CHEMICAL COMPOSITION ANALYSIS OF PALM OILS IN IJEBU-ODE, OGUN STATE

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ABSTRACT

Palm oil is one of the major fats and oils produced in Nigeria. It forms an important ingredient in the diet of many people in Ijebu-ode Ogun State, Nigeria. The quality of palm oil is mostly determined by the following parameters: Free Fatty Acid (FFA) content, Iodine Value (IV), Peroxide Value (PV), Moisture Content, Saponification Value (SV) and Impurity Content. This study attempts to investigate the chemical composition analysis of palm oil. sold in major markets in ljebu-Ode, Ogun State, Nigeria. Twenty branded and unbranded palm oil samples were collected from three markets in Ijebu-Ode. They were analyzed for saponification value. Acid value and peroxide value using [1][2]. The results obtained showed that the Saponification value (SV) ranges from 183.03±0.15-220.89±0.05mgKOH/g. Acid value (AV) from 8.64±0.10-12.96±0.05mgKOH/g and Peroxide value (PV) from 7.50±0.10-15.00±0.15meq/kg. All the parameters investigated had values within the [3]/[4] standards. It can thus be concluded that palm oil from Ijebu-ode has a good shelf-1ife, is suitable for both domestic and industrial applications and there is no evidence of adulteration notable from their chemical compositional analysis. *[African Journal of Chemical Education—AJCE 13(1), January 2023]*

INTRODUCTION

Foods are any substances that provide nutritional support that the body needs. It is mostly gotten from plants or animals and houses essential nutrients like carbohydrates, fats, proteins, vitamins or minerals. Foods are categorized into several classes based on the type of nutrient they contain and the functions they perform in the body. These classes are carbohydrates, protein, vitamins, fat, minerals, and water.

Fat is a macronutrient. It is needed by the body for energy, cell structure and functioning. Based on physical characteristics, fats are categorized as saturated and unsaturated. Saturated fats are solid at room temperature. Foods such as butter, cheese and the white marbling in steak are good examples of saturated fat. Unsaturated fats on the other hand are liquid at room temperature and they include food such as Olive, cottonseed, soya and palm oils. An oil is any neutral, nonpolar chemical substance that is a viscous liquid at ambient temperatures and is both hydrophobic/water fearing and lipophilic/fat Loving. Oils may have their origin from animals, vegetables, or petrochemicals. Oils are used for food, fuel, lubrication, and the manufacture of products like paints, plastics, and other minerals.

Vegetable oil can be gotten from tree crops, animal crops and as byproducts. Most vegetables are obtained from beans (soyabeans) or seeds (cottonseed), which generally furnish two valuable commodities- oil and a protein-rich meal. Seeds are extracted by pressing or by solvent extraction or a combination of both. Oils such as palm oil and Olive, on the other hand, are pressed out of the soft fruits (endosperm). Seeds give oils in different proportions. In 2000, world average oil yields were Soyabean (18.3%) rapeseed (38.6%), sunflower (40.9%) groundnut (40.73%), cottonseed (15.1%), coconut (62.4%), palm kernel (44.6%), sesame (42.4%), and linseed (33.5%), average for all oilseeds (25.8%) [5]. In addition, yields from palm fruit (40-50%), Olive (25-30%), and corn (about 5%) are as indicated [5]. Some oils, such as virgin olive oil do not require further treatment, but most are refined to an extent before use. Vegetable oil is an important material for mankind's survival. Therefore, the edible vegetable oil quality and supervision become big problems for the national economy and people's health. However, to reap huge gains and meet up with the high rate of demand, manufacturers add shoddy animal oils to vegetable oil, for instance, oils extracted from chicken, duck and even the body of dead animals [6].

