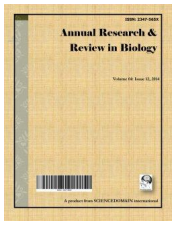

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Palm Oil: An Over - Acclaimed Cooking Oil in Nigeria

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Author's contribution

The sole author designed, analyzed and interpreted and prepared the manuscript.

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ABSTRACT

Palm oil, the oil derived from palm fruit, is the major oil used for cooking in Nigeria. Palm oil has half of its fatty acids made up of saturated fatty acids and 43% made up of palmitic acid. The unrefined red palm oil is the form in which most Nigerians use palm oil and it is generally regarded safer for cardiovascular health than other branded vegetable oils. Although the overall contribution of palm oil to cardiovascular health is still controversial and subject to on-going research, the high concentration of saturated fatty acids in palm oil presents palm oil as detrimental oil to cardiovascular health since dietary saturated fatty acids is an important risk of cardiovascular disease.

Keywords: Palm oil; cardiovascular disease; palmitic acid; saturated fatty acid; Nigeria.

1. INTRODUCTION

Palm oil is an edible vegetable oil derived from the mesocarp of palm fruit of the oil palms, primarily the African oil palm *Elaeis guineesis* [1] and to a much lesser extent from the American oil palm *Elaeis oleifera* [2] and the Maripa palm *Attalea maripa.* [3] It is called *Epo-pupa, Manja* and *Mmanu* in the three most widely spoken Nigerian Languages. [4] The African oil palm (*Elaeis guineensis*) is native to west and southwest Africa, occurring between Angola and Gambia [5]. It is particularly abundant in Nigeria. Mature palms are single-stemmed, and can grow

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well over 20 m tall. The leaves are pinnate, and reach between 3-5 m long. The flowers are produced in dense clusters; each individual flower is small, with three sepals and three petals. The palm fruit is reddish, about the size of a large plum, and grows in large bunches. Each fruit is made up of an oily, fleshy outer layer (the pericarp), with a single seed (the palm kernel), also rich in oil [3].

Although Nigeria, in the 1980s, has lost its dominant position as the world leading producer and exporter of palm oil, [6] palm oil still remains the main vegetable oil produced in Nigeria and it is consumed in all its regions. [7] Nigeria is currently the third largest global producer, behind Indonesia and Malaysia [6]. Palm oil production accounted for 1.5% of the national agricultural GDP in 2006. [8] Nigeria palm oil production output represented 3% of the world production in 2010 [6] and 55% of African output. [7] The output is however not enough to match the local consumption. Indeed, the national demand has grown faster than the domestic supply. [9] Consequently, Nigeria imports palm oil to satisfy the local demand. Nevertheless, Nigeria has a potential to increase its production through the application of improved processing methods and better marketing; since palm oil production in Nigeria is characterized by traditional processing methods which are energy sapping and low in efficiency [10].

Palm oil is used in Nigeria for food and non-food consumption. Domestic dietary use accounts for more than half of the palm oil consumed in Nigeria. [6] The traditionally extracted, unrefined oil, also called Technical Palm Oil (TPO), is the form in which most household use palm oil for cooking [7]. Consequence of the presence of carotenes, Technical Palm Oil is dark red in color and has a characteristic flavor. Hence, Nigerians call it red oil and it occupies an important position in the Nigerian cuisine. In fact, in most Nigeria communities, it is unethical to cook some dishes with any other edible oil but the red oil [11].

Although cardiovascular diseases typically affect older adults, its antecedents, notably atherosclerosis is evident early in life. Hence, primary prevention efforts are necessary from childhood. [12] Of the risk factors that can be modified to improve cardiovascular health is healthy dietary lipid. [13] Palm oil has about half of its fatty acid content made up for saturated fatty acids, [14] a condition that is rare among vegetable oils. Consumption of saturated fatty acids increases the serum level of low density lipoprotein (LDL) [15] and high density lipoprotein (HDL). [16] Also, The World health Organization warns that saturated fat is a risk factor of cardiovascular diseases. [17] However, Due to the accustomed flavour of the unrefined red palm oil, Nigerians eat more palm oil than any other edible oil and it is erroneously regarded safer for cardiovascular health compared to branded vegetable oils which are manufactured from soybean, peanut, cottonseed, sunflower, olive and rapeseed. [18,19] The branded vegetable oils, as opposed to "red oil", are termed "white oil" in the Nigerian traditional markets and are considered less healthy for dietary consumption. This work therefore aims to provide evidences to debunk this erroneous claim.

