QUALITY ASSESSMENT OF TRADITIONALLY PROCESSED COCONUT, PALM, "DZOMI" AND PALM KERNEL OILS SOLD ON SELECTED MARKETS IN ACCRA

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ABSTRACT

Fats and oils form part of the Ghanaian diet and many are sold on the market. The storage conditions and packing of these oils can affect their safety and hence their wholesomeness for consumption. This study evaluates quality of some oils from selected markets in Accra. The moisture content, peroxide value, iodine content, saponification value and free fatty acid content of the samples were determined. Most of the oil samples had moisture levels exceeding the permissible levels –1% (for palm oil and 'dzomi') and 0.1-0.5% (for coconut and palm kernel oils). This predisposes the oils to early onset of rancidity. Similarly, most of the oils had iodine values outside the acceptable levels, indicating possible adulteration. However, rancidity had not started in the oils investigated as revealed by their free fatty acid contents recording below the Codex standards – 10mg KOH/g oil for palm oils and 'dzomi'; and then 4mg KOH/g oil for coconut and palm kernel oils. The same applied to the peroxide values. The quality of oils can be improved through good storage and elimination of excess moisture in the packages.

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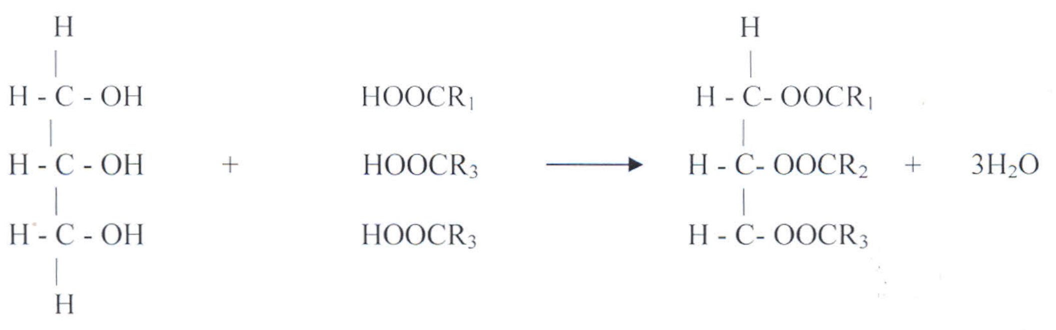
1.0 INTRODUCTION

Fats and oils (Lipids) are water - insoluble substances of plants or animal origin which consist predominately of glycerol esters of fatty acids or triglycerides. The word "fat" is originally used to refer to triglycerides that are solid or more correctly, semi solid at ordinary temperatures whereas the word "oil" is used for triglycerides that are liquid under the same conditions. Structurally, a triglyceride is a condensation product of one molecule of glycerol with three molecules of fatty acids to yield three molecules of water and one molecule of a triglyceride:



Fat and oils constitute most of our diet. Fats and oils, besides being the most concentrated source of energy; also contribute to the palatability, flavor and satiety value of food. Fats and oils are a carrier of the fat soluble vitamins A, D, E and K and the essential fatty acids important for growth and maintenance of many body functions. Dietary fats are capable of acting on the composition, organization and functions of membranes.

Fats are a major form of energy storage in the body. They contain about 120 calories per tablespoon or 9 kilocalories per gram. Most edible oils sold on the Ghanaian market give off flavors and aromas which are a major signs of rancidity and hence deterioration. This deterioration attains higher rate in the raining season as explained by some oil sellers (Baidoo and Johnson, 2002). Since fats and oils are part of our daily dietary intake, it is important to assess their nutritional qualities. As an important component of our diet and a source of livelihood for many farmers and processors, the oil being sold on the market must meet certain quality standards. This is to ensure continual production and marketing and to also meet the nutritional and health requirements of consumers.

1.1 MAIN OBJECTIVE

The objective of this study is to assess the quality status of palm kernel oil, coconut oil, palm oil and "dzomi" sold on selected markets in Accra and hence determine the extent to which they meet set standards of quality to ensure the intake of wholesome fats and oils.

1.2 SPECIFIC OBJECTIVES

The specific objectives of the study are:

i. to determine the moisture, free fatty acid, peroxide content, saponification value and iodine contents of samples of coconut, palm kernel, 'dzomi' and palm oils.

ii. To compare quality indices to the Codex standards and the Asian and Pacific Coconut Community (APCC) standards.

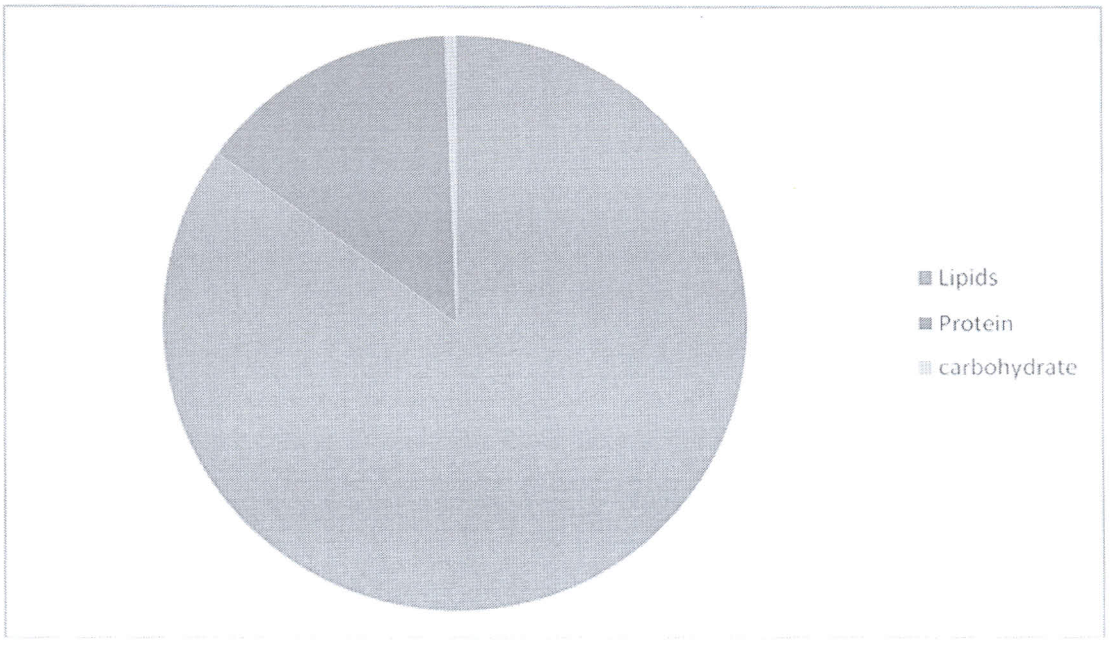
2.0 LITERATURE REVIEW

2.1 FATTY ACIDS FROM PALM OIL

The principal fatty acids of palm oil are palmitic and oleic together with smaller amounts of stearic and linoleic acids. Another type of fatty acid product derived from palm oil is a crude preparation of a single acid, usually palmitic or stearic; each acid containing some of the other, including some oleic acid. Palmitic acid preparation may reach 90-98% purity with virtually no oleic acid whilst stearic acid preparation contains 50 - 98% of the acid with low amounts of oleic acid. The purity of oleic acid produced ranges from 70 - 80% with lesser amount of linoleic acid.

