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Analytical Indices and Comparative Evaluation of Some Metalsin Palm Oil, Groundnut Oil and Soybean Oil from Nigeria

Awuzie Chioma Irene*

Department of Science Laboratory Technology, Federal Polytechnic Oko, Anambra State, Nigeria

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Abstract

Samples of palm oil, groundnut oil and soybean oil were collected from Ose and Ochanja markets of Onitsha town of Anambra State, Nigeria. They were analyzed for copper, iron, chromium, aluminium, lead and cadmium. The concentrations ($mgkg^{-1}$) of each of these elements were determined. Palm oil gave 11.371, 0.079, 2.3319, 0.1780, 1.9358 and 0.0220 for iron, copper, chromium, lead, aluminium and cadmium respectively. Groundnut oil gave 8.5109,0.0633,2.7067, 0.1631, 1.7742 and 0.0207 for iron, copper, chromium, lead, aluminium and cadmium respectively. For soybean oil sample, the levels ($mgkg^{-1}$) were 8.7519,0.0475,1.7559,0.1631,0.3837 and 0.0200 for iron, copper, chromium, lead, aluminium and cadmium respectively. Values of the physical properties showed that the saponification value (SV) ranged from 191.00 KOH/g of oil. Groundnut oil has the highest SV and soybean oil gave the least SV; iodine values (IV) are in the range of 124.4-51.20, Wij's; 31.76-6.83 values were obtained for viscosity; acid value (AV) were obtained as 5.54-4.2 and specific gravity (SG) were found as 1.01276-0.86.Allthese concentrations were within the limits of the accepted values by regulatory bodies. Hence these oils were safe for consumption.

Keywords: Saponification, Comparative, Physio Chemical Parameters, Trace Metals, Heavy Metals, Oil Samples.

*Corresponding author: alwayschioma4sure@yahoo.com

1. Introduction

Fats and oils are class of compounds called lipids. Lipids are constituents of plants and animals that are insoluble in water, but soluble in organic solvents, which consist predominantly of long chain fatty acid esters of glycerol and are known as triglycerides. The quest for fats and oils has continued to receive attention, because of high consumption of fat. However, it has been observed, that the amount of saturated fat consumed, is the primary factor to be taken into consideration, because it increases the bad LDL cholesterol in the blood stream, which leads to coronary heart disease, clogged arteries and stroke[1].

It has also been realized that poly-unsaturated fatty acids are not beneficial to health as previously believed. Mono-unsaturated fatty acid is more beneficial than poly-unsaturated fatty acid. Fats and oils are sourced from terrestrial and marine plants and animals. They have lower densities than water. Animal fats are obtained from the fatty tissue of hogs, cattle, sheep, poultry, etc, butter is obtained from milk.

Vegetable oils are extracted from various plant seeds and nuts, primarily from soybean, cotton seed, corn, peanut, sunflower, olive, coconut,

linseeds, tung, castor etc. Marine oils are obtained mostly from herring, sardine and pilchard. Marine fats include liver oils, blubber oils and fish oils.Fat and oil can be isolated from their sources in various ways. The modern way of processing is by chemical extraction, using solvent extracts, which produces higher yields. This is quicker and less expensive. The most common solvent is petroleum – derived hexane. This technique is used for most of the "newer" industrial oils such as soybean and corn oils.

Another way is physical extraction, which is devoid of solvent. These are traditionally achieved by different types of mechanical milling, squeezing to produce oils such as palm oil, olive etc. This method is of three types, namely expeller pressed extraction which is either the screw press or ram press. Oil seed presses are commonly used in developing countries, the amount of oil extracted from these methods vary greatly and also fats and oils obtained from various sources, differ from one another in their physical and chemical properties because they contain varying amounts of different mixed esters.

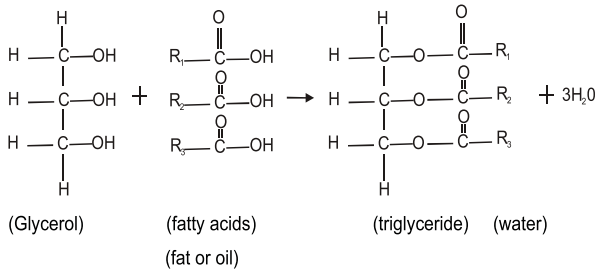

Figure 1: Molecular structure of fats and oil (the combination of propane- 1,2,3-triol with fatty acids, which are long chain carboxylic acids) [1].Where; R_1 R_2 and R_3 represent the long fatty acid side chains.

