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Cosmetic or Dietary Vegetable Oils Sampled in the Cameroonian Market May Not Expose Consumers to Lipid Oxidation Products Generating Oxidative Stress and Inflammation

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Abstract

Vegetable oils are a source of energy, essential fatty acids, antioxidants and fat-soluble vitamins useful for human health care and development. These oils also contribute to organoleptic quality of their products' derivatives. However, their chemical and physical properties can be modified by the mode of their extraction, storage and distribution. These modifications might negatively affect the nutritional quality of the oils. The goals of this study were to: sample different vegetable oils for cosmetic or dietary use marketed in Cameroon, and verify purity and oxidation states of each kind of oil through determination of its acidity, iodine, peroxide, saponification, refractive indexes and the conformity of the labeling. The carotene content, the level of polar components and specific absorbance were also determined. As the result, six oils namely palm, palm kernel, coconut, black cumin, peanut and shea butter were collected. Apart from labeling, chemicals and physicals parameters analyzed were generally in accordance with the Cameroonian and Codex Alimentarius standard. This study suggests that vegetable oils sampled in the Cameroonian market may not expose consumers to lipid oxidation products generating pathological oxidative stress and inflammation. However, efforts in application of existing standard need to be done as far as labeling are concerned.

Keywords

Vegetable Oils, Quality Control, Labeling Compliance, Lipid Oxidation, Oxidative Pathology

1. Introduction

Vegetable oils derived from oil plants. Oil is extracted from seeds or kernels. These oils are composed of triglycerides, which contain primarily polyunsaturated and monounsaturated fatty acids. In developing countries like Cameroon, the commercial sector is strongly liberalized. There are little or no quality standards, and limited information on the quality of locally consumed foods. Oils and fats, employed particularly for cosmetic or alimentation use, are typical examples [1] [2]. On the other hand, vegetable oils are oxidized during processing and storage *via* autoxidation and photosensitized oxidation. Oxidative stability of vegetable oils are particularly related to their unsaturated fatty acids [3]. Some fatty acids are more fragile than others. Under certain conditions, they degrade and the vegetable oil loses its properties. The main sources of degradation are: oxidation, degradation by heat: hydrogenation (above 180˚C), and lipolysis: degradation of fatty acids in the presence of enzymes (lipase, etc.). The oxidative potential of vegetable oil and butter depends on the nature and concentration of the fatty acids composing it. Generally speaking, the more double bonds the fatty acid has, the higher its oxidation rate. The oxidation of fatty acids leads to their transformation into molecules, which can be toxic to the body. In practice, this oxidation phenomenon is easily identifiable because it is responsible for a change in the appearance of the vegetable oil (rancid odor, change in color). Certain factors accelerate this oxidation but are not necessary and sufficient elements to trigger the oxidation phenomenon: oxygen, light (UV), contact with pro-oxidant metals (Iron or Copper: Be careful with the conditioning!), the presence of pigments such as chlorophyll, the presence of enzymes (lipases, etc.), and also and above all the heat which will act as a catalyst on these reactions. That is to say, it will accelerate chemical reactions. Other factors will slow down this phenomenon, notably the intake or the natural richness of the oil in vitamin E.

The oxidative mechanisms are based on complex and radical reactions that always result in a significant loss of oil quality in both sensorial (rancidity) and nutritional values (loss of polyunsaturated fatty acids and vitamin E). Oxidation is among mechanism of degradation of oil. It is sometimes associated to polymerization and hydrolysis of the oil's chemical compounds. Lipids oxidation is one of the most important issues related to the health effect such as oxidative stress related to chronic disease, mainly inflammation and cardiovascular disease. However, providing people with healthy, nutritious and affordable oils is important for food security [4]. Moreover, for a healthy diet World Health Organization (WHO) has established that 30% of energy consumption should originate from vegetable oils and fats [5]. Vegetable oil remains an indispensable ingredient in the human daily life diet. It's a cooking medium (due to its sensory attributes) as supplier of energy to maintain body normal temperature [6]. In this study, we have decided to control the quality of the commonly consumed oils produced in local or imported. Commercially vegetable oils in Cameroun for cosmetic or alimentation include at least: palm oil, palm kernel oil, coconut oil, black cumin oil, peanut oil and shea butter. In this work, physical and chemical characteristics of the six oils were analyzed as well as their compliance with the Cameroonian standard NC 04: 2000-20 on the labeling of prepackaged foods. Our main objective was to see if those oils may have a high degree of degradation or oxidation which may expose of humans health to lipid oxidation products. In addition, does the information provided by the labeling comply with the standards?