2.2 FUNCTIONS OF EDIBLE OILS

Fats besides being the most concentrated source of energy contribute to the palatability, flavor and to the satiety value of food. Fat is a carrier of the fat soluble vitamins A,D, E and K and the essential fatty acids, important in growth in the maintenance of many body functions. Dietary fats are capable of acting on the composition, organization and functions of membranes. Fats are a major form of energy storage in the body. In terms of total consumption, palm oil makes up 17% of the world consumption of 95 million tones. The various benefits of palm oil include its proven quality and versatility in a variety of food and non food applications.



Source: Masora (1977)

Fats and oils eaten should contain polyunsaturated or monounsaturated fatty acids necessary for human health. These fatty acids are called essential fatty acids. Most oils are high in monounsaturated or polyunsaturated fats and low in saturated fat. But few plant oils, including coconut, palm kernel and palm oils are high in saturated fats and are considered as being solid fats for nutritional purposes.

2.2.1 Coconut oil

Coconut oil is a colourless to slightly yellow oil obtained from the copra/kernel/meat of the coconut palm, *Cocos nucifera* L. It has a pleasant odour and taste when fresh but gives a rancid odour when old. Virgin coconut oil is obtained from fresh and mature meat of coconut by mechanical or natural means. This can be done with or without heat in which case alteration of the oil does not occur. Coconut oil has a low melting point and consists of about

92% saturated and 8% unsaturated fat. Its predominant fatty acid is lauric acid. Approximately 80% of the triglycerides in coconut oil are trisaturated with lauric acid concentration at sn-2 position and octanoic acid at the sn-3 positions.

2.2.2. Palm kernel oil

Palm kernel oil is obtained from the kernels of the palm *Elaeis guineesis*. The oil content of the kernel is about 45% to 50%. Virgin palm kernel oil is yellowish to brownish in colour and able to withstand high temperatures. Palm kernel oil has a narrow melting point of 25-28^{0}C and has a much sharper solid fat content profile (Siew, 2004)

Palm Kernel oil is mainly of saturated fat (80 - 85% saturated and 15% monounsaturated) and low in lauric acid. Saturated fat refers to the sum of all fatty acids without double bonds. Polyunsaturated fat refers CIS, cis-Methylene interrupted polyunsaturated fatty acid; whilst monounsaturated fats are the Cis-monounsaturated acids. It has been indicated by some researchers that palm-oil may decrease cholesterol levels in the blood - however some findings contradict these claims (Haw, 2003).

2.2.3. Palm oil

Palm oil is a form of edible vegetable oil obtained from the fruit of the palm tree; precisely at the outer fibrous pulp of the fruit of the oil palm, *Elaeis Guineesis* (Haw P., 2003). It is reddish because it contains a high content of A-carotene (30mg per 100 g) and B- carotene (30mg per 100 g) together with about 60mg Vitamin E. Palm oil is composed of fatty acids, esterified with glycerol (Kock *et al.*, 1996). It is one of the few vegetables oils relatively high in saturated fats and thus is semi- solid at room temperature. It is about 45% saturated, 40%

monounsaturated and 10% polyunsaturated. The oil palm consists mainly of 16 carbon saturated fatty acids called palmitic acid and monounsaturated oleic acid. Below are the approximate concentration fatty acids in palm oil:

Table 1. Fatty acid content of palm oil

Type of fatty acid	Composition (%)
Palmitic C26	44.3
Stearic C18	4.6
Myristic C14	1.0
Oleic 18	38.7

2.3. QUALITY PARAMETERS OF OILS

A number of physical and chemical parameters have been established for the analysis and testing of oils/fats to establish their identity and also assess their quality and purity. Although some of them are empirical, others are specific measurements of the characteristics of the oils/fats. Relative density, refractive index at 40 °C, moisture (%), insoluble impurities (%), saponification value, iodine value, unsaponifiable matter (%), acid value and Polenske value are all identity characteristics. Colour, free fatty acid, Peroxide value, Total plate count, metal contaminants, odour and taste are for quality characterization. Some of the analyses for quality characterization are explained below.

2.3.1. Peroxide value

Oxidation of fat and oils cause rancidity and it is known that, the first product of oxidation of oil is a hydroperoxide. This hydroperoxide then decomposes to form an aldehyde acid, a hydrocarbon, an oxoacid and ketone which pronounce or give rise to off flavors (Rossel, 1987)

Peroxide value (PV) is an index that indicates the amount of oxidation a fat has undergone. The extent of oxidation is measured by the amount of free iodine the oxidized fat can liberate from Potassium-Iodide (KI). PV is useful and a good guide to quality assessment of fat/oil after processing and storage. Freshly refined oil should have a PV less than 1meq/kg oil, and oil that has been stored for sometime after refining may have PV's up to 10meq/kg oil before undue flavor problems are encountered.

The peroxide Value means a transient product of oxidation, i.e. after forming peroxides, breaks down to form other products. The entire test of peroxide value measures the amount of iodine released when Potassium Iodide reacts with rancid fat. A low value may represent either the beginning of oxidation or advanced oxidation, which can be distinguished by measuring peroxide value over time.

2.3.2. Saponification value

Saponification is the process of breaking down or degrading a neutral fat with alkali.

It is defined as the milligrams of potassium hydroxide required to neutralize the fatty acids resulting from the complete hydrolysis of one gram of the sample.

Another definition is the amount of alkali necessary to saponify a given quantity of fat or oil. Soap is formed during saponification. It is used to characterize fatty acids or esters and to measure the average molecular mass of all fatty acids present.

This is the reaction that goes on during saponification:

Triglycerides + 3KOH ⟶ Glycerol + Potassium salt of fatty acids (e.g Potassium stearate)

Saponification value (SV) is determined by heating a fatty acid sample under reflux with an ethanolic Potassium hydroxide solution and then back-titrating the excess hydroxide with a standardized hydrochloric acid solution until a faint pink end point is obtained. The titration is normally carried out immediately after the heating stage; otherwise a lower SV is obtained due to the absorption of CO_2 by the solution from the atmosphere.

A higher SV indicates that the fatty acid in the sample has a low average molecular mass. It was observed that the SV decrease with an increasing carbon chain length of the fatty acids. This parameter is important for soap producers in determining the quantity of caustic soda required to completely saponify fat or fatty acids.