2. CHEMICAL COMPOSITION OF PALM OIL

Palm oil has more than 95% of its content saponifiable. [20] This saponifiable fraction is made up of triacylglycerides which are fatty acids (acyl chains) attached to a glycerol backbone. [21] During extraction process, the triacylglycerides however attracts lipophilic but unsaponifiable cellular components which include tocopherols, tocotrienols, sterols, ubiquinones and pigments. [20] The major fatty acids contained in palm oil are myristic (14:0), palmitic (16:0), stearic (18:0), oleic (18:1) and linoleic (18:2). [14,22] The most concentrated fatty acid in palm oil is palmitic acid which makes up about 43% of the fatty acid in the oil and is more concentrated in palm oil than in any other vegetable oil. [22] Hence it got its name from palm oil. Unlike most other vegetable oils, palm oil has half its fatty acid content made up of saturated fatty acids [14]. Consequently, it is semi-solid at room temperature. Other notable highly saturated vegetable fats are palm kernel oil which has 81% of its fatty acids saturated, [23] Coconut oil which has 86% of its fatty acids saturated [23] and Shea butter which also has half of its fatty acids saturated. [24] The fatty acid profile of palm oil as presented by Sundram and Co-workers [20] is shown in Table 1.

Apart from very few free fatty acids, most of the fatty acids in palm oil exist as acyl groups attached to glycerol to form triacylglyceride molecule. Since different fatty acids are present in palm oil, different combinations of fatty acids

Table 1. Typical fatty acid profile (%) of palm oil

Fatty acid name	Fatty acid chain length	Mean	Range observed	Standard deviation
Lauric	12:0	0.3	0-1	0.12
Myristic	14:0	1.1	0.9-1.5	0.08
Palmitic	16:0	43.5	39.2-45.8	0.95
Palmatoleic	16:1	0.2	0-0.4	0.05
Stearic	18:0	4.3	3.7-5.1	0.18
Oleic	18:1 (n-9)	39.8	37.4-44.1	0.94
Linoleic	18:2 (n-6)	10.2	8.7-12.5	0.56
Linolenic	18:3	0.3	0-0.6	0.07
Arachindic	20:0	0.2	0-0.4	0.16

attached to the glycerol are possible. In palm oil, the most predominant combinations are POP and POO (P-palmitic acid, O-Oleic acid); each making up about 20% of the triacylglycerides in palm oil. The fully saturated triacylglycerides, predominantly tripalmitin, make up 7%-10% while the fully unsaturated triacylglycerides constitute 6 to 12% of the triacylglycerides in palm oil. The middle position (Sn-2 position) of the glycerol molecule is specifically for unsaturated fatty acids. Therefore, more than 85% of the unsaturated fatty acids are located in the Sn-2 position of the glycerol molecule [25].

The minor constituents of palm oil are of two classes. The first class consists of saponifiable free fatty acid and fatty acid derivatives, such as diacylglycerides, monoacylglycerides, phosphatides, esters and sterol derivatives. The second class consist of unsaponifiable but lipophilic compounds such as free sterols, hydrocarbons, tocopherols, triterpene alcohol, pigments, aliphatic alcohols, chlorophylls, carotenoids and volatile flavour components, such as aldehydes and ketones. [26] Free fatty acids, monoacylglycerides and diacylglycerides do not occur naturally in significant amounts except in palm oil from damaged fruits. Such oils would have undergone partial hydrolysis resulting in the production of free fatty acids, water and the partial glycerides (monoacylglycerides and diacylglycerides) [20].

Sterols make up a sizable portion of the unsaponifiables in vegetable oils. The content of sterol in palm oil is about 0.03% of its total composition. Plant sterols are generally termed phytosterols and are notably campesterol, sitosterol and stigmasterol. Cholesterol, though generally regarded as an animal sterol, is also found in plants. [27] Cholesterol makes up to 6.7% of the sterol fragment of palm oil. Other noticeable sterol in palm oil include Δ5-avenasterol (0-2.8%) Δ7-stigmasterol (0- 2.8%) and Δ7-avenasterol (0-4%). [26] Palm oil contains a recognizable amount of vitamin E in the form of tocopherol and tocotrienol. Crude palm oil contains 600 to 1000 ppm of tocopherol and tocotrienols. [28] Palm oil, like tomatoes, carrots, pumpkins and many other fruits, but unlike other vegetable oils contains carotenoids which give it its red coloration. [29] Carotenoids are precursors of vitamin A with β-carotene having the highest pro-vitamin A activity. [30] Palm oil has 15 times more Retinol Equivalents than carrot and 300 times more than tomato. There are about 13 different carotenoids in crude palm oil, all of which amounts to a concentration of about 500-700ppm. Alpha-carotene and Beta-carotene however make up more than 80% of the total carotenoids in palm oil. [31] Table 2 gives the composition of unsaponifiable fraction of palm oil as presented by Sundram [32].