2. Materials and Methods

Oils were all available in Cameroon. They were purchased from local market and supermarket in Yaoundé. Both physical and chemical characteristics of oils were determined. All the samples were taken at the same time (fall) trying to ensure that these productions came from the harvest year. The transport and storage of samples before analysis is carried out protected from light in optical and glass containers to limit the effects of possible migrations, and in thermal (25˚C) and hydrometric (70%) conditions. identical and stable. All analyses and normative data come from the fact sheets on ANOR (Standards and Quality Agency) and AFNOR (French Standardization Association).

2.1. Fatty Acid Methyl Esters (FAME) Analysis

150 µL of oil in 2 mL of hexane was trans-methylated with 200 µL of a cold solution of KOH in methanol (2 M), according to the European Standard NF EN ISO 12966 [7]. Fatty acid methyl esters (FAMEs) were analyzed in accordance with the European Standard NF EN ISO 5508. Analyses were performed on a Varian Gas Chromatograph CP3800 equipped with the flame ionization detector (GC-FID) (T = 250˚C), using a capillary column using a DB-FastFAME 30 m × 0.25 mm, 0.25 µm. The carrier gas was hydrogen (column flow 30 cm/s at 40 cm/s) and the split ratio was 1:100. The oven temperature was programmed as follows: 2 min at 120˚C, increased from 120˚C to 240˚C at 4˚C/min, held for 7 min. FAMEs were identified by comparing the retention times with the standard solution of Supelco 37 Component FAME Mix (Sigma-Aldrich, St. Louis, MO, USA).

2.2. Refractive Index

Refractive index of vegetable oils was measured at 40˚C using "Abbemat 200" Refractometer with a precision of ±0.000 nD at a wavelength of 589 nm, according to the methods described in the ISO 6320 4th edition (2000).

2.3. Quality and Oxidation Index

Acidity was measured and expressed as the quantity (in mg) of potassium hydroxide used to neutralize free fatty acids (FFA) present in 1 g of oil. We followed the analytical methods described in NF EN ISO 660.

Peroxide value (PV) was stated as milliequivalents of active oxygen per kilogram of oil (meq O_2 kg^{-1}). It is determined by titrating iodine liberated from potassium iodide with sodium thiosulphate solution, as described in NF EN ISO 3960.

Hydroxyl value is defined as the number of milligrams of potassium hydroxide equivalent to the hydroxyl content of one mg of the sample. The analytical methods described in NF T60-213 were followed.

UV absorbance (UV) K232 and K270 extinction coefficients were calculated from absorption at the exact λ wavelengths in nm, following the analytical methods described in NF EN ISO 3656.

2.4. Saponification Index

This parameter is defined as the weight of potassium hydroxide, in milligrams, needed to saponify one gram of oil and was evaluated following the analytical methods described in All the normative data being available on different sites with direct access (AFNOR and Engineering Sciences), we did not consider it necessary to explain them.

2.5. Unsaponifiable Matter

The amount of the unsaponifiable matter is calculated according to the NF EN ISO 18609.

2.6. Contain of Carotene

Analysis of carotenoids was determined at 446 nm and 269 nm, following EN ISO 17932 protocol.

2.7 Level of Polar Components

The content of total polar compounds in oil sample was determined based on the methods of NF EN ISO 8420.

Briefly, a glass column (35 cm in length and 2.1 cm in diameter) was used for chromatography. The oil sample (2.5 g) was loaded into the packed column and the non-polar fraction was eluted. The content of total polar compounds (%) was calculated as the mass fraction of the total polar compounds in the oil sample in percentage.