The oil palm (West Africa's most important oil-producing plant) fruit produces two distinct types of oils: crude palm oil which has an orange red color, extracted from the fruit's mesocarp and crude palm kernel oil which has a brownish-yellow color, extracted from the seeds (that is, kernel). Palm oils consist of mainly palmitic and oleic acids and palm kernel oil contains mainly Lauric acid. Red palm oil (RPO), besides providing calorie density to the diet, is also the richest natural source of β-carotene, a precursor of vitamin A and an antioxidant that destroys singlet oxygen and free radicals [7]. Palm oil is the richest natural source of carotenoids in terms of retinol (provitamin A) equivalent [8]. According to [9], palm oil serves as an antioxidant because it contains vitamin E, and also contains about 45% tocophenols and 55% tocotrienols. The carotenoids (500-700ppm) are responsible for the characteristic deep orange-red color [5]; while its semi-solid consistency at tropical room temperature is mainly due to the presence of triacylglycerols of palmitic and oleic acids [10]. Palm oil is unique among vegetable oils in having a significant amount of saturated acids (10-15%) at the 2-position of its triacylglycerols (TAGS) [5]. The quality of palm oil is mostly determined by the following parameters: free fatty acid (FFA) content, Iodine value (IV), Peroxide value (PV), moisture content, saponification value (SV) and impurity content. The chemical composition analysis is the determination of these parameters which are relatively used as an index of adulteration or deterioration of the oil.

In Nigeria, the high demand (consumption) for palm oil which is growing faster than supply (productiwon) has created a wide gap. This widening gap between demand and production has resulted in increasing reports of adulteration [12]. Adulteration of fats and oils has been the subject of many studies since it is an old problem. The practice has been to sell cheaper oils in place of or mixed with more expensive oils. Adulteration of palm oil has gained widespread speculation in Nigeria. Palm oil producers in order to increase the quantity produced and maximize profit have reportedly adulterated palm oil, failing to consider the effects this adulteration might have on the quality of the palm oil and the consumers. The adulterants reportedly used include carrot, papaya, natural potash and red dye; with potash and red dye being the preferred and most widely used adulterants due to their abundance and low cost.

The problem under consideration in this study is to determine the chemical compositional analysis of palm oils in Ijebu-Ode local government of Ogun states. Thus, the study is meant to analyze the oil samples for their saponification value, fatty acid value, and peroxide value. Different researchers have also worked on the analysis of palm oils and their adulteration in various parts of the world, like Malaysia, India and the Western parts of Nigeria. But this study focuses on Ijebu-Ode area. Past research such as those reported by [12][13], to mention a few, had focused on the analysis and characteristics of these adulterants using complex analytical tools such as gas chromatography, High-Pressure Liquid Chromatography, FTIR e.t.c. So far, there are very few studies and research on the analysis of palm oil samples using titrimetric methods. Also, there is little data on chemical compositional analysis in the region. The present study attempts to minimize the cost, stress and availability of the procedure by carrying out the determination using the titrimetric method of analysis. This study is confined to chemical compositional analysis and determination of adulterants in palm oils in Ijebu-Ode local government area, Ogun State, Nigeria. The study is centred on palm oils from Ijebu-Ode markets only, it does not include other parts of the country.

CHEMICAL COMPOSITION OF PALM OIL

Free Fatty Acid (FFA)

Free fatty acid reflects the amount of fatty acid hydrolyzed from triacylglycerols. According to SON, the standard level of FFA for palm oil is between 3.5 and 5%. The FFA value can be affected by the duration of storage of the fruit used to possess the Palm oil and the length of storage of palm oil after processing [14]. Long storage of the palm fruit results in over-ripe thereby leading to a high level of FFA [15]. In the study [16] it was reported that adulteration is another factor that also affects the FFA value of palm oil. [17] reported that a high FFA value has a high tendency of decreasing the ability of the lever to store sugar.

Saponification Value (SV)

Saponification value is a measure of the average weight of all the fatty acids present. It can also be said to mean the chain length of the FFA. As the saponification value of the palm oil increases, the molecular weight of the oil decreases vis-versa. According to the standard organization of Nigeria, saponification value for palm oil ranges between 190 and 209 mgKOH/g. A significantly high proportion of saponification value of palm oil (260.22 ± 1.38mgKOH/g) suggests that the oil can be used for soap production [18] but is not unsuitable for human nutrition (consumption) [19]. Adulteration increases the saponification value of palm oil making palm oil a good raw material for soap making [18]. [20] reported that palm oils with saponification value within the range of 195.76 - 198.75 mgKOH/g show no evidence of adulteration and are suitable for both domestic and industrial uses. This is in accordance with [21] findings that palm oils with saponification values from 129.04 – 198.03 mgKOH/g are not adulterated and are suitable for domestic and industrial applications as well as export trade.

