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Original Research Article

Physiochemical Properties of some Vegetable Oils and their Blends

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Abstract

In the present study, blending of palm oil was done with palm kernel oil, soyabean oil and groundnut oil. Palm oil was blended with palm kernel oil, soyabean oil and groundnut oil in three different proportions i.e., PO:PKO (70:30, 90:10 and 50:50); PO:SO (70:30, 90:10 and 50:50) and PO:GO (70:30, 90:10 and 50:50). Physio-chemical characteristics of individual oils and their blends were determined. Saponification value was highest in groundnut oil and lowest in soyabean oil. Iodine value was lowest in palm kernel oil and highest in soyabean oil. Soyabean oil had the highest peroxide value and groundnut oil had the lowest peroxide value. Free fatty acid value was highest in soyabean oil and lowest in palm oil. Soyabean oil had the highest conductivity and palm kernel oil had the lowest conductivity. Density was highest in palm kernel oil and lowest in soyabean oil. There was a general positive effect of the physio-chemical properties of the blends making the blends more effective for cooking, health and last longer. Therefore blending of vegetable oil has an effect on the physio-chemical properties.

KEYWORDS: Free fatty acid value; Iodine value; Peroxide value; Physio-chemical properties; Saponification value

INTRODUCTION

The term oil is used to describe all substances that are greasy or oily fluid at room temperature (Buba, 2005). One of the problems surrounding the oils is the stability of the oils themselves. According to a study by Choe and Min (2006), this is due to auto-oxidation and photo-oxidation that occurs during processing and storage. The instability of oils produces toxic compounds as a result of the decomposition of nutritional quality giving rise to undesirable taste and flavor.

Leonardis and Macciola (2012) showed that thermal stability of virgin olive oil greatly increased when blended with palm oil if the composition of olive oil is around 20% or less. Blending of oil can also reduce the risk of cloudy and partial crystallization in palm olein (Siddique,2010). The overall quality of blended edible oil can be preserved and improved as a result of the blending. By blending, oil with sustainable viscosity can be obtained because it allows the blends to remainfree from any added chemicals (Siddique, 2010).

The blending of oils has been encouraged in the recent past and it is gaining importance on a nutritional basis, thus blended oils have been used for frying purposes (Aremu, 2013). Oils and fats used for commercial frying applications must be stabilized to prevent any changes caused by oxidation, polymerization or hydrolysis during high temperature use.

Direct blending with other fats, fractionation, hydrogenation and inter-esterification has been attempted to improve the fat functionalities and thus optimize their application in food products. Of the modification techniques, direct blending of fats is the most commonly used method as it has been considered to be a cheap and non-destructive technique.

The properties of the related blends have not yet been investigated and reported in detail, and it is essential to understand the physic-chemical properties of the blends in order to better predict their functionality in more complex food systems (Tawfik, 2015). Therefore, this

study was carried out to determine the physico-chemical characteristics of soyabean oil, groundnut oil and palm kernel oil blends with palm oil in terms of the density, conductivity, acid value, free fatty acid percentages, iodine values, saponification values and peroxide values.

MATERIALS AND METHODS

Palm oil (PO), groundnut oil (GO), soya bean oil (SO) and palm kernel oil (PKO) were purchased from a local market in Benin City Nigeria. The samples were kept in the refrigerator below 4^0C for storage. They were taken out of the refrigerator well in advance prior to study, to attain thermal equilibrium with the ambient temperature of the lab. All chemicals and reagents used were of analytical grade.

Preparation of blends

A 100ml mixture of palm oil and other vegetable oil were placed in triplicates in 250ml beakers for each blend and were mixed by using a mechanical stirrer at 180rpm for 15min. Blends of palm oil viz PO + GO, PO +SO and PO + PKO were prepared in three ratios i.e 90:10, 70:30 and 50:50.

Determination of Density

The density of the oils was determined by a mass over volume measurement using a graduated cylinder. An empty graduated cylinder was weighed. The empty graduated cylinder was then filled with oil half full. The volume was noted and the weight. The weight of oil in the graduated cylinder was calculated by subtracting the weight of cylinder without oil with the cylinder containing the oil.