The structural formula shows that fats and oils contain three ester functional groups. Fats and oils are esters of tri-alcohol, glycerol or glycerine. Therefore they are commonly called triglycerides or triacylglycerol.

The major types of fat are saturated fats and unsaturated fats. Saturated fat is a fat that is made from saturated fatty acid. It has no double bond in its hydrocarbon chain Example is tristearine, it contains only single bond. It is considered the "bad fat". So, if saturated fat is bad, it would only make sense that unsaturated fat would be good. Unsaturated fat is a fat made from unsaturated fatty acids. It contains one or more double bond in its hydrocarbon chain, example is triolein. There are two types of unsaturated fats, namely: poly-unsaturated fat and mono-unsaturated fat. The main difference between good fats and bad fats is just that the bad fats (trans and saturated) contains little unsaturation, meaning no more hydrogen atoms can be added. They contribute to clogged arteries and typically go hand in hand with higher cholesterol in the body.

Trace elements are of sufficient benefit to man when consumed in the right proportion, and lack of trace elements in diet may constitute health problem that may be devastating. Heavy metals on the other hand are sometimes being characterized as being toxic or poisonous. Since trace elements provide nutritional value, they are sometimes referred to as micro nutrients. However, it may come as a surprise to some people that certain heavy metals are included as a sub class of this family. This includes materials such as mercury, lead, cadmium and even arsenic which can be found in vitamin supplements manufactured for human consumption. While these are in fact necessary for proper nutrition in nearly microscopic amounts, too much can be toxic [2].

Furthermore vegetable oils are essential daily condiment because of its various uses in our everyday living. These oils are therefore highly

priced. Unfortunately, it has been reported that some of these vegetable oils are being adulterated with diesel automobile hydrocarbon which is miscible with vegetable oils. This adulteration is alleged to change the quality of vegetable oils and consequently have negative effects on the consumers [3]. Hence there is need to determine the concentration of both heavy metals and trace elements in these vegetable oils in Onitsha town, Anambra State, Nigeria, so that consumers will know the qualities of these vegetable oils. Thus this paper reports, comparative evaluation of iron, chromium, copper, lead, aluminium and cadmium in palm oil, groundnut oil and soybean oil in Onitsha town from Nigeria.

2. Materials and Methods

2.1Sample collection

Three varieties of edible vegetable oils namely: groundnut oil, palm oil and soybean oil were collected at two different markets (Ose and Ochanja markets respectively) within Onitsha town of Anambra State, Nigreia. The collected oil samples were packed in polyethylene bottles and stored below 20°C until analysis were carried out. All plastics and glassware were cleaned and soaked in nitric acid solution overnight and rinsed with distilled water[4].

2.2 Sample digestion

2g of each of the samples were weighed into a beaker on an electronic weighing balance.5ml of each of concentrated nitric and sulphuric acids were added to the beaker already containing 2g of the oil. Into the beakers 2ml of hydrogen peroxide were added and then heated on a heating mantle until a clear solution was obtained. The content of the beaker were allowed to cool and then filtered. The resulting solution was made up to 50ml using distilled water and then transferred into a plastic bottle for metal analysis by AAS method [4].

3. Results and Discussion

3.1 Results

Vegetable oil samples in Onitsha town markets were analysed for physiochemical parameters. The results of the analysis are presented in Tables 1 and 2 below.

Parameters/Oil Samples	Palm Oil	Groundnut Oil	Soybean Oil
Iodine Value	51.20 ± 0.75	59.60±2.00	124.40±3.00
Saponification Value	200.00 ± 0.86	221.60± 2.00	191.00±0.00
Acid Value	5.54±0.0032	4.90±0.17	4.20±0.20
Specific Gravity	0.86± 0.000057	1.01±0.0000095	0.94±0.00041
Viscosity	6.83± 0.047	29.23±0.047	51.76±0.124

Table 1: Average value of physical parameters of various vegetable oil samples found in Onitsha town.

OilSamples/Metals	Fe	Cu	Cr	Pb	Al	Cd
Palm Oil	11.3701	0.0708	2.3319	0.1780	1.9358	0.0220
Groundnut Oil	8.5109	0.0633	2.7067	0.1031	1.7742	0.0207
Soybean Oil	8.7519	0.0475	1.7559	0.1031	1.8387	0.0200

Table 2: Values (mg kg^{-1}) of Trace Metals of vegetable oil Samples found in Onitsha town.