2.3.3. Free fatty acids

The acidity of fats/oils is normally a measure of the extent to which hydrolysis has liberated the fatty acid from their ester linkage with their parent glycerides molecule. This is the reason why acidity is reported as percentage free fatty acids (%FFA). This quality parameter gives an indication of the care and control exercised during processing; i.e indication of fresh oil/fat quality and of the amount of hydrolysis that has taken place.

Free fatty acids (FFA) are the results of the reaction of water and fats at frying temperatures. Very high levels of FFA (about 3-4%) can result in excessive smoking of the oil and unsatisfactory flavors of the product.

It is one of the quality parameters adopted to indicate the quality of fatty acids. The sample is first dissolved in a suitable solvent (neutralized ethanol) before titrating it with a standard alkali (standardized Sodium hydroxide) in the presence of Phenolphthalein as an indicator until a permanent pink colour is obtained. High FFA value indicates low molecular mass of the fatty acids. The FFA of the fatty acids decreases with an increasing number of carbon atoms.

2.3.4. Iodine value (IV)

The iodine value measures the unsaturation moiety of fatty acids expressed as the number of grams of halogen (Iodine) absorbed by a 100g of the fat or oil sample. Higher IV commonly has poor colour and poor oxidate stability properties.

The fat or oil is treated with excess of Hubl solution which contains Iodine monochloride and this reacts with the unsaturated part(s) of the fat or oil molecule.

$$-CH{=}CH- \quad + \quad ICl \longrightarrow -CHI-CHCl \; + \; ICl$$

Excess Hübl Soln (unreacted Hübl solution)

Iodine is then liberated from the unreacted Hiibl solution by the addition of potassium Iodide.

$$ICl + KI \longrightarrow KCl + I_2$$

The amount of Iodine liberated is determined by titration with standard Sodium thiosulphate:

$$2Na_2S_2O_3 + I_2 \longrightarrow Na_2S_4O_2 + 2NaI$$

2.3.5. Colour

Colour and appearance of oils are of importance to consumers. Oil is of best quality when they are of good brightness but traditionally processed coconut and palm kernel oils are known to be yellowish. Whilst palm oil and "Dzomi" are known to be red, this means that oils of dark colours are not of good quality. It shows possible contamination or rancidity of the oil.

2.4. NUTRITIONAL IMPORTANCE

Coconut oil, palm kernel oil, Palm oil and "Dzomi" are far better for consumption than we have generally being led to believe. Though coconut oil has high saturated fat content, this saturated fat is not the same as other saturated fats. It does not contain trans fats that produce insulin- resistance, diabetes, cancer and autoimmune disease as described in trans fat metabolic poison.

Coconut oil consists of medium-chain fatty acids which are metabolized very differently so they are burned as fuel rather than stored as fat. These medium-chain fatty acids are potent antimicrobial agents. In addition, coconut oil helps in weight loss in ways that no other fat can match.

Palm oil is the largest natural source of the cotrienol part of the vitamin E family (Kock *et al.,* 1996). It is also high in vitamin K and dietary Magnesium; therefore, it is nutritionally valuable. It is used in cooking, soap making, cheese powder formation, preparation of margarine and biscuits. The tocotrienol found in palm oil has antioxidant and anti-cancer properties and is therefore medicinal. Tocotrienols are capable of scavenging and quenching free radicals.

2.5. FACTORS AFFECTING OIL QUALITY

Oil is said to be spoilt when it becomes rancid through oxidation. Some oxidative reactions can decrease the nutritional quality of oils and foods. In fact, oxidation products are potentially toxic as proven by Razmal *et al.* (2006) that palm kernel oil is slightly toxic to *S. costatum* after oxidation. Also highly oxidized fats contain toxic compounds such as liposoluble contaminants like PAHs, PCBs and dioxins (Haw, 2003). According to Fennema (2000) auto-oxidation (a reaction with oxygen via a self-catalyzed mechanism) is the main reaction involved in oxidative deterioration through auto oxidation by:

i. Chemicals known to interfere with other well establish able free radical reaction.

ii. Catalytic effect of light and free radical producing substances

iii. High yields of hydro peroxides ROOH

iv. Quantum yield exceeding unity when the oxidation resulting is limited by light.

v. Relatively long induction peroxide observed when starting with a pure substrate

Oil in storage also decreases in quality with age. Locin and Jacobsberg (1965) showed that after destructing of enzymes, oil storage could deteriorate through auto-catalytic hydrolyses.

The fatty acids already present in small quantities act as a catalyst in the reaction between the triglycerides and water.

The rate of oxidation increases with elevated temperature. As the temperature is increased, change in oxygen partial pressure influences oxidation rate because oxygen becomes less soluble in lipids and water. The oxidation is initiated by hydroperoxide decomposition, and accelerated by pro-oxidants such as trace metals and heat but retarded by the presence of antioxidants such as ß-carotenes. The primary products of oxidation are hydroperoxides and these decompose to form aldehydes, acids, hydrocarbons oxides and Ketones, which give rise to off-flavors in rancid oils.

Rancidity is promoted by atmospheric oxygen, light and moisture, and leads to changes in odour and taste. The contamination of oils with water (high water activity) and other impurities and bleach abilities encourage high rate of free fatty acids formation through the activities of lipolytic enzymes (Lipases). Fats and oils are insoluble in water. However, contact with water may give rise to soluble lower fatty acids and glycerol, which causes rancidity together with changes in colour (yellow to brown), odour and taste as well as gelling and thickening.

Another major cause of oil quality reduction is adulteration. Traditional oil producers, processors and sellers add dyes to oil to give it an appealing colour. Some of these dyes are carcinogenic (e.g Sudan dyes) and others may be toxic at higher quantities which result in either immediate or long term health effects.

Also sellers adulterate oils with other types of oils (rancid and cheaper oils) and as well mix oils from different sources stored under different conditions. This reduces oil quality and its maximum storage. It is known that palm kernel is used to adulterate coconut oil, palm oil to adulterate "Dzomi" and rancid oil with fresh oil.

Different types of oil have different iodine values; therefore Iodine value is a useful means to check the type of oil and contamination with other types of oil.

3.0 MATERIALS AND METHODS

3.1 MATERIALS

Five samples each of palm and 'dzomi' oils were purchased randomly from the Makola market in Accra and coded as MKD1, MKD2, MKD3, MKD4, and MKD5 respectively. Five other samples each of coconut oil and plam kernel oil were also purchased randomly from Mallam Atta Market from different vendors. These samples were coded as: MLK1, MLK2, MLK3, MLK4, MLK5 for coconut oils; and MLC1, MLC2, MLC3, MLC4, MLC5 for palm oils.

3.2 METHODS

3.2.1 Moisture determination

Moisture levels of the samples were determined using standard methods (AOAC, 1990). About 3g of the sample was weighed into an already dried and pre-weighed can. It was put in a hot air oven at 104°C for four hours. It was cooled in a desiccators re-weighed.