The density is then calculated by dividing the mass in grams by the volume using the equation $\rho = \frac{M}{V}$

Determination of Conductivity

Conductivity meter principle is a digital representation of solution conducting with conduction current capacity. Conductivity (G) is a resistance (R). So when the two electrodes (usually platinum or platinum black) into the solution can be used to measure the resistance between two electrodes R. According to Ohm's Law, certain temperature, the value of this resistor and electrode spacing of L(m) is proportional to the cross-sectional area and the electrode A(cm^2) inverse, i.eR = G (L/A) which is the resistivity, is long 1cm, 1cm^2 cross sectional area, for the resistance of a conductor, which depends on the nature of the material. The electrical conductor (G) can be expressed as the type G=1/R = (1/ρ) x (A/L) =K x (1/J), K = 1/ρ called conductivity, J = L/A called electrode constant. Electrolyte solution conductivity refers to the distance of 1cm between two parallel electrode is filled with 1cm^3 solution with conductance. Based on the formula of visible when known electrode constant (J) and to test the solution resistance or conductance (R) (G) can be obtained by conductivity.

Determination of Peroxide value

Approximately 5g of all the blended oils were weighed and put in a 250ml conical flask. A blank flask which has no oil was prepared. The flasks were added with 30ml of mix solvent acetic acid. Chloroform was added and left for a minute while swirling the flask occasionally. Then 30ml of distilled water was added. The mixture was then titrated with 0.1N of sodiumthiosulphate until brown colour was obtained and 0.5ml of 1% starch solution was added and titration continued until the blue/grey colour vanished. The mixture must be vigorously shaken during titration to ensure all the iodine is liberated from the chloroform layer.

Calculation

$$\text{Peroxide value} = \frac{S - B \times N \times 1000}{W}$$

S = Titration of Sample
B = Titration of Blank
N = Normality of thiosulphate (AOCS Method Cd 8b – 90- Peroxide value Acetic Acid – Chloroform method – Revision 2011).

Determination of iodine value

Weigh 5g of sample add 10ml of carbon tetrachloride, 20ml of wiji's solution was added. Allow to stand in the dark for 30mins, add 15ml of 10% KI solution and add 100ml of water. Titrate with 0.1M thiosulphate solution using starch as indicator.

Calculation

$$\text{Iodine value} = \frac{12.69\ (B-S)\ N}{W}$$

S = Titration of Sample
B = Titration of Blank
N = Normality of thiosulphate (AOAC official method of analysis (1984) chapter 28.028)

Determination of saponification value

2g of sample was weighed. 25ml of alcoholic KOH was added to the sample. Reflux was done in boiling water for 1hour, shaking frequently. 1ml of 1% phenolphthalein was added. Titrate hot with 0.5M HCl

Calculation

$$\text{Saponification value} = \frac{56.1\,(B - S)N}{W}$$

B = Volume in ml of standard hydrochloric acid required for the blank
S = Volume of ml of standard HCl required for the sample
N = Normality of Standard HCl
W = Weight of the oil for the test (AOAC 17th edition 2000, official method 920.160)

Determination of free fatty acids

Approximately 5g of all the blended oils were weighed and added into 250ml conical flask. Then, the sample was dissolved with 50ml 99% isopropanol and mixed completely. Finally, the mixture was titrated with 0.1N sodium hydroxide solution. The last drop was achieved when the colourchanged to pink for at least 30 seconds (AOAC method Ca 5a – 40, 1993).

RESULTS AND DISCUSSION

Density

The density varies due to the different arrangement of the fatty acids of the glycerol backbone of the triglyceride molecule. Therefore, density is related to the chemical properties of the oils such as chain length and saturation/unsaturation. The table below showed that the density was lowest in soyabean oil. It explains that the density decreases with an increase in unsaturation and increases with high saturation and polymerization (Kim et al; 2010). The densities of vegetable oils were related to the standard range of 0.898 – 0.907glmL approved by the Standard Organization of Nigeria (SON, 2000).

