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Physicochemical Characteristics and Microbial Population of Palm Oil Sold in Major Markets in Yenagoa Metropolis, Bayelsa States, Nigeria

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Abstract

Palm oil has found application in both food and several industries. This study evaluated some physicochemical quality and microbial population of palm oil sold in some major markets in Yenagoa metropolis, Bayelsa State, Nigeria. A total of twenty eight palm oil samples were obtained from seven markets, four being from each market. Standard procedures were employed to enumerate the microbial population and physicochemical quality of palm oil. The microbial population ranged from 3.802- 4.858 Log cfu/ml and 2.287 – 3.792 Log cfu/ml for bacteria and fungi respectively. The results of the physicochemical ranged from 4.503 - 8.467 (free fatty acid i.e. FFA), 2.600 - 9.275 Meq/kg (peroxide value), 3.775 – 12.000% (Impurity level), 0.550– 2.425% (moisture content) 191.50– 203.05mgKOH/g (saponification value) and 0.9250 - 0.9875 (Specific gravity). The Analysis of variance showed that there were significant differences ($P < 0.05$) in all the physicochemical in most of the markets apart from saponification value. Parameters such as FFA, impurity, moisture, specific gravity, saponification value were not within the recommended limits, while the microbial population was within the maximum range recommended by Nigerian Agency for Food and Drug Administration Control (NAFDAC) for vegetable oil.

Key words: Bayelsa state, Market, microbial population, physicochemical properties, quality

1 Introduction

Palm oil is the most exploited and applied vegetable oil in Nigeria. Quality assessment of palm oil is an important index in evaluating its applications. About 55% of palm oil consumed in Nigeria is produced domestically and the rest 45% deficit are met through importation from major producing nation such as Indonesia and Malaysia. Presently, Malaysia and Indonesia account for about 89% of global palm oil, while Thailand, Columbia and Nigeria account for about 6% and the rest of the oil palm producing nations account for 5%.

Palm oil is semi-solid and saturated at room temperature and can tolerate high level of heat and resists oxidation. Palm oil contain natural antioxidants. Palm oil is orange red to brownish and/ or yellowish-red in colour [1, 2] and is insoluble in universal solvent such as water and soluble in organic solvents like trichloromethane and alcohol [3]. Palm oil is widely used as food or as an input in feed production. Palm oil has also found application in industries such as pharmaceutical, detergent and soap, confectionaries, margarines, cosmetics and biofuel such as biodiesel.

The quality of palm oil processed in Nigeria is influenced by the level of hygiene practiced by the processors in the processing mills. The imported palm oil often gets impaired due to prolong storage and /or transfer in unhygienic condition/container. Poor palm oil quality with regard to microbial and physicochemical properties affects some of its down streams applications. The physicochemical quality affects the industrial use of the palm oil such as biodiesel production [4]. The microbial composition influences its food application and in traditional medicine, hence causing health related effects. Several microorganisms are capable of flourishing in the palm oil. The type of microbial species and population pose danger to individual that consumes raw palm oil. Though, during cooking heat is applied which often eliminates or reduce the microbial populations, but some individuals still consumes raw palm oil especially in the rural areas.

Majority of palm oil microbial species is part of normal flora which could have been introduced into the palm oil from the field and during processing especially by individuals under poor hygienic conditions. Some of these microorganisms often cause diseases on ingestion of raw palm oil. The microorganisms that have been widely reported to be found in palm oil include *Enterobacter, Bacillus, Proteus, Micrococcus, Staphylococcus, Aspergillus, Candida, Mucor* and *Penicillium* species [3, 5, 6], *Trichphyton schoenleinii* and *Microsporium canis*as [7]. These microbes are known to cause disease conditions. For instance, *Proteus* species is capable of causing urinary tract infection [3], *Aspergillus* species is capable of causing aspergillosis, endophthalmitis, meningitis, pulmonary osteomyelitis, endocarditis, myocarditis; *Candida* and *Mucor* species causing candidiasis and mucormycosis respectively [5]. *Enterobacter* species often causes respiratory tract infections, septicemia and meningitis [6].