3.2.1 Iodine value

This was done according to the method by Hübl (1964). This was done by reacting oil with known amount of excess Halogen, iodine or iodinechloride. The reduction of the excess halogen with Potassium iodide (KI) and titrated with standard Sodium thiosalphate using starch solution as free iodine indicator. The result was expressed as the number of grams of iodine absorbed by 100g of sample, irrespective of the hydrogen combination

3.2.2 Sponification value

Saponification value was determined according to the method of Pearson (1970). The sample was refluxed with an alkali, and by saponification the fats, waxes compounds, lipids and free fatty acids then form soaps. In the process KOH (alkali) reacts with a triglyceride, and three moles of Potassium hydroxide and three moles of Potassium hydroxide also react with one mole of fat. The mixture was boiled under reflux condensation until saponification was complete and the remaining potassium hydroxide was determined by back filtration with 0.50N HCl. The fat with low molecular mass fatty acid consequently has a high saponification value.

3.2.3 Free Fatty Acids (FFA)

Free fatty acids content was determined according to Nielson (1998). In brief, the determination of FFA was carried out by dissolving a weighed amount of fat in hot neutralized 95% ethanol and titrated with 0.10N NaOH (sodium hydroxide) using 1.0% Phenolphthalein as an indicator.

3.2.4 Peroxide value

Peroxide value was determined according to the method from Laboratory Handbook for Oils and Fats Analyst (1966). The oil samples were dissolved in glacial acetic acid chloroform (2:1). Upon addition of excess Potassium iodine which reacts with the peroxides iodine was liberated. The solution then was titrated with standardized Sodium thiosulphate using a 1.0% starch indicator. The peroxide value is expressed as the milliequivalents oxygen per kilogram of fat.

3.3 Data analysis

Means of determinations were calculated using Microsoft Excel 2007.

4.0 RESULTS AND DISCUSSION

Since quality deterioration of oils is related to hydrolysis and oxidation, free fatty acids, peroxide value and color needed to be evaluated to assess the quality status of traditionally processed oils on the market.

4.1 Moisture

Each sample was analyzed for moisture to determine its susceptibility to rancidity since rancidity is promoted by moisture and to determine if there is the likelihood of any microbial contamination. According to the codex standards for palm oils (amended 2003, 2005), the maximum level for moisture should be 0.1%.From the analyses, it was noted that all the samples contained significantly high amount of moisture exceeding the recommended maximum level (Figure 1); with sample MKD-4 recording the least and sample MKP-3 recording the highest. This indicates that, the latter is more prone to rancidity and microbial contamination than the former. Attributing factors may be poor storage materials and probably, the availability of water in storage containers.

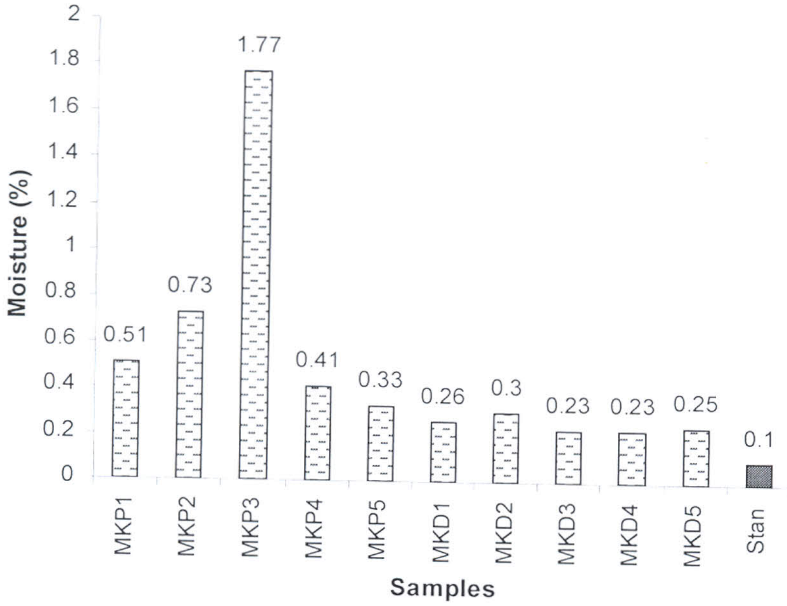


Figure 1. Moisture content of selected palm oil and 'dzomi'

Figure 1 indicates that two samples of coconut oil (MKC 2 and MKC5) and those of the palm kernel oil (MKK1 and MKK 4) had low moisture contents ranging from 0.3 to 0.4. The remaining samples had high moisture contents implying that most of the oils contain an appreciable amount of moisture that can cause the onset of rancidity. The graph also indicates that coconut oils had higher moisture contents than palm kernel oils.

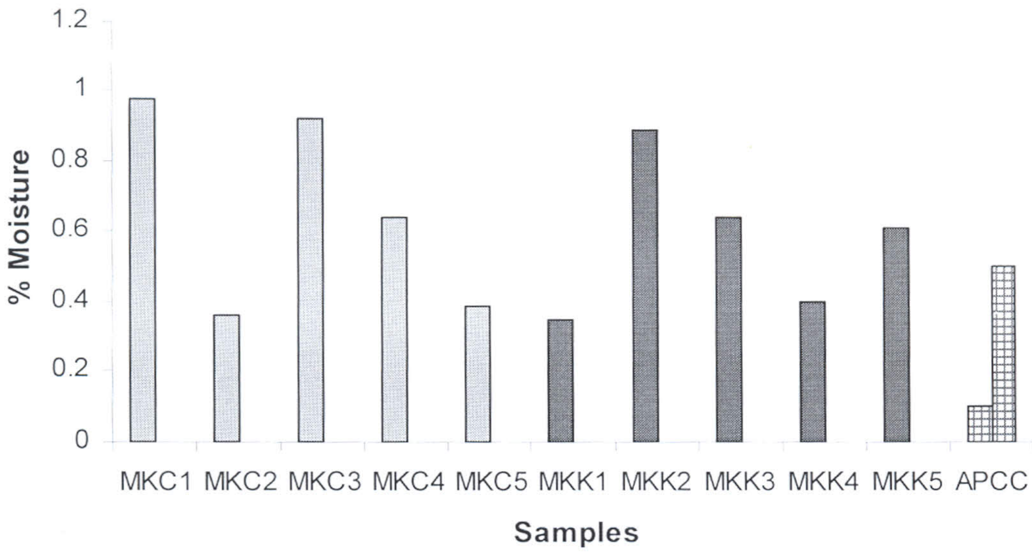


Figure 2. Moisture content of selected coconut and palm kernel oils

4.2 Iodine Value (IV)

Iodine value aids in the identification and quality evaluation of oils. The higher the iodine value, the greater is the oil to oxidative rancidity. There were a lot of variations within the values of the samples (Figure 3). MKD2 was the only sample that fell within the acceptable range of 50-55 (Codex-Stan 210, 2003, 2005). Apart from MKP5 whose value was above 55, the remaining sample fell below 50 with MKD4 recording the least (Figure 3). Although all the samples analyzed were oils made from the fruit of oil palm, the values showed that all the palm oil samples and four of the 'dzomi' samples may have been adulterated since they did not fall within the acceptable range. Also, sample MKP5 is more prone to oxidative rancidity than the other since it recorded the highest iodine value.