Acid value (AV)

Acid value is a relative measure of rancidity as free fatty acids are normally formed during the decomposition of oil glycerides. The accepted acid value for palm oil as recommended by [3] and [22] is from 10 - 15%. Like other parameters, Adulteration also has the potential of increasing the acid value of Palm oil thereby making the oil less quality [16]. A high acid value is unset of rancidity. Oils that taste or smell unpleasant will consequently have high acid value. Increased acid value is probably caused by a variety of agents: Presents of moisture in the oil, elevated temperature and so on [6]. According to [23] acid value of 12.06 + 0.4 0mgKOH/g or above indicates high FFA and leads to the tendency to become rancid.

Peroxide Value (PV)

Peroxide Value which determines the shelf life of the oil is a measure of oxidation of the palm oil. High peroxide value shows that the oil has been oxidized while low peroxide value means that the oil can stay longer without being oxidized. Like acid value, Peroxide value is another useful indicator of rancidity. It indicates an early stage of rancidity occurring under mild conditions. Standard peroxide value as recommended by [3] and [22] is 10meq/Kg. [20] stated that peroxide value from 7.80 to 8.40meq/Kg shows no evidence of adulteration and are good for domestic and industrial application. This is in accordance with the report of [21] that palm oils with peroxide values within the range of 7.90 to 8.80meq/Kg are of good quality. Adulteration of palm oil with adulterants such as red dye reduces the peroxide value of the oil. Consequently, formation of peroxides in unadulterated palm oil occurs at a faster rate compared to adulterated palm oil and may be attributed to the presence of naturally occurring antioxidants in the red dye [12]. [16] also reported that adulteration of palm oil with red dye reduces the peroxide value of the palm oil to 12.00meq/Kg significantly lower than the SON/NIS standard. The oxidation stability of palm oil is a major advantage of the oil. Greater peroxide value is an indication of high oxidation of the oil. Peroxide values between 20 to 40meq/Kg mostly have a rancid taste [11].

METHODOLOGY

Sample and Sampling Techniques

Twenty samples of palm oils were collected for this study. Two different brands of palm oil (namely Kings and Marmador palms oil and eighteen (18) locally processed palm oils were collected from three markets in Ijebu-Ode, Ogun State. Among the various markets in Ijebu-Ode; New-market, Itale and Oke-aje markets were purposely selected for sampling. The rationale for the selection of these markets is to enable the researcher to have a narrowed-down population from which the sample can be drawn. The oils were randomly purchased from each market. These markets were selected because they are the most patronized markets in Ijebu-Ode. Samples were collected and tightly packed in a container to prevent further oxidation or contamination and kept in the laboratory away from sunlight.

Sample Coding

Tablet 1: Sample codes and their location or brand

S/N	Sample Code	Brand/Location
1	A	Kings Palm Oil
2	B	Marmador Palm Oil
3	C1 – C6	Local Palm oils from New Market
4	D1 – D6	Local Palm oils from Oke-Aje Market
5	E1 – E6	Local Palm oils from Itale Market

Methods for the Determination of Chemical Composition of Palm Oil

1. **Determination of Saponification Value**

Approximately 2g of each of the oil samples were respectively weighed into different conical flasks and 25ml of ethanolic potash was added. To another flask was added the same quality and quantity of the ethanolic potash but omitting the oil sample, this was used as blank. All the flasks were boiled in a water bath for 30 minutes with frequent shaking. Two drops of phenolphthalein indicator were added to each flask and titrated with 0.5M HCL with vigorous shaking without delay until the pink color just disappeared and the volume of titrant used was recorded. The titration was repeated twice for each sample. The Saponification number (or value) of each sample was calculated as follows:

$$\text{Saponification Value} = \frac{(B - S) \times M \times 56.1}{W}$$

Where: Saponification value is measured in mgKOH/g of sample
B = Volume of titrant (ml) for blank
S = Volume of titrant (ml) for Sample
M = Molarity of HCL (mmol/ml)
56.1 = Molecular weight (MW) of KOH (mg/mmol)
W = Sample mass (g)

2. Determination of Acid Value

Twenty-five (25mL) of ethanol was added to 1.5g of each oil sample contained in different conical flasks. The mixture was boiled in a water bath and left to cool followed by the addition of two drops of phenolphthalein indicator. The mixture was titrated with 0.1M NaOH with constant shaking for proper mixing until the endpoint was reached. This is indicated by a slight pink colour that persists for 30s. The volume of titrant used wall recorded. The titration was repeated twice for each sample. The acid value of each sample was calculated using the formula below:

$$\text{Acid Value} = \frac{V \times M \times 56.1}{W}$$

Where:
V = Volume of NaOH titrant (ml)
M = Molarity of NaOH titrant (mol/1000mL)
W = Sample mass (g)

