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Physico-chemical properties of groundnut oil and their blends with other vegetable oils

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ABSTRACT

Groundnut oil was blended with other edible oils such as palm oil and rice bran oil for the enhancement of its market acceptability. The physico-chemical properties like viscosity, density, specific gravity, refractive index, conductivity, optical rotation, acid value, saponification value, iodine value and peroxide value of vegetable oils and their blends in 95:5 to 85:15 proportions were evaluated. The result of the present study will help the oil producing industry to find out the most economically viable oil blends for cooking purposes, with maximum nutrition as well as desirable physico-chemical properties.

Key words: Oil blend, Groundnut oil, viscosity, iodine value.

INTRODUCTION

Vegetable oil is an important and widely used lipid source for our everyday (diet products). Its application is increasing day by day for food purposes and for the manufacturing of a number of toiletry products. However, some vegetable oils are not up to standards to meet consumer satisfaction in terms of their physico-chemical properties or for the texture and stability of the food products (Reyes- Hernandez *et al.*, 2007).

The food value of the edible lipids also depends on chemical properties like iodine value, peroxide value, acid value, saponicfication value etc, as well as on some physical properties like solidification temperature, colour, appearance etc. To impede the solidification of sesame oil at low temperatures, Shibasaki and Yamane (2000) used lipase catalyzed self-interesterifiction and found that the melting temperature of the oil is reduced substantially.

In oil research, the viscosity of the oil is a very important factor. In food it draws the interest of the customer, and oils with lower values of viscosity, density and low melting point are highly desirable to consumers. In order to design an advanced technological process it might be an important parameter. Oils with lower melting points become rancid due to the presence of unsaturation in them. Furthermore, the rancidity of oils depends on the period, temperature and process of storage (Aidos *et al.*, 2002; Tan and Man, 2002; Wu and Nawar, 1986).

Now a day's vegetable oil blends lubricant view to utilizing them as possible alternative to petroleum based lubricant. Because due to blending lubricant shows higher boundary lubrication mechanism due to presence of long hydrocarbon chain which gets oriented outwards in almost a perpendicular direction in a monolayer adsorbed oil. The time required for fresh lubricant to become unfit for use is known as useful life of a lubricant. During useful life of lubricant how many hours' lubricant works depends upon its lubricant properties such as viscosity, acid value, iodine value, saponification value.

For improving these properties there exist many research works but none of them have been evaluating lubrication properties of vegetable oil blends. The main aim of this work is to find the change in physical and chemical properties of groundnut oil (GNO) which blended with one another in different mixing ratios of other vegetable oils such as palm oil (PO) and rice bran oil (RBO).

EXPERIMENTAL SECTION

The vegetable oils such as groundnut oil (GNO), palm oil (PO) and rice bran oil (RBO) were purchased from local markets. All the analytical and GC grade chemicals and solvents used were supplied by Himedia (Mumbai, India).

2.1. Preparation of blends

A 100 ml mixture of groundnut oil and other vegetable oil were placed in duplicates in 250 ml beakers for each blend and were mixed by using a mechanical stirrer at 180 rpm for 15 min. Blends of groundnut oil viz. GNO+PO and GNO+RBO, were prepared in three ratios i.e., 95:5, 90: 10 and 85:15 (Bhatnagar *et al*., 2009). The selection of three ratios i.e. 95:5, 90: 10 and 85:15 was based on recommendations given by Prevention of Food Adulteration Act (PFA) (1954). According to PFA 4^{th} Amendment Rules 1992, blending of any two vegetable oils (wherein the component oil used in the admixture is not less than 20%) has been permitted.

2.2 Density and viscosity

The density of the oils was determined by a mass over volume measurement. The viscosity of the oils and their blends was determined by BROOKFEILD DVII + Pro viscometer at a constant shear rate at constant temperatures which were controlled by a microprocessor assisted water bath using spindle S51.

2.3 Determination of Specific gravity

Pycnometer, i.e. specific gravity bottle was used in measuring the density/specific gravity. The specific gravity of oil is the ratio of the weight in air of a given volume of the oil at a define temperature to that of the same volume of water at same temperature (AOAC, 1980). Cleaned, dried pycnometer was weighed. It was filled with water maintained at 20ºC and weighed again. The bottle was emptied, dried and filled with oil and weighed. The value was calculated using equation.

$$\text{Specific gravity} = \frac{\text{Weight of oil}}{\text{Weight of water at 20ºC}}$$

2.4 Determination of Refractive Index

The refractive indices, $\eta 40\ D$, (RI), of the oils and fat samples were measured using the Abbe refractometer connected to a thermostatically controlled water bath that maintained the temperature of the refractometer at 40 ± 0.1ºC. The determination of refractive indices was done following the procedures of Cocks and van Rede (1997).

2.5 Conductivity

Conductivity meter principle is a digital representation of solution conductivity 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 the Ohm's law, certain temperature, the value of this resistor and electrode spacing of L (CM) is proportional to the cross-sectional area, and the electrode A (cm2) inverse, i.e.: R= ρx (L/A) which is the resistivity, is long 1cm, 1cm2 cross-sectional area for the resistance of a conductor, which depends on the nature of the material. According to the type, the electrical conductor (G) can be expressed as the type : G=1/R= (1/ρ) x (A/L) =K × (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 electrodes is filled with 1cm3 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.

2.6 Optical rotation
Polarimetry measures the rotation of polarized light as it passes through an optically active fluid. The measured rotation can be used to calculate the value of solution concentrations; especially substances such as sugars, peptides and volatile oils. A polarimeter consists of a polarized light source, an analyzer, a graduated circle to measure the rotation angle, and sample tubes. The polarized light passes through the sample tube and exhibits angular rotation to the left (-) or right (+). On the side opposite the polarizer is the analyzer. Using optics, visual fields are manually adjusted by the user to measure the optical rotation angle.