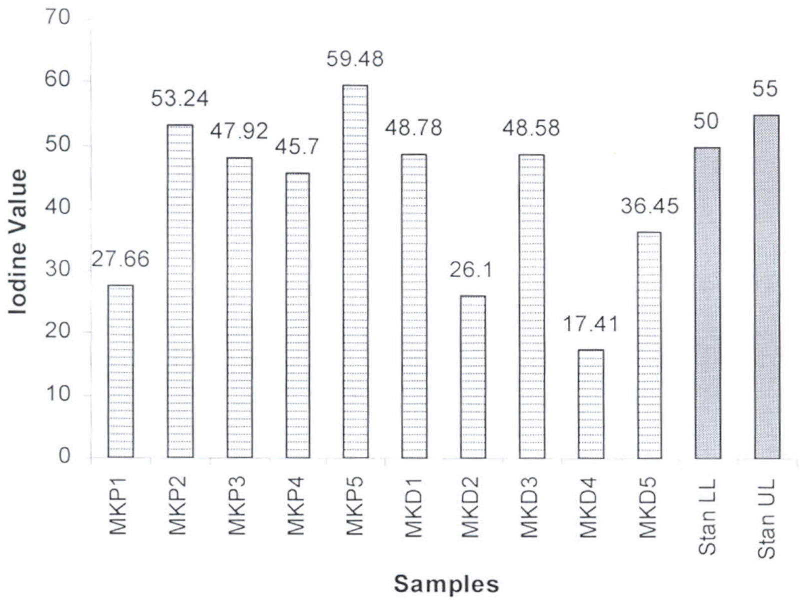


Figure 3. Iodine values of selected palm oil and 'dzomi'

Iodine values of coconut and palm kernel oils were high with respect to the Codex standard and APCC standard. But in comparative terms, the iodine values obtained for palm kernel oil were generally higher than that of coconut oil (Figure 4). The high iodine values recorded in both oils may be due to certain contaminants in the oil or adulteration with other types of oils.

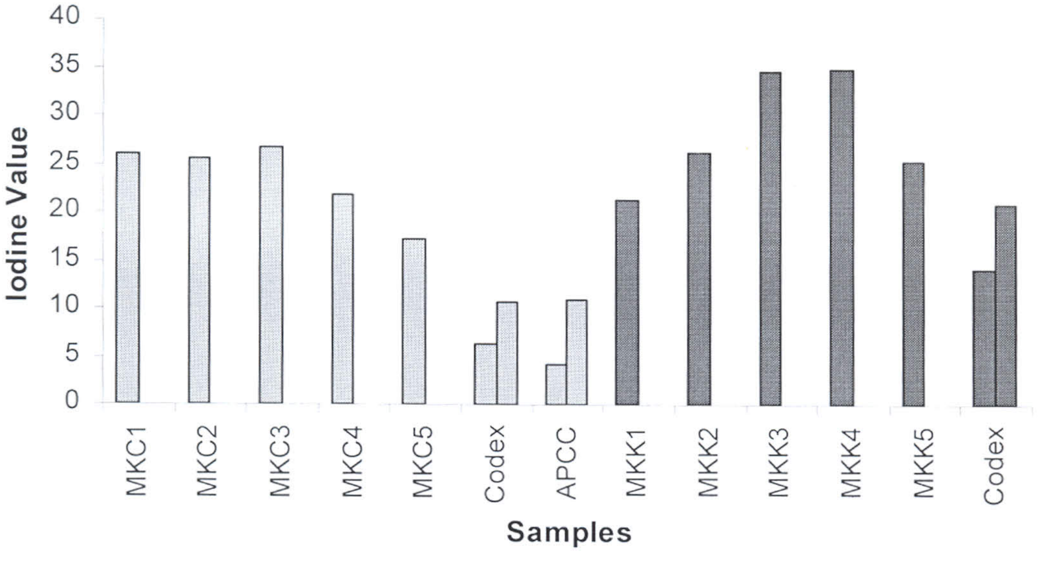


Figure 4. Iodine values of selected coconut and palm kernel oils

4.3 Saponification Value

For identification purpose and for checking of adulteration, saponification value was determined in all the samples. The result showed that, the saponification values for the samples, with the exception of sample MKP4, MKP5 and MKD4, ranged between 190-209 (Codex-stan 210, 2003, 2005) (Figure 5). This could mean that, those samples whose saponification value did not fall within this range may have been adulterated with other oils or with other chemicals such as Sudan dyes.

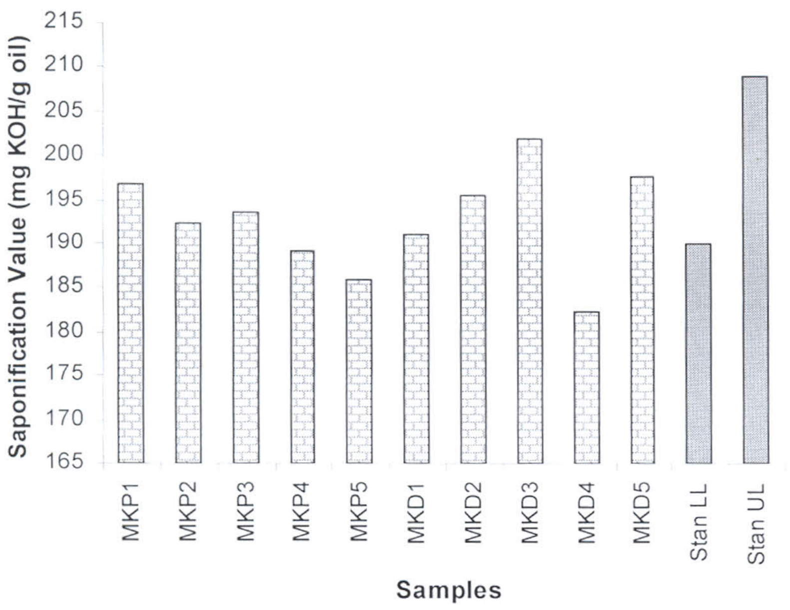


Figure 5. Saponification values of selected palm oils and 'dzomi.'

With respect to the Asian and Pacific Coconut Community (APCC) and Codex standards, all the different samples of coconut oils fell outside the range of saponification value set for them. MKC1 value is above the set standard range whiles MKK2, MKK3, MKK4 and MKK5 fell below the range (Figure 6). This implies that the coconut oils have been contaminated or adulterated and this has a great consequence on oil quality and as such carry health implications when consumed. The adulteration may be with palm kernel oil or any other rancid oils.