2.8. Conformity of the Labeling

Samples analyzed complied with the Cameroonian standard NC 04: 2000-20 on the labeling of prepackaged foods.

3. Results and Discussion

The use of refined oils is common for many food and beverage products. Each use of these ingredients must strictly comply with regulations and legislation relating to food safety. Guaranteeing quality and safe products is an essential commitment to human health.

The concerns of consumers and legislators regarding the use of these oils are legitimate. General attention has recently focused on contaminants generated during the processing process, including for example glycidyl esters, potentially present in refined vegetable oils. Suppliers of vegetable oils must therefore at least commit to reducing the presence of these contaminants as much as possible or even eliminating them completely. The next international regulatory limits will concern contaminants generated during processing processes.

3.1. Fatty Acid Methyl Esters (FAME)

For each oil, the main analyzed saturated or unsaturated fatty acids are shown in Table 1. In this figure we find higher amount of arachidic acid in practical values (*Norm value)* compared to theoretical one (*Sample value)*. Oleic, palmitic, and linoleic acids are presented in all oils as well as the polyunsaturated linoleic, that play a very important role on oil stability [8]. There are two major families of essential fatty acids. The first one is omega-6 polyunsaturated fatty acids, its precursor and major representative is essential linoleic acid (LA). Its majority derivative is arachidonic acid, conditionally essential. The second group is omega-3 polyunsaturated fatty acids. Its essential precursor is alpha-linolenic acid (ALA). Omega-6 has many properties like Omega 3. They are just as essential for reproduction and immune defenses, and also allow us to preserve our cardiovascular system. Clearly, a good balance between these two types of Omega is clearly necessary for our body. In Cameroon, palm kernel oil is sometimes used in cooking because of its lower cost than other oils and remains stable at high cooking temperatures. This oil can also be stored longer than other vegetable oils [9]. This choice of palm kernel oil is life-saving for the preservation of health (Table 1 and Table 2).

3.2. Iodine Value (IV)

The IV is the mass of iodine in grams that is consumed by 100 g of oil. The IV provides an overall status of unsaturation of the oils. Iodine value increases with increasing of unsaturation of oil. Our values are in accordance with those suggested by ISO 3961 norm. This accordance could be related to absence of degradation or oxidation of oil or fat.

Table 1. Oils composition of fatty acid methyl ester (FAME) (N: Norm value; S: Sample value).

FAME	**Octanoate**		**Laurate**		**Myristate**		**Palmitate**		**Stearate**		**Oleate**		**Linoleate**		**Arachidate**	
	Percentage (%)															
Oils	**N**	**S**	**N**	**S**	**N**	**S**	**N**	**S**	**N**	**S**	**N**	**S**	**N**	**S**	**N**	**S**
palm	0	0	0.2	1.60	1	1.38	40 - 42	41.21	3 - 5	4.83	40 - 43	40.44	8 - 10	8.49	0.4	0
palm kernel	0	0.99	40 - 50	1.27	16 - 20	1.39	6 - 8	40.74	0	3.59	5 - 8	35.08	1 - 3	7.89	0	0
coconut	-	3.82	41.21	46.47	23.90	17.24	16.50	7.47	3.14	3.52	9.47	5.37	1.61	3.94		0
black cumin	0	0	0	3.75	0	1.13	10 - 15	20.90	3 - 4	16.87	18 - 29	9.78	50 - 60	6.09	0	3.14
shea butter	0	0	0	0	0	0	2 - 9	1.59	20 - 50	36.07	40 - 60	50.45	<1	0.52	<1	0.75
peanut	0	0	0	0	0	0	8 - 10	10.60	2 - 4	2.08	43 - 55	45.04	30 - 32	29.24	1 - 2	1.05

Table 2. Chemical and physical characteristics of vegetable oils. N: Norm value and S: Sample value.