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Some species of *Micrococcus* can degrade sweats to produce unpleasant odors; some *Penicillium* species can cause keratitis, otomycosis; some species *Staphylococcus* can cause bacteremia, genitourinary disease among sexually active person especially females; some species of *Pseudomonas* such as *Pseudomonas aeruginosa* can cause skin and soft tissue infections, urinary tract infections, gastrointestinal tract, bone and joint infections, respiratory infections, endocarditis, central nervous infections, necrotizic enterocolitis and giving port of entry for septicemia and bacteremia. These microorganisms are opportunistic in nature are capable of affecting individuals that have suppressed immune system.

Physicochemical parameters such as free fatty acid (FFA) increase due to long storage and microbial infestation prior to processing. This basically causes rancidity in the palm oil, which reflects in the taste and odour of the palm oil. Other physicochemical quality parameters of palm oil include peroxide value, moisture content, iodine value, saponification value, impurity level etc. The quality of palm oil processed from various palm oil mills in Nigeria has been widely reported in Literature [1, 3, 5, 8 – 11]. Also the palm oil sold in some major market in different states in Nigeria abound in Literature; Delta state [12], Jos metropolis, Plateau state [6], Abia state [13], Ibadan, Oyo state [14] and Kogi state [7]. The microbial population and physicochemical quality of palm oil sold in major markets in Yenagoa metropolis has not been documented, hence the need for the study.

2 Materials and Methods

2.1 Study site

This study was carried out in Yenagoa metropolis, the Bayelsa state Capital. The state has several markets that trade nearly every day of the week. Nearly all the markets are located along the express way (i.e stretching across Igbogene, Akenfa, Agudama-Epie, Tombia, Opolo, Kpansia and Swali). Some of the palm oil dealers do sell in more than one market depending on the day it trade. Basically, the population of the state has been increasing due to urbanization and industrialization. Hence, the number of people that consumes palm oil on daily basis is also increasing.

2.2 Sample collection

Four samples of oil palm displayed for sales were purchased from seven different markets in Yenagoa metropolis. The sample meant for microbial analyses were transferred into sterile McCartney bottles.

2.3 Enumeration of total heterotrophic bacteria and fungi counts

The Microbial population from the palm oil samples was enumerated using serial dilution pour plate method described by Pepper and Gerba [15]. About 1.0ml of the sample suspension was serially diluted with sterile distilled water and aliquots of the dilutions were aseptically plated into Nutrient Agar for bacteria and Potato Dextrose Agar for fungi. The agar plates were inverted and incubated at 35°C for 24– 48 hours and 30°C for 72- 120 hours for bacteria and fungi respectively. The colonies that grew on the medium were counted and expressed as colony forming units (cfu)/ml of the palm oil samples.

2.4 Physicochemical properties of the palm oil

The physicochemical parameters studied include specific gravity, FFA, saponification value, moisture content, impurities level and peroxide value. Specific gravity and saponification value were determined using the method described by Akinola et al. [1], Ohimain and Izah [4], Ohimain et al. [3]. Free fatty acid was determined based on the method described by Tagoe et al. [16], Aletor et al. [9], Ohimain and Izah [4], Ohimain et al. [3, 11]. Impurity content were similarly determined based on the method described by Tagoe et al. [16], Ohimain and Izah [4]. Moisture and peroxide value analyzed based on method describe by Ohimain et al. [3, 11].

2.5 Statistical Analysis

SPSS software version 16 (SPSS Inc, Chicago) was used to carry out the statistical analysis on the microbial load and the physicochemical parameters of the palm oil. A one-way analysis of variance (ANOVA) was carried out at $\alpha = 0.05$, and Duncan's multiple range test was used to determine the source of the observed differences. Microbial population densities were log transformed prior to ANOVA. Pearson's correlation matrix was used to identify the relationship among the physicochemical parameters of the palm oil.