3. CARDIOVASCULAR DISEASE

Cardiovascular disease refers to a class of diseases that affect the cardiovascular system, [33] principally cardiac disease, vascular diseases of the brain and kidney, and peripheral arterial disease. [34] The causes of cardiovascular diseases are diverse but atherosclerosis and hypertension are the most common. Also, aging increases the risk of cardiovascular diseases, even in healthy asymptomatic individual. [35] Types of cardiovascular diseases include: Coronary artery disease, Cardiomyopathy, Hypertensive heart disease, Heart failure Pulmonary heart disease, Cardiac dysrhythmias, Inflammatory heart diseases which are Endocarditis, Inflammatory cardiomegaly and Myocarditis, Valvular heart disease, Cerebrovascular disease, Peripheral arterial disease, Congenital heart disease and Rheumatic heart disease.

Table 2. Composition of unsaponifiable fraction of palm oil

Components	%	Mg/kg (in palm oil)
Carotenoids		
α-carotene	36.2	
β- carotene	54.4	
γ-carotene	3.3	500 – 700
Lycopene	3.8	
Xanthophylls	2.2	
Vitamin E		
α *-tocopherol*	28	
α *-tocotrienol*	29	500 – 800
γ - *tocotrienol*	28	
δ - *tocotrienol*	14	
Sterols		
Cholesterol	3	
Campesterol	22	~300
Stigmasterols	17	
β-*sitosterol*	56	
Phosphatides		500 – 1000
Total alcohols		
Triterpenic alcohol	80	~800
Alipahtic alcohol	20	

Cardiovascular diseases are the leading cause of global death [36] and are projected to remain the single leading cause of death till 2030. [37] Cardiovascular diseases were responsible for 17.5 million deaths in 2012, representing 31% of all global deaths. [38] Mortality due to cardiovascular diseases, according to World Bank analysis, has been declining in many high-income countries since the 1970s. [39,40] Conversely, cardiovascular disease and the consequent deaths have increased at a fast rate in low- and middle-income countries. [41] Over 80% of Cardiovascular deaths now take place in low- and middle-income countries. [36] Nigeria, like other middle-income countries, [42] is witnessing a general increase in deaths due to cardiovascular diseases [43-45].

Cardiovascular diseases are multi-factorial and several risk factors have been identified. These risk factors include: age, gender, unhealthy diet, physical inactivity, family history of cardiovascular disease, excessive alcohol consumption, tobacco use, obesity, raised blood sugar (diabetes mellitus), raised blood pressure (hypertension), raised blood cholesterol (hyperlipidemia), psychosocial factors, poverty and low educational status and air pollution. [38, 46-48] Although the individual contribution of these risk factors to the progression but not necessarily onset of cardiovascular disease varies considerable between different communities and ethnic groups, the overall contribution of these risk factors are very consistent. [49] While some of these risk factors such as gender, age or family history, are immutable; many important cardiovascular risk factors are modifiable by social change, lifestyle change, drug treatment and prevention of hyperlipidemia, hypertension, and diabetes.

3.1 Cardiovascular Diseases and Saturated Fat

Mainstream heart-health, government, and medical communities including the American Dietetic Association, [50] the World Health Organization, [51] the Dietitians of Canada, [50] the British Heart Foundation, [52] the British National Health Service, [53] the World Heart Federation [54] and the European Food Safety Authority [55] advise that saturated fat is a risk factor for cardiovascular disease. However, there are studies in recent times whose results suggest otherwise [56,57]. In 2014, a systematic review and meta-analysis of 72 published studies, totaling 530,525 participants, looked at observational studies of measured fatty acid levels in the blood, observational studies of dietary intake of fatty acids, and intervention studies of polyunsaturated fat supplementation. The authors of the review concluded that low consumption of saturated fatty acids and high consumption of polyunsaturated fatty acids is not clearly supported as a guideline for reducing the risk of cardiovascular diseases. [57] Similarly, a 2010 meta-analysis of prospective cohort studies supported by the National Dairy Council including 348,000 subjects found no statistically significant relationship between cardiovascular disease and dietary saturated fat. [56]

There have been serious criticisms of the meta-analyses whose results concluded that dietary saturated fat is not a risk factor of cardiovascular diseases. The work done by Chowdhury and co-worker [57] which concluded that "Current evidence does not clearly support cardiovascular guidelines that encourage high consumption of polyunsaturated fatty acids and low consumption of total saturated fatty acids" was criticized by Dr. Walter Willett of Department of Nutrition at Harvard School of Public Health who warns that there are serious omissions in the analysis and the conclusion is mis-leading. [58] Also, the 2010 meta-analysis that found no statistically significant relationship between dietary saturated fat and cardiovascular disease [46] has been

criticized for inaccuracy and for biasing in the direction of the study's conclusion [59,60].