3. Determination of Peroxide Value

The method reported by [1] was used. 2g each of the oil samples were respectively weighed into different flasks and 15ml of the mixture of acetic acid (CH_3COOH) -chloroform ($CHCl_3$) in the ratio of 3:2 respectively was added to the oil sample. 0.5mL saturated potassium iodide was added to each conical flask and allowed to stand for five (5) minutes, thereafter, 15mL of distilled water was added and titrated with 0.1M $Na_2S_2O_3$ until a yellowish colour disappeared, then 0.5ml of starch was added and Titration continued to a colourless endpoint. The volume of titrant used was recorded. The titration was repeated twice for each sample. The peroxide value for each sample was calculated from the equation as follows:

$$\text{Peroxide Value} = \frac{(S - B) \times M \times 1000}{W}$$

Where: Saponification value is measured in meq/Kg of sample
B = Volume of titrant (mL) for blank
S = Volume of titrant (mL) for Sample
M = Molarity of $Na_2S_2O_3$ solution (meq/mL)
1000 = Conversion of Units (g/Kg)
W = Sample mass (g)

RESULTS AND DISCUSSION

Table 2: Chemical composition of palm oils in Ijebu-Ode

S/N	Samples	Saponification Value (mgKOH/g)	Acid Value (mgKOH/g)	Peroxide Value (meq/Kg)
1	A	215.28 ± 0.15	8.81 ± 0.15	7.50 ± 0.10
2	B	210.38 ± 0.10	9.09 ± 0.10	10.00 ± 0.05
3	C1	206.87 ± 0.15	10.04 ± 0.15	10.00 ± 0.05
4	C2	211.08 ± 0.15	11.05 ± 0.05	7.50 ± 0.10
5	C3	193.55 ± 0.10	9.26 ± 0.15	12.50 ± 0.10
6	C4	220.89 ± 0.05	9.37 ± 0.05	10.00 ± 0.15
7	C5	199.86 ± 0.15	9.59 ± 0.05	15.00 ± 0.05
8	C6	201.26 ± 0.15	12.01 ± 0.10	15.00 ± 0.15
9	D1	194.95 ± 0.10	11.72 ± 0.05	7.50 ± 0.10
10	D2	192.74 ± 0.10	9.71 ± 0.10	10.00 ± 0.05
11	D3	190.74 ± 0.10	12.17 ± 0.10	10.00 ± 0.15
12	D4	174.61 ± 0.05	12.23 ± 0.10	15.00 ± 0.05
13	D5	191.44 ± 0.15	12.90 ± 0.10	7.50 ± 0.15
14	D6	192.14 ± 0.10	10.94 ± 0.10	10.00 ± 0.05
15	E1	174.61 ± 0.15	11.84 ± 0.15	12.50 ± 0.10
16	E2	191.44 ± 0.05	12.96 ± 0.05	10.00 ± 0.05
17	E3	188.64 ± 0.05	11.67 ± 0.10	7.50 ± 0.10
18	E4	190.04 ± 0.05	9.99 ± 0.10	7.50 ± 0.10
19	E5	201.26 ± 0.05	8.64 ± 0.10	10.00 ± 0.15
20	E6	183.03 ± 0.15	9.26 ± 0.15	10.00 ± 0.05
Mean ±_S.D		196.25 ± 12.33	10.66 ± 1.43	10.25 ± 2.55

Table 3: Recommended (Standards) Chemical Composition of Vegetable Oils by FAO/WHO (1993).

S/N	Vegetable Oils	Saponification Value (mgKOH/g)	Acid Value (mgKOH/g)	Peroxide Value (meq/Kg)
1	Palm oil	190 - 209	≤ 10	≤ 10
2	Groundnut oil	187 - 196	≤ 0.6	≤ 10
3	Coconut oil	248 - 265	ND	≤ 10
4	Grapeseed oil	188 - 194	ND	≤ 10
5	Soyabean oil	189 - 195	≤ 0.6	≤ 10
6	Cottonseed oil	189 - 198	≤ 0.6	≤ 10
7	Sunflower oil	183 - 194	≤ 0.6	≤ 10
8	Palm kernel oil	230 - 254	ND	≤ 10

Table 4: Recommended (Standards) Chemical Composition of Edible Oils as specified by NIS (1992).