Oils	AV		IV		RI		PV		SV		Unsaponifiable matter	
	N	S	N	S	N	S	N	S	N	S	N	S
palm	10	10.1 ± 0.01	44 - 58	50.7 ± 0.008	-	-	2.2 - 10.3	9.4 ± 0.002	195 - 205	204 ± 0.2	0.5% - 1.2%	0.5% ± 0.007%
palm kernel	0.3 - 0.6	0.5 ± 0.01	16 - 19	18.4 ± 0.001	1.449 - 1.452	1.456	15 - 21	17.3 ± 0.015	242 - 254	253 ± 0.7	0.2% - 0.8%	0.3% ± 0.011%
coconut	0.6	0.54 ± 0.01	7 - 10	8.7 ± 0.001	1.448 - 1.450	1.455	7 - 11	8.9 ± 0.004	250 - 262	259 ± 0.5	0.15% - 0.60%	0.2% ± 0.009%
black cumin	24	24.1 ± 0.02	126	127 ± 0.060	1.470 - 1.480	1.474	≤15	15.1 ± 0.008	195	195 ± 0.7	0.5% - 2%	0.8% ± 0.043%
shea butter	2	2.0 ± 0.02	64 - 72	69 ± 0.024	-	-	12 - 14	13.9 ± 0.005	160 - 195	189 ± 0.5	2% - 15%	14.5% ± 0.308%
peanut	0.08 - 0.6	0.2 ± 0.01	84 - 102	92 ± 0.034	1.468 - 1.472	1.468	≤5	4.2 ± 0.003	188 - 195	195 ± 0.4	0.6% - 1%	0.8% ± 0.028%

3.3. Acidity Value (AV)

The acid index is expressed as the amount of potassium hydroxide (KOH), in mg, needed to neutralize 1 g of oil or fat. It's a measure of the free fatty acids (FFA) present in the fat or oil. An increment in the amount of FFA in a sample of oil or fat indicates hydrolysis of triglycerides. Such reaction occurs by the action of lipase enzyme and it is an indicator of inadequate processing and storage conditions (*i.e.*, high temperature and relative humidity, tissue damage). As far as our results are concerned, they are in agreement with NF EN ISO 660 norm.

3.4. Refractive Index (RI)

Most processors to measure the change in unsaturation as the fat use refractive index or oil is hydrogenated. The refractive index of oils depends on their molecular weight, fatty acid chain length, degree of unsaturation, and degree of conjugation [10]. Both IV and RI indexes are important characteristics, which determine the degree of saturation or unsaturation of fats and oils. It appears that our results of RI are in accordance with those suggested by ISO 6320 4th edition (2000) norm.

3.5. Peroxide Value (PV)

The PV of an oil or fat is used as a measurement of the extent to which rancidity reactions have occurred during storage. This parameter expresses the oxidation in its early stages. Values were in agreement with NF EN ISO 3960 norm. So, the oils tested were not engaged in their early stages of oxidation. Also, we found no evidence of rancidity.

3.6. Saponification Value (SV)

SV indicates how much potassium hydroxide is needed to saponify 1 g of oil or fat. It's an indicator of the average molecular weight and hence chain length. The greater the number of saponification, the more short- and medium-chain fatty acids the fat contains. Values found in this study are in accordance with those suggested by ISO 3657 norm. This could suggest that oils or fat tested have not been submitted to degradation.

3.7. UV Absorbance (UV)

Black seed oil and shea butter were highly concentrated. Even in high level of dilution, they showed absorbance that exceeded 0.8. The specific extinction at 232 and 270 nm of the five left samples (palm oil, palm kernel oil, coconut oil and peanut oil) are shown in Figure 1.

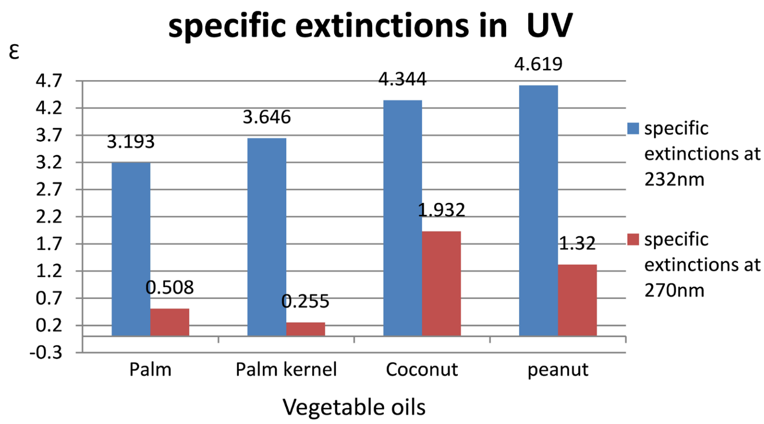

Figure 1. Specific extinction of oils samples at 232 and 270 nm.