3 Results and Discussion

Table 1 presents the microbial population of palm oil sold in major markets in Yenagoa metropolis. The total heterotrophic bacteria ranged from 3.802-4.858 Log cfu/ml being significantly not different ($P > 0.05$) among the various markets. Total fungi ranged from 2.287 - 3.792 Log cfu/ml. The microbial population recorded in this study is in agreement with other studies. For instance, the microbial load of palm oil sold in Jos metropolis, Plateau state Nigeria ranged from 9.4×10^4 to 1.61×10^4cfu/ml [6], 8.0×10^3 to 3.7×10^4cfu/ml for mould load [14]. However, the result obtained in the current study is far from microbial count of 7.6 Log cfu/ml reported for palm oil sold in some markets in Nigeria after 8 months of storage [17]. The microbial population recorded in the current study is however comparable to the microbial load of palm oil produced by smallholder's processors in Rivers state, Nigeria [5] and semi-mechanized processors in Bayelsa state [3]. The microbial population from the palm oil samples was within the minimum standard microbiological population (10^4cfu/ml) recommended by the Nigerian Agency for Food and Drug Administration (NAFDAC) [6]. The population of the microbes could be associated with the duration of storage after processing.

The physicochemical quality parameters of the palm oil samples sold in Yenagoa metropolis are presented in Table 2, while Table 3 presents Pearson's correlation coefficient matrices for the analyzed physicochemical parameters. The FFA ranged from 4.503 to 8.467 being significantly different among the markets ($P<0.05$) apart from Swali and Agudama-Epie that were not significantly different ($P>0.05$). FFA significantly correlated ($P < 0.01$) with peroxide value ($r=0.493$), specific gravity ($r=0.639$),

moisture content (r=0.798) and impurity level (r=0.889) (Table 3). The results of this study were higher than previous findings. Okechalu *et al*. [6] sampled palm oil sold within Jos Metropolis and found that the FFA ranged from 2.67 – 4.20%. Enemuor et al. [7] reported FFA of palm oil sold in Anyigba Market, Kogi state, Nigeria as 6%. Also, the FFA content of palm oil processed from some palm oil mills in some Nigeria states including Kogi [10], Osun and Ondo [1] and Imo [8] were lesser than this study. The findings from these studies were also not in consonance with other study. Olorunfemi et al. [14] reported FFA of palm oil sold in Ibadan in the range of 13.93 to 19.00%. The FFA content recorded in this study was similar to values obtained in other studies in southern Nigeria including Delta state [9], Rivers [11] and Bayelsa [3]. The range of percentage FFA from this study indicates that the palm oil sold in Yenagoa is of poor quality.

Table 1: Microbial population of palm oil sold in major markets in Yenagoa metropolis, Bayelsa state, Nigeria

Markets	Total Heterotrophic Bacteria, Log cfu/ml	Total fungi, Log cfu/ml
Swali	4.783±0.142b	3.792±0.285c
Agudama-Epie	4.416±0.293b	3.298±0.028b
Tombia	4.858±0.039b	3.279±0.018b
Akenfa	4.697±0.025b	3.294±0.006b
Igbogene	4.400±0.246b	3.306±0.002b
Kpansia	3.802±0.012a	2.287±0.006a
Opolo	4.763±0.003a	3.304±0.005b

Each value is expressed as mean ± standard error (n = 4). Different letters in each column indicate significant differences at *P*< 0.05 according to the Duncan Multiple Range Test

Table 2: Physicochemical properties of palm oil sold in major markets in Yenagoa metropolis, Bayelsa state, Nigeria