Four of palm kernel oil samples fell in the Codex saponification range and one sample (MKC 2) fell below the range (Figure 6). This implies that the palm kernel oil samples are of good quality since majority show no signs of adulteration and/or contamination. They are also of good quality compared to the coconut oil in this context.

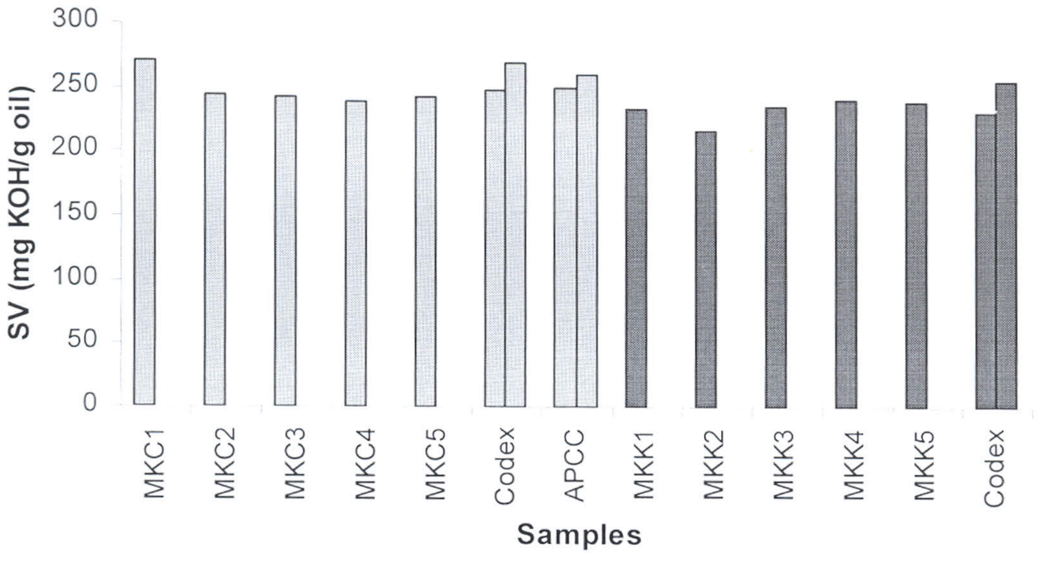


Figure 6. Saponification values for selected coconut and palm kernel oils.

4.4 Free fatty acids

Rancidity leads to off – flavors and these in turn lead to quality deterioration. To determine if any off – flavors have developed, the free fatty acids of each sample were determined. The FFA recorded for the palm oil and 'dzomi' samples were well below 10.0mg KOH/ g oil (Codex standard 210, 2003, 2005) (Figure 7) with sample MKD3 recording the least. Though sample MKP2 and MKD1 recorded large numbers for FFA, they were not up to the level where off- flavors are likely to develop. Oxidation leads to the formation of hydroperoxides which decompose to form an aldehyde, a hydrocarbon, an oxoacid and ketones which give rise to off-flavor (Rossel, 1989). In addition, peroxide value is a quality parameter which indicates the amount of oxidation a fat has undergone, Figures 9 and 10. It can be seen that the peroxide values were well below 15 mill equivalents of active oxygen/kg oil (Codex-Stan, 2003, 2005) indicating that the samples have not undergone much oxidation to lead to off-flavors. This might explain why the FFA fell below 10.0mg KOH/ g oil.

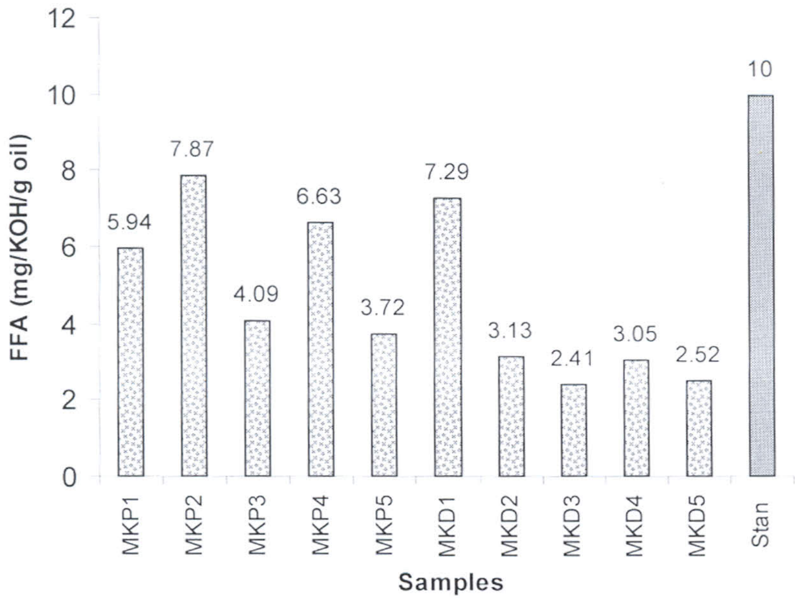


Figure 7. Free fatty acids of selected palm oil and 'dzomi'

By the Codex standard, the maximum percentage of free fatty acid contents for the coconut and palm kernel oil is 4mg KOH/ g oil. The coconut and palm kernel oils under study did not show any sign of rancidity (Figure 8). This confirms earlier findings of Baidoo and Johnson (2002) in which FFA content of palm kernel oil and coconut oil sold on two selected tertiary markets in Accra did not show signs of rancidity. But, FFA for virgin coconut oil according to Asian and Pacific Coconut Community (APCC) standard is 0.5% and only one out of the five samples attained this standard (Figure 8). This means MKC 1, MKC 3, MKC 4 and MKC 5 show signs of rancidity and are, therefore, of poor quality for consumption. However, MKC2 is of good quality and suitable for export as well.

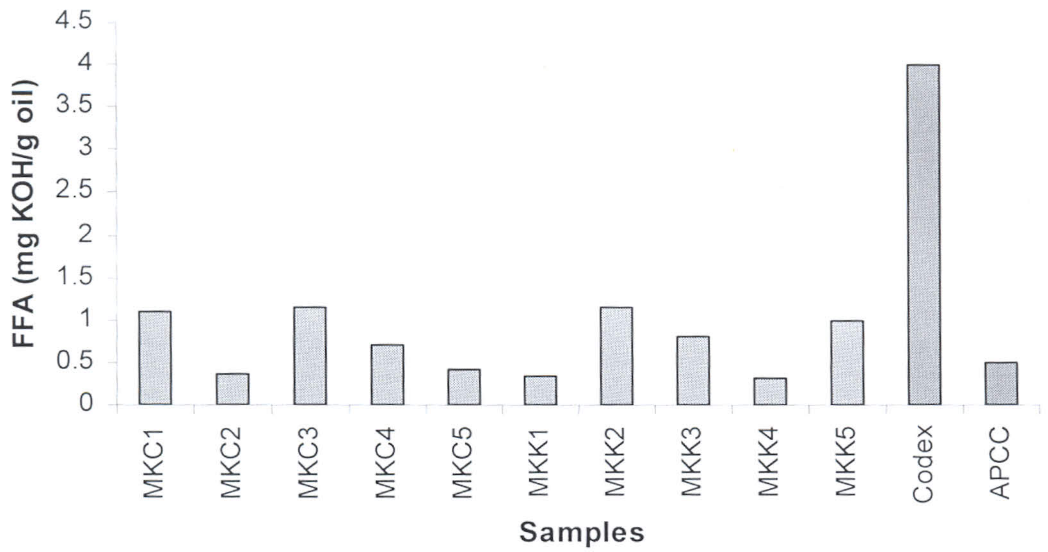


Figure 8. Free fatty acids of selected coconut and palm kernel oils.