Saponification Value (mgKOH/g)	Acid Value (mgKOH/g)	Peroxide Value (meq/Kg)
245 - 255 (Depending on the oil)	0.6 Maximum	10 Maximum

The chemical properties of the palm oil samples, and their recommended standards are in tables 2 and 3 respectively. Saponification is an indicator of the molecular weight of triacylglycerols (TAGS) of oils. This value gives an index of the average fatty acid chain length present in the test oil [24]. High Saponification Value indicates a high proportion of low fatty acids. Since saponification value is inversely proportional to the average molecular weight [18]. The saponification value for the branded palm oil samples (A and B) were two 215.28mgKOH/g and

210.38mgKOH/g which is relatively higher than the [3] and [22] standards. The high saponification values may be due to the presence of local additives or adulterants as reported by [16].

However, the saponification values for the unbranded palm oil samples from new market with sample labels C1, C2, C3, C4 C5 and C6 are 206.87mgKOH/g, 211.08mgKOH/g, 193.55mgKOH/g, 220.89mgKOH/g, 199.86mgKOH/g and 201.26mgKOH/g respectively. These saponification values are within the recommended standard (except C2 and C4 which are higher) and are in accordance with the findings of [20] that saponification value within the range of 195.76 - 198.75mgKOH/g is of good quality and show no evidence of adulteration. The saponification values of C2 and C4 are higher than the recommended standard for palm oil but fall within the range of standard for palm kernel oil [3][22].

This result showed that the high saponification value might be a result of the presence of trace amount of palm kernel oil in the oil samples and since both oils are from the same plant and have almost the same color, there is possibility of adulteration or contamination without being noticed. This result is in accordance with [16] findings that adulteration or contamination has the potential of increasing the saponification value of Palm oil. Also, the unbranded palm oil samples from Oke-aje market with sample labels D1, D2, D3, D4, D5 and D6 had saponification values of 194.95mgKOH/g, 192.74mgKOH/g, 190.74mgKOH/g, 174.61mgKOH/g, 191.44mgKOH/g and 192.14mgKOH/g respectively, while palm oil samples from Itale market with samples label E1, E2, E3, E4, E5 and E6 had saponification values (SV) 174.61mgKOH/g, 191.44mgKOH/g, 188.64mgKOH/g, 190.04mgKOH/g, 201.26mgKOH/g and 183.03mgKOH/g Respectively.

These values were within the SON/NIS recommended standard and the result is similar to those obtained by [21] palm oils with saponification values from 129.44 - 198.03mgKOH/g are not contaminated or adulterated and are therefore suitable for domestic and industrial applications as well as export trade. Acid value (AV) is a measure of the free fatty acid in oils. The higher the acid value, the higher the free fatty acid which also means decreased oil quality. The acid values for the branded palm oil samples with sample labels A and B were 8.81mgKOH/g and 9.79mgKOH/g respectively, while the acid values of the unbranded palm oil samples from new market with sample labels C1, C2, C3, C4 C5 and C6 were 10.04mgKOH/g, 11.05mgKOH/g, 9.26mgKOH/g, 9.37mgKOH/g, 9.59mgKOH/g and 12.01mgKOH/g respectively. Also, acid values of the unbranded palm oil samples from Oke-aje market with sample labels D1, D2, D3, D4, D5 and D6 were 11.72mgKOH/g, 9.71mgKOH/g, 12.17mgKOH/g, 12.23mgKOH/g, 12.90mgKOH/g and 10.94mgKOH/g respectively, while that of Itale market with sample labels E1, E2, E3, E4, E5 and E6 are 11.84mgKOH/g, 12.96mgKOH/g, 11.67mgKOH/g, 9.99mgKOH/g, 8.64mgKOH/g and 9.26mgKOH/g respectively.

The acid values were higher than [3] recommended standard but are within the recommended standard by [25], except for C2, C6, D1, D3, D4, D5, E1, E2 and E3, and are in line with [23] finding that acid value of 12.06 + 0.04mgKOH/g or above indicates high free fatty acid and leads to a tendency to become rancid (that is off flavor). The deviation observed in the acid values of the aforementioned exceptions can be due to the various factors which include, presence of moisture in the oils, as these oils were produced locally and without adequate precautions or under standard conditions. The high acid value may also be because of elevated temperature [6]. It can be observed that these exceptions are unbranded palm oils that are exposed to sunlight on daily basis during sales. Long exposure of these oils to the sun or heat can increase the acid value, thereby making the oil susceptible to rancidity.