Markets	FFA, %	Saponification value, mgKOH/g	Peroxide value, Meq/kg	Specific gravity	Moisture, %	Impurity, %
Swali	8.467±0.463e	191.50±7.681a	9.275±0.155f	0.9875±0.005b	2.400±0.158c	12.000±0.374f
Agudama-Epie	8.253±0.410e	194.10±2.784a	9.000±0.238f	0.9770±0.008b	2.425±0.193c	10.400±0.187e
Tombia	6.730±0.646d	198.80±1.256a	4.450±0.185c	0.9645±0.005b	1.575±0.111b	6.850±0.290d
Akenfa	5.320±0.408b	196.98±2.590a	5.450±0.150d	0.9350±0.014a	1.525±0.155b	3.775±0.063ab
Igbogene	4.503±0.112a	203.05±1.109a	7.300±0.212e	0.9250±0.010a	0.950±0.087a	3.450±0.132a
Kpansia	6.223±0.312cd	196.20±2.123a	2.600±0.158a	0.9743±0.006a	1.425±0.179b	4.475±0.193c
Opolo	5.840±0.408bc	201.92±2.553a	3.400±0.196b	0.9660±0.006b	0.550±0.065a	4.300±0.147bc

Each value is expressed as mean ± standard error (n = 4). Different letters in each column indicate significant differences at *P*< 0.05 according to the Duncan Multiple Range Test

Apart from palm oil from Swali and Agudama-Epie, the peroxide values were significantly different (P<0.05) ranging from 2.600 - 9.275 Meq/kg. Peroxide value significantly correlates (P < 0.01) with moisture content (r=0.638) and impurity level (r=0.703) (Table 3). The result from this study is in agreement with other studies. Agbaire [12] reported peroxide value from palm oil sold in some markets in Delta state as 7.8 – 8.4Meq/kg. Udensi and Iroegbu [13] reported peroxide value of palm oil sold in some major markets in Abia state, Nigeria in the range of 7.9 – 8.8Meq/kg. The peroxide value of palm oil processed in some Nigeria states including Kogi [10], Bendel (now Delta) [9], Osun and Ondo [1], Rivers [11], Bayelsa [3] and Imo [8] are comparable to the values obtained in this study. However, high peroxide value has been reported in some literature. Okechalu *et al.* [6] reported peroxide values of 23.2 – 35.5 meq/kg from palm oil sold in major markets in Jos metropolis, Plateau state. Ohimain et al. [3] also reported high peroxide value from palm oil processed from semi-mechanized palm oil mill in Bayelsa state, which were not comparable to the findings of this study. The peroxide value of palm oil from this study is within the permissible limit of 10MeqO_2/kg of standard specified by World Health Organization [18] and Standard Organization of Nigeria [19]. Basically, peroxide value is an indication of the stability and or rancidity of fat by reason of the amount of lipases, stages of oxidation and extent of spoilage [11].

Table 3: Pearson's correlation matrix of the physicochemical quality parameters of palm oil sold in Yenagoa metropolis, Bayelsa state, Nigeria

Parameters	FFA,%	Saponification value, mgKOH/g	Peroxide value, Meq/kg	Specific gravity	Moisture content, %	Impurity level, %
FFA,%	1					
Saponification value, mgKOH/g	-0.164	1				
Peroxide value, Meq/kg	0.493**	0.180	1			
Specific gravity	0.639**	-0.388*	0.083	1		
Moisture content, %	0.798**	-0.162	0.638**	0.387*	1	
Impurity level, %	0.889**	-0.152	0.703**	0.613**	0.792**	1

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).
N=28; n=4

The level of impurities of the palm oil sold in major markets in Yenagoa metropolis ranged from 3.775 – 12.000%, being significantly different (P<0.05) from all the markets. Impurities level from this study is higher than previous report. Agbaire [12] reported level of impurity from palm oil sold in some markets in Delta state as 0.11 – 0.14%. Enemuor et al. [7] reported impurity content of palm oil sold in Anyigba Market, Kogi state, Nigeria as 0.2%. Also, the findings were higher that the impurity value reported from palm oil from mills in some Nigerian states including Kogi [10], Imo [8]. The impurity content were comparable to the value reported in palm oil from palm mills in Rivers state as reported by Ohimain et al. [11]. Higher impurity level (19.87%) has been detected in palm oil from semi-mechanized palm oil mill in Bayelsa state [3]. The impurity content observed in the current study were higher than 0.01% recommended for maximum impurity limit [18]. The high impurity level of the palm oil could be associated to poor hygienic disposition of the processors and palm oil marketers. The impurity content could also has been increased by the addition of second grade oil to the palm oil during processing. This is a major practice of smallholder oil palm processors in Nigeria [2, 3].