3.2 Discussion

The result obtained (Table 1) showed that the saponification value (SV) range from 221.6-191.00 to KOH/g of oil; Groundnut oil has the highest SV and Soybean oil gave the least SV. Iodine values (IV) are in the range of 124.4-51.20;Wijs 31.76-6.83 values were obtained for viscosity; acid values (AV) were obtained as 5.54-4.2 and specific gravity (SG)were found as 1.01276- 0.86. The data conforms to standard range approved by the Standard Organization of Nigeria (SON), and other works [5-6].

The result of the metal analysis(using AAS analysis) is shown in Table 2. From the result it was observed that Fe has the highest concentration in the entire oil samples. The concentrations are: 11.3701, 8.5109 and 8.7519 mg/kg for palm oil, groundnut oil and soybean oil respectively. A report by Ali et al. (2005) of the concentration of some metals in the environment of Makera, Kaduna, Nigeria revealed same trend [7]. Although, the concentration of Fe is highest amongst the metals in these oil samples but it is essential nutrient of blood; digestion of large amount can lead to its accumulation in the body leading to tissue damage and hyper haemoglobularia [8].

The AAS analysis also revealed that Cr was also present in the vegetable oils that we analysed. The levels of chromium (mg/kg^{-1}) are 2.3319, 2.7067 and 1.7559 for palm oil, groundnut and soybean oil respectively. Chromium is found in two forms, the trivalent +3 form found in food which is biological active and hexavalent +6 which is toxic that results from industrial pollution.

In this regard however we are focussing on the trivalent form of chromium found in foods [9]. Safe and adequate daily dietary intake range for Cr for adults and adolescents is 50 to 200kg. In 2001, dietary recommended intakes for Cr were established as shown: for children: 0-6 months = 0-2 µg/kg, 7-12 months = 5 µg/kg, 1-3years= 11 µg/kg, 4-8years=15 µg/kg, 9-13 years =25 µg/kg and 21 µg/kg, 13-18years=35 µg/kg, 24 µg/kg,29 µg/kg and 44 µg/kg, 19- 50years = 35 µg/kg, 25 µg/kg,30 µg/kg,45 µg/kg, less than 5 years =30 µg/kg and 26 µg/kg [9]. Chromium +3 is less damaging to the health due to the absorption by the body (greater than 1%), but Cr^{+6} is acutely poisonous and on contact with the skin triggers dermatitis, allergies and irritations, thus considered as carcinogenic to human [10].

The concentration of Cu in palm oil, groundnut oil and soybean oil were determined to be 0.0708, 0.0633 and 0.0475mg/kg^{-1} respectively. Its concentration was determined to be highest in palm oil and lowest in soybean oil. According to Iyaka et al. (2007); In general the recommended value for intake of copper by World Health Organisation (WHO) is 1.3mg/kg per day as the maximum.

For children of 1-3 years = 0.3mg/kg per day, 1-8 years = 0.4mg/kg per day, 9-13 years = 0.7mg/kg per day, 14- 18years = 0.9mg/kg per day.

For pregnant women = 1 mg per day and for nursing mothers aged 14 – 50 maximum allowable level is 1.3mg per day. The result obtained is within acceptable limit [11].

The concentration of lead in palm oil, groundnut oil and soybean oil are 0.178,0.1631 and 0.1631 mg/kg respectively. Lead level of10ug/dl or above is a cause for concern. Lead has harmful health effect even at lower levels and there is no known exposure level [12].This means that even the low concentration of lead present in vegetable oil is harmful, if the oil samples are consumed for a very long period of time, since lead can show an accumulated harmful effect.

There is therefore need to improve on the quality of the oils by limiting the oil samples to the lowest possible lead level. In addition, exposure to amount of lead above $0.01mgl^{-1}$ is detrimental to health as it may result in possible neurological damage to foetuses, abortion and other complication in children under three years old [7].The result for aluminium showed the following concentration;1.9358,1.7742 and 1.8387 $mgkg^{-1}$ for palm oil, groundnut oil and soybean oil respectively. The highest

concentration was observed for palm oil and the lowest for groundnut oil. Aluminium can show accumulated values. Accumulated values associated with central nervous system and bone toxicity(for a tiny new born, this toxicity dose would be 10 to 20 µg and for an adult it would be about 350 µg). Dietary Al intake is 10 µg per day incase of drug administration. Consumption survey, the author estimated daily Al intake that it may reach 50-100mg per day.

Cadmium was also determined and the concentrations are 0.0220,0.0207 and 0.0200 mg/kg for palm oil, groundnut oil and soybean oil respectively. Smokers may receive twice the daily dose of Cd as non-smokers (people breathing in cigarette smoke) may also inhale Cd. Vegetables, cereals, grains and crops grown on contaminated oil with high level of Cd may contain small amount of Cd. Kidneys and livers of animals and shellfish can contain high levels of Cd than other foods. In agricultural areas, phosphate fertilised soil may contain higher level of Cd than unfertilized soils [4].