The peroxide value determines the degree of oil oxidation. It is a useful indicator of the early stage of rancidity occurring under mild conditions [22]. The peroxide value of the palm oil samples with sample labels A, B, C1, C2, C4, D1, D2, D3, D5, D6, E2, E3, E4, E5 and E6 range between 7.50 - 10.00meq/Kg. These values were closely related to the standard value of 10meq/Kg recommended by [3], [4] and [25]. However, higher peroxide value was obtained for C3, C5, C6, D4 and E1 (12.50 - 15.00meq/Kg). This value indicates the unsets of primary oxidation due to lipid degrading enzymes like peroxidase and lipoxygenase [22]. At this level, the rancid taste might not be noticeable since they are below the peroxide value of 20 - 40meq/Kg [11]. The results were also comparable with those obtained by [16] findings that adulteration of palm oils with red dye reduces the peroxide value of the palm oil to 12.00meq/Kg which is much lower than the SON/NIS standard, but higher than the results obtained by [20] and [21] that peroxide value from 7.80 - 8.40meq/Kg is of good quality and shows no evidence of adulteration.

CONCLUSIONS AND RECOMMENDATIONS

The quality of Palm oil is mostly determined by the chemical constituents which are saponification, acid and peroxide values. Any increase or decrease in the value of these parameters from the recommended standard can relatively be used as an index of adulteration or deterioration of the palm oil. The results obtained from this study showed that the saponification values, acid values and peroxide values of the palm oil samples investigative were within the standard recommended by [3] and [22] and were also comparable with the results of past findings of [16][21] and [20], with only a few exceptions which may have occurred due to difference in storage factors or handling. Since measurements of common quality parameters of fat and oil may not be helpful in identifying palm oil adulteration with red dye, it cannot, therefore, be ascertained that the palm oil samples investigated show no evidence of adulteration. The results obtained, however, indicated that palm oil samples from New-market and the branded palm oil samples had greater industrial values (for soap production) than palm oils from Oke-Aje and Itale markets. This is as a result of their higher saponification values which showed the suitability of the oils for soap production. However, samples from Itale market and Okey-aje market and the branded palm oil samples may have higher shelf-life (due to their low peroxide values) than the palm oil samples from New-market because of the observed high peroxide value in the oils from these markets.

In conclusion, palm oils from Ijebu-Ode have a good shelf-life and are suitable for both domestic and industrial applications.

It has been understood that the quality of palm oil is a very important issue in food chemistry. This research is proven to support existing knowledge on the chemical composition of Crude Palm Oil and will aid future researchers, as they will be able to leverage the findings of this research to make informed hypotheses in the future. The school curriculum is in a dynamic state, it calls for continuous content updates.

On the basis of these findings, the following recommendations were made:

i. Update of school curriculum to reflect storage and packaging materials as factors that affect the composition/quality of Crude Palm Oil.

ii. Universities in conjunction with the quality assurance agency should set up an informal information session with the accreditation process for Local palm oil retailers to educate them on better and more effective methods of handling and storing their palm oils.

iii. At the formal level of education, secondary school students should be educated on the usability of Crude palm oils based on their chemical composition. The food chemistry aspect of their science curriculum school is designed in such a way that they are well informed on which palm oil is suitable for domestic or industrial applications.

iv. Local palm oil producers should be given grants in form of business loans to encourage their output because their product seems to be industrially better than branded palm oils.

Furthermore, college students seeking to conduct their thesis in a related field would find this article informative enough for their literature review. [26] reported that Fourier Transfer Infrared (FTIR) Spectroscopy is accurate and precise enough for rapid analysis of lard in palm oil. [27] also discovered that differential scanning calorimetry (DSC) can distinctly identify refined, bleached and deodorized palm oil samples adulterated with different animal body fats. [28] discovered in his finding that, measurement of common quality parameters of fats and oils may not help identify palm oil adulterated with red dye and further suggest that evaluation of sensory attributes, particularly color, taste and mouthfeel, can be considered a reliable approach.

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