4.5 Peroxide value

Peroxide values obtained for the palm oil and 'dzomi' samples were acceptable as they all fell below 15 milliequivalents of active oxygen/kg oil (Codex standard 210, 2003, 2005) (Figure 9). Although sample MKP5 recorded a large peroxide value it was, however, not up to the point for the onset of rancidity. This corresponds to the work by Baidoo and Jonhson (2002). Peroxides will develop to a certain extent during storage before use with the quantity depending on time, temperature and exposure to light and air. (Pearson, 1970).

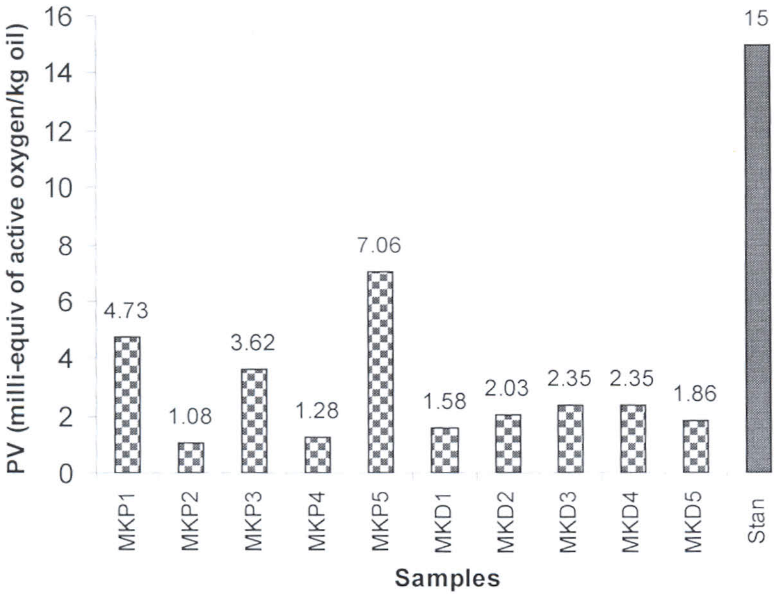


Figure 9. Peroxide values of palm oil and 'dzom'

Peroxide values (PVs) were higher in the palm kernel oil than the coconut oil, indicating that the onset of rancidity will be faster in palm kernel oil than in coconut oil (Figure 10). This also indicates that palm kernel oil will loose its quality (go rancid) faster than coconut oil. Both oils under study did not show any signs of rancidity when their PVs were compared to the Codex standard (PV of <10meq/kg oil). According to the APCC standard (PV of 3meq/kg oil), sample MKC 1 exceeded the required standard whiles the remaining samples fell below the standard. This implies that all the coconut oils are of good quality since they are without any onset of rancidity, except MKC 1.

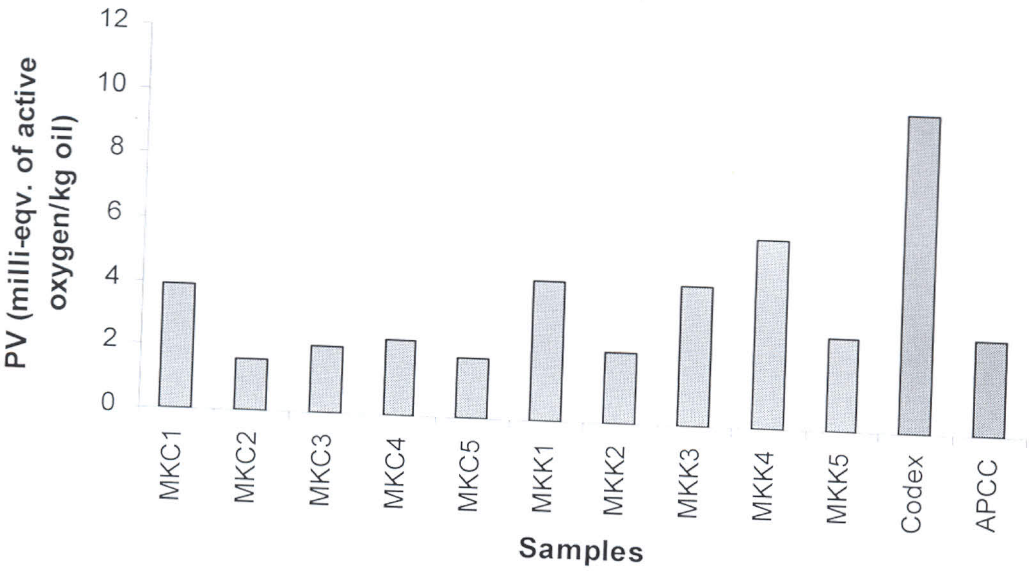


Figure 10. Peroxide values of selected coconut and palm kernel oils

5. CONCLUSION

More than half (60%) of both oils (palm kernel oil and coconut oil) showed high moisture content and may have undergone oxidative rancidity; with 40% of both oils showing no onset of rancidity due to their low moisture levels.

All the coconut oils showed some level of adulteration because of their unacceptable Saponification and Iodine values. These are signs of adulteration and/or contamination. The free fatty acid (FFA) and peroxide values indicated that both oils show no signs of rancidity (using the Codex standards). But three of the coconut samples showed signs of rancidity when compared to the APCC standards.

Majority (80%) of the coconut oil were bright and white but MKC 2 and MKC 5 had the best records in colour whiles 20% showed poor brightness and whiteness. However, all the five samples of palm kernel oil were dark with bad brightness.

The palm oil and 'dzomi' samples had quality characteristics which do not show the onset of rancidity and, therefore, can be consumed without any side effects. However, with indication from the saponification value and iodine value, it can be concluded that 60% of the palm oils and 'dzomi' sold on the Makola market are adulterated.

RECOMMENDATIONS

- Containers for oil storage should be completely dry after cleaning to prevent water from contaminating the oil.

- Containers for oil storage should have air – tight covers to prevent contact with oxygen, light and other contaminates.

- Government should offer assistance to the traditional oil producers to enable them bring out well packaged palm oils and 'dzomi' for public use.

- More work should be done on the quality evaluation of palm oil and 'dzomi' in relation to storage time and temperature.