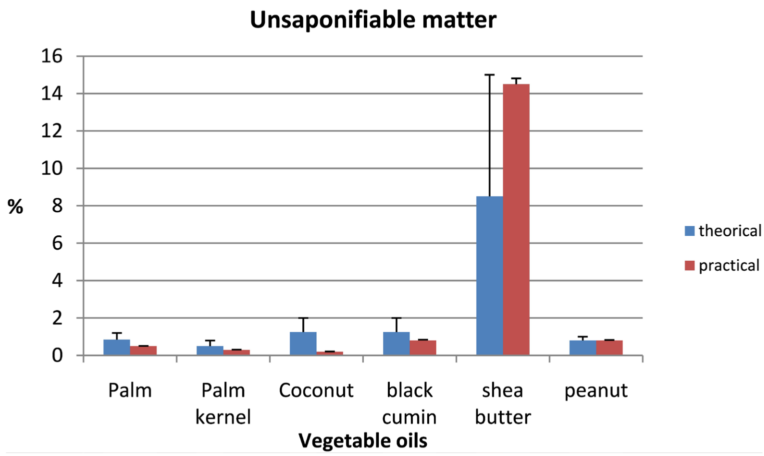

Figure 2. Unsaponifiable matters content of studied oils.

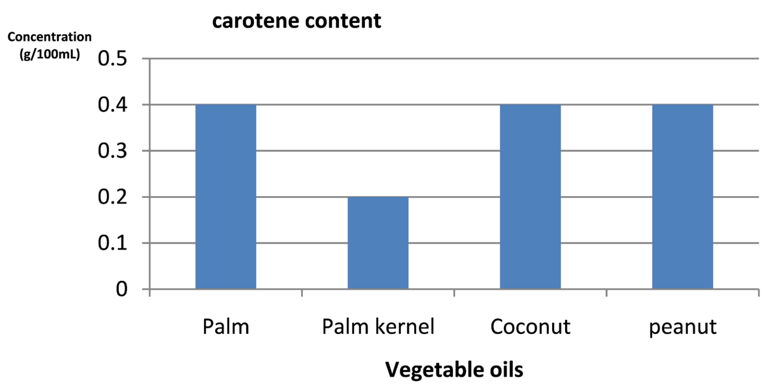

Figure 3. Carotene content of studied oils.

Unsaponifiable matter

Unsaponifiable matter (USM) is known to contain hydrocarbons, terpene alcohols, sterols, tocopherols and other phenolic compounds, which may act as oxidation inhibitors (**Figure 2**). Vegetable oils typically contain 0.5 - 2.5 percent of USM while some others have higher amounts. The obtained values are in accordance with those suggested by the NF EN ISO 18609 norm. Obtained data are also in agreement with those of L. PULP *et al.* [11].

Carotene content

The carotene content of different vegetable oils (palm, palm kernel, coconut and peanut) is shown in **Figure 3**. Palm kernel shows the lowest value. Analysis of carotenoids was determined at 446 nm and 269 nm, following EN ISO 17932 protocol. Carotene is present in our six vegetable oils. Beta carotene is the most available and therefore important source of pro-vitamin A in the diet of most people living in developing countries, providing about 66% of vitamin A in their diets. The carotenoids (e.g. beta-carotene and lycopene) are micronutrient antioxidants that have integral role in regulating vital metabolic reactions in the body [12]. Carotenoids play an important potential role by acting as biological antioxidants protecting cells and tissues from the damaging effects of free radicals. The latter could cause many diseases such as cancer [13]. Carotenoids also enhance immune function by a variety of mechanisms and improve cardiovascular health [14].