EPA has also established maximum contaminant level (MCL) of 0.01mg/ L (10µg/L) for Cd in drinking water. It has proposed a maximum contaminant level goal(MCLG) of 0.005mg/L(5µg/L).The Food and Drug Administration(FDA) limits the amount of Cd in food to 15 parts of Cd per million parts of food. WHO has established tolerable weekly intake (PTWL) for Cd at 7 µg/kg of body weight. This PTWL weekly value corresponds to a daily tolerable intake level of 70 µg for Cd for the average 70 kg man and 60 µg of Cd per day for average 60 kg woman. Vegetable oils and fats contain trace levels of various metals depending on many factors such as species, soil used for cultivation, irrigational water, variety and stage of maturity, pollution made of processing, storage and contaminations. These metals may enter the food minerals from the soil through uptake of minerals by crops food processing, environmental contamination(as in application of fertilizer).Metals play important negative and positive roles in human life from the results obtained the levels are within tolerable limits. But as it is known, many metals can bio accumulate in human systems, hence careful processing of raw materials, storage and exposure to the general environment should be strictly monitored [7].

4. Conclusions

The result above showed that palm oil has 11.370mgkg^{-1},0.078mgkg^{-1}, 2.3319mgkg^{-1}, 0.1780mgkg^{-1},1.9358mgkg^{-1} and 0.0220mgkg^{-1} for iron, copper, chromium, lead, aluminium and cadmium respectively. In groundnut oil, the concentrations (mgkg^{-1}) were obtained as 8.5109, 0.0633, 2.7067, 0.1631, 1.7742 and 0.0207 respectively. For the soybean oil sample, the levels (mgkg^{-1}) were 8.7519, 0.0475, 1.7559, 0.1631, 0.3837 and 0.0200 for iron, copper, chromium, lead, aluminium and cadmium respectively. Values of physical properties showed that the saponification value(SV) ranged from 191.00KOH/g of oil, groundnut oil has the highest SV and soybean oil gave the least SV; iodine values(IV)are in the range of 124.4 -51.20,Wij's;31.76-6.83 values were obtained for viscosity; acid value (AV) were obtained as 5.54-4.2 and specific gravity (SG) were found as 1.01276-0.86.Allthese concentrations were within the limits of the accepted values by regulatory bodies except iron. The level of these metals may be at least reduced by not exposing the vegetable oils during and after processing to contaminated materials. Hence, these oils are safe for consumption.

5. Recommendation

The human body uses oils and fats in diets for

three purposes as energy sources as a structural component and to make powerful biological regulators. These metals present in edible vegetable oil could be from the soil, pollution or even during manufacturing process. Some elements such as Cu, Zn, Fe can act as nutrients and are important for health while others such as Ni, Pb, Cd, Ag, Hg may be harmful especially when not consumed in the right proportion. The level of these metals especially those that are harmful may be reduced by more careful handling practices. Vegetable oils are one out of the many sources of essential trace elements. This contains many of these elements that are essential for human health. Therefore, children and pregnant women should be advised to consume in right proportion those vegetable oils that contain an adequate concentration of the metals. The human body in general needs an amount of one or two of the vegetable oils since they contain a variety of essential metals which not only improves the standard of their health but for effective growth and development of their body. Most metals when taken in acceptable and appropriate quantities can be of nutritional importance however, the side effects of metals in oils arise from their intake in large concentrations due to their route of disposal and pollution. The dangers and threatening effects of these metals can be prevented as follows;

a) Appropriate regulatory measures and establishment of facilities for environmental sound collection and disposal of hazardous waste containing heavy metals with high concentration.

b) Promoting of technical solutions such as unleaded petrol and filter system for smelter.

c) Awareness campaign must be created on the production of oil, storage and probably the rate of consumption of the respective vegetable oils.

d) The establishment of cleaner production programmes in oil production industries.

e) Establishment of information services for industry on technology and ways to prevent or reduce and eliminate pollution by heavy metals.

f) Production in both industries and at local level should be done by using stainless steel equipment.

g) The dumping of refuse around the plant should be avoided since refuse dump areas are common source of heavy metals.

h) Subsequent research work should be carried out by relevant ministries to identify and control the concentrations of metals present in the edible oil. This is to ensure that only the correct and required concentrations of these metals are present in oil.

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