Furthermore, systemic reviews from reputable medical journals concluded that dietary saturated fat is a risk factor of cardiovascular diseases [61-71].

3.2 Palm Oil and Cardiovascular Disease

The overall contributions of palm oil to cardiovascular health are controversial and subject to ongoing research. While several studies have linked palm oil with increase risk of cardiovascular diseases [72] and consequently deaths, [73] some other research works maintained that palm oil is not linked to the risk of cardiovascular disease. [74] Some studies even concluded that palm oil improve cardiovascular health. [75] Also, while some studies concluded that palm oil is not a safe substitute for hydrogenated fat (trans fat) because palm oil results in adverse changes in the blood concentrations of apolipoprotein B and LDL cholesterol just as trans fat does, [76,77] others argue that palm oil is an acceptable replacement for trans fat [78].

However, considering the fatty acid profile of palm oil, half of its fatty acids are saturated. [14,22] This is much unlike most vegetable oils including rapeseed oil, corn oil, cotton seed oil, olive oil, peanut oil, safflower oil and soybean oil; all of which are made up of less than 20% saturated fat. [79] A well refined branded vegetable oil manufactured from these oils will therefore have a lower percentage of saturated fatty acids hence a less risk to cardiovascular health. Dietary saturated fatty acid has been implicated in the onset and progression of cardiovascular diseases [61-71].

Shea butter, a vegetable fat that is also used as dietary lipid in Nigeria, though also has half of its fatty acid saturated, [80,81] has been reported to reduce circulatory cholesterol concentrations in experimental animal. [82-84] This paradox can be explained by the fact that the saturated fatty acid concentration of palm oil is constituted majorly of palmitic acid (16:0), [14] while that of Shea butter is constituted majorly of stearic acid (18:0). [24] Different saturated fatty acids contribute differently to cardiovascular disease. In epidemiological and clinical studies, Stearic acid (18:0) was found to be associated with lower LDL compared to any other saturated fatty acid. [85] Also, an isotope labeling study in humans [86] concluded that the fraction of dietary stearic acid (18:0) that oxidatively desaturates to oleic acid (18:1) is 2.4 times higher than the fraction of palmitic acid (16:0) analogously converted to palmitoleic acid (16:1). These demonstrate that dietary palmitic acid (16:0) contributes to progression of cardiovascular disease than stearic acid (18:0).

Sundram and co workers [20] claim that the saturated fatty acid content of palm oil is balanced by its unsaturated fatty acids and concluded that there is no risk of cardiovascular diseases related to palm oil consumption. However, it has been demonstrated that while there is no clear health benefit of replacing saturated fatty acids with starchy foods [65], replacement with unsaturated fatty acids reduced the risk of cardiovascular disease. A decrease as slight as 5% in dietary saturated fatty acid amounted to 13% decrease in cardiovascular disease occurrence and 26% decrease in deaths. [66] Replacing “red oil” with “white oil” in a Nigerian diet will decrease saturation by about 30% which will definitely be a positive move toward cardiovascular health. Also, a typical Nigerian diet is characterized by the presence of red meat (usually beef) [87,88] which promotes cardiovascular disease. [89,90] Hence, the need to reduce other cardiovascular risk factors in Nigerian diet.

The unsaponifiables of vegetable oils, usually sterols, vitamin E and triterpene alcohols [31,81, 91-94] are generally appreciated for health benefits including antioxidant, anti-cancer and circulatory cholesterol reducing abilities. [95-98] The presence of these unsaponifiables in palm oil however does not give an edge to palm oil since these unsaponifiables are present in most vegetable oils. [31,81,91-94] A particular unsaponifiable component that is exclusive to palm oil amongst vegetable oil is carotenoid. [29] The overall contribution of carotenoids to the progression of cardiovascular disease is however under controversial with some studies reporting disadvantageous relationship. [99]

4. CONCLUSION

Consequence of having half of its fatty acid saturated and high level of palmitic acid, palm oil is no safer dietary oil compared to branded vegetable oils manufactured from soybean, peanut, cotton, sunflower, olive and rape.

5. RECOMMENDATION

Since it is clearer that vegetable oils from different sources contribute differently to cardiovascular health, the National Agency for Food and Drug Administration and Control (NAFDAC) should disallow the use of the generic terms “vegetable fat” or “vegetable oil” in the ingredients list of packaged foods in Nigeria. Food producers in Nigeria, like in the European Union, [100] should be required to list the specific type of vegetable oil or fat used, including palm oil. Also consumers should be made aware of the risk involved with consumption of palm oil.

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COMPETING INTERESTS

Author has declared that no competing interests exist.

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