Level of polar components

Since oils polar components are the result of oil degradation, all oils exceeding 25% of polar compound are unfit for consumption. In fact, they are potentially carcinogenic. In **Figure 4**, black seed oil should not be used as food oil. It is worthy to notice that itwas manufactured more than three years ago.

Conformity of Labelling

Labeling must not cause confusion in the mind of the purchaser or the consumer. In particular, specify NC 04/2000-20 norm (Cameroonian standard) no confusion on the characteristics of the food and in particular on the nature, identity, composition, quantity, durability, origin or provenance, method of manufacture or manufacture. As shown in **Figure 5** efforts must be made on:

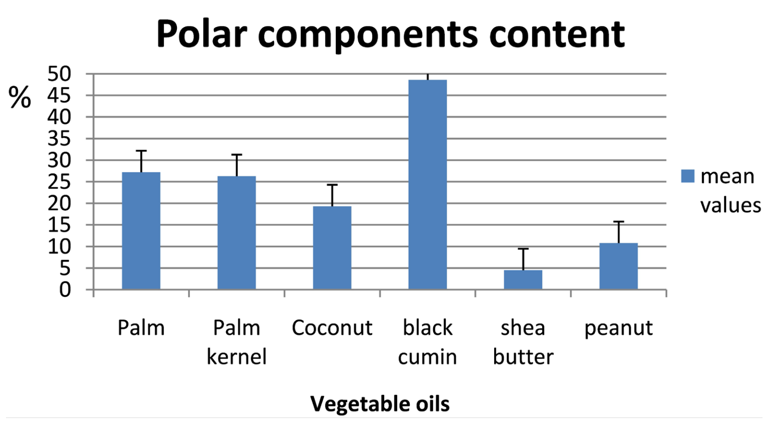

Figure 4. Polar components content of oils.

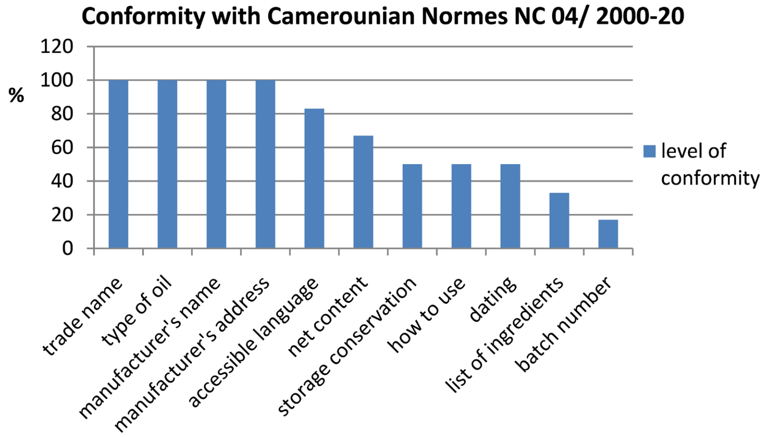

Figure 5. Samples analyzed in regard to Cameroonian standard NC 04: 2000-20 on the labeling of prepackaged foods.

storage, conservation, how to use, dating, list of ingredients and batch number.

4. Conclusion

On one side, vegetable oils represent a major component of the food system, an important source of energy and an important economic commodity for producers. On the other side, the public is increasingly concerned with the health benefits and nutritional properties of vegetable oils. This study carries out the chemical analysis and health-promoting benefits of the six collected oils. Those oils are rich in components with an important potential role by acting as biological antioxidants (carotene, unsaponifiable matter, polyunsaturated linoleic), source of vitamin A (carotene), essential for reproduction, immune defenses, protection of cardiovascular system (the polyunsaturated linoleic). Also, the absence of degradation or oxidation is suggested by the values of iodine, acidity, peroxide, saponification and polar components which are in accordance with the Cameroonian and Codex Alimentarius standard. Results showed that vegetable oils sampled in the Cameroonian market exhibited levels of oxidation and degradation in accordance with the standards. Those oils may not expose consumers to lipid oxidation products generating pathological oxidative stress and inflammation. However, efforts in application of existing standard need to be done as far as labeling are concerned on three main points: ingredients list, batch number present and dating.

Conflicts of Interest

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

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