Conductivity

The present study has shown that soyabean oil had the highest conductivity of 0.23 followed by groundnut oil (0.16), palm oil (0.09) and palm kernel oil (0.05). In terms of the blends Po:Go (70:30) had the highest conductivity at 0.14 while PO:PKO (50:50) had the lowest with 0.02. The result of the conductivity is presented in the table below. It is evident from the result that conductivity increases with increase in the unsaturation of the oil, i.e with iodine value.

Acid value

Acid value (AV) is an important indicator of vegetable oil quality. According to Demian (1990), acid values are used to measure the extent to which glycerides in the oil have been decomposed by lipase and other physical factors such as light and heat. Maximum acid value was found in soya bean oil followed by the blend of palm oil and soyabean oil in the ratio 90:10. The minimum acid value was found in the blend of palm oil and groundnut oil in the ratio 90:10. The higher acid value in vegetable oils used in present study might be due to the more content of polyunsaturated fatty acids thereby resulting in breakdown of triglycerides increasing the free fatty acids which further increases the fat acidity. From the results, the acid value of palm oil blended with groundnut oil in the ratio 90:10 is markedly low which indicates good lubricating properties as compared to other vegetable oils in the table below. Low acid value, prevents the oxidation of oil which ultimately prevents corrosion hazards, gum and sludge formation. The results obtained in the present study, indicated that the acid value of the oil corresponds to low levels of free fatty acids present in the oil, which also suggested low levels of hydrolytic and lipolytic activities in the oils.

Free Fatty Acid Values (FFA)

The amount of free fatty acid is estimated by determining the quantity of alkali that must be added to the fat to render it quite neutral. Hydrolytic rancidity occur when glycerol further convert into fatty acid (Freeman and Heamsberger, 1993). Of the oils without blending, soyabean oil had the highest FFA value of 4.20% while palm oil had the lowest FFA value of 1.70%. The high FFA content of the soya bean oil could be as a result of split soyabeans, which result from mechanical damage during handling and over drying, reduce storage life and oil yield, and increase losses during oilrefining (Hammond et al; 2005). Splits (typically the cotyledon splits into two halves) and broken beans (more than two pieces) increase free fatty acid (FFA) into 8%, phosphatides,iron and peroxide contents of the crude oil. Heat damaged beans have high FFA content and darken the oil colour, both changes in oil quality increase refining loss (T.L. Mounts, 1980). For palm oil, the low FFA (1.70%) should be due to the refining process it undergone. The palm oil blended with other vegetable oils had a general increased FFA. PO:SO (90:10) had FFA 3:80%, PO:SO (50:50) had FFA of 2.70%, PO:GO (70:30) had FFA of 2.60%, PO:GO (50:50) had FFA of 2.55%, PO:PKO (70:30) had FFA of 2.50%, PO:PKO

Table 1. Physiochemical properties of vegetable oil and their blends

Sample	Density (%)	Conductivity (μ/s)	Acid value (%)	Ffa (%)	Peroxide value (meqo$_2$/ kg)	Iodine value	Saponification value (MgKOH/g)
Palm oil	0.9021	0.09	3.40	1.70	11.20	37.10	203.30
Pal kernel oil	0.9046	0.05	3.30	1.75	16.80	30.70	210.40
Soyabean oil	0.8982	0.23	8.40	4.20	17.20	70.60	185.10
Groundnut oil	0.8992	0.16	3.80	1.90	10.20	66.60	213.20
70:30 PO:PKO	0.9028	0.07	4.90	2.50	5.00	33.20	182.30
90:10 PO:PKO	0.9055	0.03	4.20	2.10	4.00	21.80	180.90
50:50 PO:PKO	0.9058	0.02	2.80	1.40	5.60	19.30	206.20
70:30 PO:SO	0.9025	0.08	3.90	2.00	2.30	34.50	194.90
90:10 PO:SO	0.9011	0.12	7.60	3.80	6.30	38.30	197.80
50:50 PO : SO	0.9043	0.06	5.40	2.70	4.30	32.20	203.40
70:30 PO : GO	0.8996	0.14	5.20	2.60	3.60	44.20	179.50
90:10 PO : GO	0.9049	0.04	1.40	0.70	3.00	29.70	193.50
50:50 PO:GO	0.9015	0.11	5.10	2.55	5.40	37.30	200.60