The moisture content of the palm oil sold in major markets in Yenagoa metropolis ranged from 0.550–2.425%. Moisture content significantly correlated (P < 0.01) with impurity level (r=0.792) (Table 3). The results from this study were higher than previous findings. Udensi and Iroegbu [13] reported moisture content of 0.14 to 0.16% for palm oil sold in some major markets in Abia state. Agbaire [12] similarly reported moisture content of 0.14 – 0.17% for palm oil sold in some markets in Delta state. Enemuor et al. [7] reported moisture content of palm oil sold in Anyigba Market, Kogi state, Nigeria as 0.3%. The finding of this study is in consonance with other reports. Okechalu et al. [6] reported moisture content of 1.09 – 1.27% for palm oil sold in Jos Metropolis, Plateau state, Nigeria. Olorunfemi et al. [14] reported moisture content of palm oil sold in Ibadan in the range of 1.2 – 2.0%. Also, the moisture content were close to the finding of Akubor and Ogu [10], Aletor et al. [9], Onwuka and Akaerue [8] from palm oil processed from palm oil mills in some Nigerian states. The values obtained were relatively higher than the limits of 0.29% recommended by SON [19].The relatively high moisture content from this study could be attributed to poor heating during clarification. High moisture content makes the palm oil susceptible to microbial attack, thereby contributing to the high free fatty acid content [16].

The saponification value of the palm oil obtained from major markets in Yenagoa metropolis were not different significantly (P>0.05) ranging from 191.50–203.05mgKOH/g. Saponification exhibited negative relationship with specific gravity (P<0.05). The findings of this study are comparable to other studies. Udensi and Iroegbu [13] reported saponification value of 191.64 – 198.03 mgKOH/g for palm oil sold in some major markets in Abia state. Agbaire [12] reported saponification value of 195.76 – 198.75 mgKOH/g for palm oil sold in some markets in Delta state. Also, the results of this study is similar to the saponification value reported in palm oil processed in some Nigerian states including Bayelsa [3], Osun and Ondo [1]. But the findings of this study were not in consonance with other study. Olorunfemi et al. [14] reported saponification value of palm oil sold in Ibadan in the range of 221.87 – 234.83 mgKOH/g. Akubor and Ogu [10], Onwuka and Akaerue [8] reported saponification value that exceeded the results of this study. However, apart from palm oil from Swali and Agudama-Epie, the saponification value reported in the current study was within the permissible limit of 195 – 205 mgKOH/g recommended by SON [19].

The specific gravity of the oil in the current study ranged from 0.9250 - 0.9875. Specific gravity significantly correlated with moisture content (r=0.387P < 0.05) and impurity level (r=0.613 P<0.01) (Table 3). The results of this study were slightly higher than previous studies. Udensi and Iroegbu [13] reported specific gravity of 0.832 – 0.880 for palm sold in major markets of Abia state. Agbaire [12] reported specific gravity of 0.859 –0.885 for palm oil sold in major markets of Delta state. However, results obtained in this study were comparable to the specific gravity content reported by Akinola et al. [1] for palm oil obtained from Osun and Ondo states. Also, Ohimain et al. [3] reported specific gravity higher than the result of this study from semi-mechanized palm oil mill in Bayelsa state, Nigeria.

4 Conclusions

Some physicochemical properties and microbial population of palm oil sold in some major markets in Yenagoa metropolis Bayelsa state were evaluated. The bacterial and fungal populations were found to be within the specified range of $x10^4$ specified by SON. Some physicochemical parameters such as FFA, moisture content, impurities level, specific gravity were higher than the permissible limits. However, Peroxide value were within the maximum limit specified by WHO. Also, apart from palm oil from Swali and Agudama-Epie, the saponification value of the palm oil analyzed during the current study was within the recommended limit.

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