Scooping of the oil should be done carefully so as to prevent any addition of moisture

- Exposure of oils to heat, light or air (oxygen) promotes lipid Oxidation; avoiding these conditions during sample storage will retard rancidity and thereby preserve oil quality.
- Further quality evaluation should be conducted on these traditionally processed oils from different places in the country in order to make concrete conclusion on the quality status of the Ghanaian virgin oils. Based on the conclusions processors and sellers could be advised on ways to improve oil quality.
- Processors and sellers must be educated on effects of adulterations on human health, in order to put a stop to it.

- Consumers should look out for water clean oils (non-colourful) when buying virgin oils for consumption.
- Although results on coconut oil and palm kernel oil are not of better quality, they still some medicinal and biochemical properties amongst others, and are therefore good for consumption.

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APPENDICES

Appendix 1

Codex Standards for coconut and palm kernel oils (amended 2003, 2005)

Parameters	Virgin coconut oil	virgin palm kernel oil
Acid value	4.0mg KOH/g oil	4.0mg KOH/g oil
Peroxide value	up to 10meq/kg oil	up to 10meq/kg oil
Saponification value	248 - 268 (mg KOH/g oil)	230 - 254 (mg KOH/g oil)
Iodine value	6.3 - 10.6	14.1-21.0
Free fatty acid	4.0mg KOH/g oil	4.0mg KOH/g oil

Appendix 2

APCC standards for coconut and palm kernel oils

Parameters	virgin coconut oil
Acid value	0.5 mg KOH/g oil
Peroxide value	3meq/kg oil
Saponification value	250 - 260 (mg KOH/g oil)
Iodine value	4.1-11
Free fatty acid	0.50%
Moisture content	0.1% -0.5%
Colour	water clean
odour and taste	free from foreign and rancid odour and taste

Appendix 3

Tables showing all the result of the quality and identification parameters analysed, and their standards.

Oil type	Sample code	moisture content (%)	FFA(mg KOH/g oil)	peroxide value(meq/kg oil)	saponiiication value (mg KOH/g oil)	iodine value (Wigs)
coconut oil	MKC1	0.98265	1.09545	3.8805	270.4864	26.0339
	MKC2	0.35625	0.2997	1.5944	243.779	25.62325
	MKC3	0.92215	1.1482	2.08115	241.8223	26.85485
	MKC4	0.63975	0.6985	2.3863	238.9405	21.9689
	MKC5	0.39185	0.4238	1.891	242.4868	17.16265
codex standard			4	10	248 – 268	6.3-10.6
APCC standard		0.1 - 0.5	0.5	3	250 – 260	4.1 -11
palm Kernel oil	MKK1	0.34825	0.3467	4.3692	234.0481	21.4609
	MKK2	0.8879	1.1465	2.19905	217.0402	26.2031
	MKK3	0.641	0.79898	4.37945	235.2337	34.6565
	MKK4	0.4012	0.32399	5.94225	241.5333	34.78885
	MKK5	0.6146	0.9955	2.89645	238.1392	25.35075
codex standard			4	10	230 – 254	14.1-21

Appendix 4. **KEY /GLOSSARY**

MKC 1 - Makola coconut oil sample 1

MKC 2 - Makola coconut oil sample 2

MKC 3 - Makola coconut oil sample 3

MKC 4 - Makola coconut oil sample 4

MKC 5 - Makola coconut oil sample 5

MKK 1 - Makola palm kernel oil sample 1

MKK 2 - Makola palm kernel oil sample 2

MKK 3 - Makola palm kernel oil sample 3

MKK 4 - Makola palm kernel oil sample 4

MKK 5 - Makola palm kernel oil sample 5 MK - Makola oil

APCC - Asian and Pacific Coconut Community

FFA - free fatty acid PV - peroxide value

SP - saponification value

IV - iodine value

Appendix 5. FORMULAE FOR CALCULATING CHEMICAL ANALYSES

1. Formula for the calculation of free fatty acid (pearson, 1970)

$$\frac{\text{Factor of dominant acid} \times \text{titre} \times \text{normality (OH)}}{10 \times \text{weight of fat.}}$$

2. Formula for the calculation of saponification value. (Pearson, 1970)

$$\frac{(\text{Blank} - \text{titre}) \times 28.05}{\text{Weight of sample}}$$

4. Formula for the calculation of peroxide value. (Pearson, 1970)

$$\frac{(\text{Titre} - \text{blank}) \times 1000 \times \text{normality } (0.002)}{\text{Weight of sample}}$$

5. Formulae for the calculation of iodine value. (Pearson, 1970)

$$\frac{12.69 \times \text{normality} \times (\text{blank} - \text{titre})}{\text{Weight sample}}$$

Appendix 6. Tables of values for 'dzomi' and palm oil

Table 1

SAMPLES	%MOIS(mean)	SD
MKP1	0.51	0.014142
MKP2	0.73	0.106066
MKP3	1.77	0.007071
MKP4	0.41	0.021213
MKP5	0.33	0.028284
MKD 1	0.26	0.098995
MKD 2	0.3	0.007071
MKD 3	0.23	0.014142
MKD 4	0.23	0
MKD 5	0.25	0.007071

Table 2

samples	PV(mean)	SD
MKP1	4.73	0.282843
MKP2	1.08	0.155563
MKP3	3.62	0.148492
MKP4	1.28	0.148492
MKP5	7.06	0
MKD 1	1.58	0.014142
MKD 2	2.03	0.141421
MKD 3	2.35	0.282843
MKD 4	2.35	0.007071
MKD 5	1.86	0.141421

Table 3

samples	FFA(mean)	SD
MKP1	5.94	0.155563
MKP2	7.87	0.070711
MKP3	4.085	0.007071
MKP4	6.625	0.502046
MKP5	3.72	0.091924
MKD 1	7.29	0.091924
MKD 2	3.13	0.106066
MKD 3	2.41	0.176777
MKD 4	3.05	0.021213
MKD 5	2.52	0.021213

Table 4

samples	SV(mean)	SD
MKP1	196.75	2.757716
MKP2	192.3	1.697056
MKP3	193.6	0.989949
MKP4	189.25	7.707464
MKP5	185.95	1.06066
MKD 1	191	1.979899
MKD 2	195.45	9.970206
MKD 3	201.9	0.424264
MKD 4	182.41	20.35053
MKD 5	197.63	2.015254

Table 5

samples	IV(mean)
MKP1	27.655
MKP2	53.235
MKP3	47.915
MKP4	45.695
MKP5	59.48
MKD 1	48.775
MKD 2	26.1
MKD 3	48.58
MKD 4	17.41
MKD 5	36.45

10.0 KEY /GLOSSARY

MKP	makola palm oil
MKD	makola 'dzomi'
PV	peroxide value
SV	saponification value
IV	iodine value
FFA	free fatty acid
LL	lower limit
UL	upper limit
Stan	standard
SD	standard deviation