(90:10) had FFA of 2:10%, PO:SO (70:30) had FFA of 2:00%. Apart from the effect of the higher FFA content on the quality of oil, it also means higher diacylglycerol (DAG) and monoacylglycerol (MAG) contents. Higher proportion of these additional oil types will affect rate of crystallization and cause cloudiness in oil at low temperature storage condition (Siew, 1996, Siew, 1999). Table 1

Peroxide Value (PV)

Peroxides are major initial reaction products of lipid oxidation that measure for primary oxidation (Warner et al; 1996). The peroxide value is defined as the weight of active oxygen contained in one gram of oil of fat (Horwitz, 1975). It therefore determines the degree of oxidation of oil as well as gives an indication of the level of deterioration of oils and fats (Okechalu et al; 2011). The peroxide values of unblended palm oil, palm kernel oil, soyabean oil and groundnut oil had high peroxide values with soyabean oil being the highest at 17.20 (meqO_2/kg) in the table above. This could be due to the unsaturated fatty acids presence which will easily react with oxygen to form peroxides (Marina et al., 2009). This indicates also a more susceptibility to oxidation (Atasie et al., 2009). Therefore it is likely that storage for a long time may lead to rancidity of the oil. Blending of the oils showed a reduced peroxide values with PO:SO (90:10) being the highest at 6.30 (meqO_2/kg) and PO:So (70:30) the lowest at 2.30(meqO_2/kg). This indicates that the blends have a good PV since they were within the codex standard which requires that a good quality oil should have a maximum PV of 10meqO_2/kg. The low PV of theblends is also inductive of low levels of oxidative rancidity of the oils and also suggests strong presence or high levels of antioxidants. A rancid taste often begins to be noticeable when the peroxide value is above 20meqO_2/kg (Adeleja, 2006). The peroxide values are low and point to the fact that the oils may not be easily susceptible to deterioration.

Iodine Value (IV)

Iodine value (IV) measures the degree of unsaturation in a fat or vegetable oil. It determines the stability of oils to oxidation, and allows the overall unsaturation of the fat to be determined qualitatively (AOCS, 1993; Asuquo et al, 2010). From the table above, iodine value was maximum (70.60%) in soyabean oil and minimum (30.70%) in palm kernel oil for unblended oils. The values are within range by PFA act which advises that any oil used to cook should not have an iodine value above 80%. There was a general decrease of the iodine values of the blended oils with PO:GO (70:30) being the maximum at 44.20% and PO:PKO (50:50) being the minimum at 19.30%. This decrease indicates the ratio of the percentage of the mixture of two oils due to the decrease in unsaturation. The low iodine values especially for the blended oils contribute to its greater oxidative storage stability.

Saponification Value

Saponification value is a measure of the average molecular weight or is an index of average molecular mass of fatty acid in the oil sample. Groundnut oil had the highest (213.20MgKOH/g) saponification value and soyabean oil had the lowest (185.10 MgKOH/g) for the unblended oils. According to Codex Standard requirement, groundnut oil exceeded the range which is 187-196 (MgKOH/g). The high saponification value indicates the more soluble soap can be made from it

(Alyas et al., 2006). This also makes groundnut oil to act as lubricant. The low value of soyabean oil was below the expected range of 189-195 MgKOH/g of oil as specified by Codex Standard requirements (1999). The lower value of saponification values for both the soyabean oil and blended oils suggest that the mean molecular weight of fatty acids is lower or that the number of ester bonds is less. This might imply that the fat molecules did not interact with eachother (Denniston et. al., 2004). The saponification values for both blends and unblended oils varied considerably. This might be due to the difference inmolecular weight of the oils. A range of 179.50MgKOH/g to 213.20 MgKOH/g was reported in this present study.

CONCLUSION

Generally the blends have improved physiochemical properties. The blends had low acid , peroxide and iodine values which promotes oxidative stability against rancidity. This stability makes it suitable for frying purposes. The stability also makes the oils to be stored for a longer period. This stability preventscorrosion hazards, gum and sludge formation.

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