwi E, Kengne A-P, Vol S, Ducimetiere P, Mbanya J-C. Waist circumference and obesity-related abnormalities in French and Cameroonian adults: the role of urbanization and ethnicity. Int J Obes. 2010 Mar;34(3):446–53.

4. Vidrih R, Vidakovic S, Abramovic H. Biochemical Parameters and Oxidative Resistance to Thermal Treatment of Refined and Unrefined vegetable edible oils. Czech J Food Sci. 2010; 28(5): 376 – 84

5. Gromadzka J, Wardencki W. Trends in edible vegetable oils analysis Part A. Determination of different components of edible oils – a review. Pol J Food Nutr Sci. 2011; 61:33-4

6. Ngando F, Mpondo E, Dikotto E, Koona P. Assessment of the quality of crude palm oil from smallholders in Cameroon. JSPPR. 2011; 2(3): 52 – 8

7. Jin R. Comparison of chemical Quality Standards for New Zealand Extra Virgin oil. [Thesis for the award of a Master's degree in Food Technology]. New Zealand: Massey University, 2014.

8. Ngando F, Mpondo E, Ewane M. Some quality parameters of crude palm oil from major markets of Douala, Cameroon. Afr J Food Sci. 2013 ; 7(12): 473 – 8

9. Kenmogne S. Etude de l'identité et la qualité de quelques types d'huiles végétales raffinées commercialisées à Douala. [Thesis for the award of a Doctor of Pharmacy]. Douala: University of Douala, 2015.

10. Angaye S, Maduelosi N. Comparative study of the physicochemical properties of some refined vegetable oils sold in Mile one Market and some departmental stores in Port Harcourt, Rivers State, Nigeria. J Agric Food Sci. 2015; 39:16 – 9

11. Castelo-Branco V, Santana I, Di-Sarli V, Freitas S, Torres A. Antioxidant capacity is a surrogate measure of quality and stability of vegetable oils. Eur J Lipid Sci. Technol. 2015; 117: 1 – 12

12. Mari S, Urszula S. Solvent influence of antioxidant activity assay of selected cold-pressed plant oils. PiJ. 2013; 14: 67 – 74

14. Prieto P, Pineda M, Aguilar M. Spectrophotometric Quantitation of Antioxidant Capacity through the formation of a Phosphomolydenum complex: Specific Application to the determination of Vitamin E. Anal Biochem 1999; 269: 337 – 41

15. Nnorom I, Ugochukwu E. Comparative Study of trace metal (Cd, Cr, Cu, Fe, K, Mg, Na and Zn) contents of local and imported vegetable oil brands consumed in Nigeria. AJPSKY.2015: 5(4): 22-9

17. Brand-Williams W, Cuvelier M, Berset C. Use of a free radical method to evaluate the antioxidant activity. J Food Sci. Technol. 1995; 28(1): 25 – 30

UNDER PEER REVIEW

18. Although, Pignitter M, Somozoa V. Are vegetable oils always a reliable source of vitamin A? A critical evaluation of analytical methods for the measurement of oxidative rancidity. Sight life. 2012; 26(1): 18 – 27

19. Singh A, Rajesh k, Madhoolika A, Marshall F. Risk assessment of heavy metal toxicity through contaminated vegetables from waste water irrigated area of Varanasi, India. J Trop. Ecol. 2010; 51(25)

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