2.7 Acid value
The -vegetable oils blends were prepared in 95: 5 to 85: 15 proportions. The acid value was determined by the titrametric methods of Pearson, 1970. According to this method, Weight out accurately about 5 gm of the oil under test into a 250 ml conical flask and add 50 ml of neutral Alcohol. Heat the flask over a water bath for about 30 minutes. Cool the flask and the contents to room temperature and add few drops of phenolphthalein indicator. Titrate with the standard N/10 KOH solution until a faint permanent pink colour appears at the end point.

2.8 Saponification value
Saponification values were determined by the AOAC official Method No. 920.160. A 0.1 N KOH solution was prepared with 95 % ethanol and distilled. 5 g of oil sample were weighed in a conical flask, the flask was connected to an air condenser and boiled until the oil was completely saponified, cooled and titrated with 0.5 M HCl using phenolphthalein as indicator.

2.9 Iodine value
The AOAC Official Method 993.20 (Wijs method) was used to determine the Iodine values. The sample was taken nearest to 0.001 g according to its iodine value and was dissolved in 15 mL of 3:2 v/v CH_3COOH and cyclohexane solution, 25 mL of Wijs solution was added and kept undisturbed in the dark following the iodine value scale, after that time it was titrated with a 0.1M $Na_2S_2O_3$ solution.

2.10 Peroxide value
The peroxide value (PV), the weight (mg) of active oxygen contained in one gram of the oil or fat and the iodine value (IV), the number of grams of iodine absorbed by 100 parts by weight of the oil or fat, were determined following the method of the AOAC (as described by Horwitz (1980).

2.11 Statistical analysis
All the experiments were performed in triplicate and the results were expressed as mean ± SD (standard deviation). Statistical comparisons were performed using Analysis of Variance (ANOVA), SPSS 17.0. Differences were considered significant at $p<0.05$.

RESULTS AND DISCUSSION

The physical and chemical properties of pure groundnut oil adulteration with lower priced vegetable oils (palm oil and rice bran oil) and their mixtures were shown in Tables.1 & 2.

3.1 Viscosity
Viscosity of oil is a measure of the oil's resistance to shear. High viscosity implies a high resistance to flow while a low viscosity indicates a low resistance to flow. Changes with temperature, decreasing temperature increases viscosity. In the present study, it can be observed that the viscosity decrease with the rise in temperature as well as the proportion of adulterants was added. From the above data, viscosity of groundnut oil blends with palm oil and rice bran oil increase in viscosity. This is due to rise in temperature enhances movements of molecule and reduces intermolecular forces so the layer of liquid easily pass over one another and thus contribute to reduction in viscosity. This phenomenon also verified by other researcher since oil viscosity depends on molecular structure and decreases with unsaturation of fatty acids (Kim *et al.*, 2010). Also from the above data, viscosity of groundnut oil blend in proportion 85:15, 90:10. Since, oil viscosity depends upon molecular structure and decrease with the unsaturation of fatty acid. It may due to double bonds that make bonding more rigid and rotation between c-c bonds become more strenuous.

3.2 Density
The density specification is suitable for excluding material other than vegetable oil, or for detecting mixtures of vegetable oil with other liquids (petroleum products, glycerol, etc). In the present study the density was increased, groundnut oil blends with palm oil and rice bran oil, in 85:15, 90:10, and 95:5 (Tables.1, 2). Statistically significant ($p<0.005$) variation occurs between the pure vegetable oil and their blends. The relative density or specific gravity of an oil at any given temperature compared to water at a specified temperature is known to increase as the mean molecular weight diminishes (i.e. with higher sapoification value), and also as the degree of unsaturation increases (i.e., with higher iodine value) (Swern, 1972).

3.3 Specific gravity
Specific gravity is the heaviness of a substance compared to that of water, and it is expressed without units. The specific gravity obtained for all oil samples are more than 1.0 when measured at 30°C (Pearson, 1976). These reductions in the specific gravity may be due to the removal of some polar compounds from the oil by alkali refining. These results are in agreement with those mentioned by Mounts (1981).

3.4 Refractive index
It is generalized that the refractive indices of oils increases with increase in the number of double bonds. With increase in temperature, the refractive indices of oil decrease. The refractive indices can also be influenced by oxidative damage of the oil.

In the present study groundnut oil was found to have a higher mean specific gravity (Tables.1, 2). This value for groundnut oil and olive oil gives indication that the oil is less thick when compared with most drying oils whose refractive indices were between 1.475 and 1.485 (Duel, 1951). A slight increase in refractive index induced by alkali refining may be to do the exclusion of some saturated fatty acids and/or compounds which could affect this property. The results agree with those stated by Mounts (1981). The significantly ($P< 0.05$) low refractive index of the groundnut oil could be attributed to the nature of the fatty acids present since refractive index decreases with the molecular weight of the fatty acids. It can also be related to its lower iodine value since refractive index decreases with unsaturation (Cock, 1966).

3.5 Electrical conductivity
The values of electrical conductivity lie in the range of about 0.256-0.440 (at 298.15 K) as is usually the case for most oils. In the present study the electrical conductivity was higher in groundnut oil blends with palm oil (Tables.1, 2). Whereas, it was low in groundnut oil blends with rice bran oil. It is evident that electric conductivity increases somewhat with increase in the unsaturation of the oil, i.e. with iodine value and decreases with increasing temperature.

3.6 Optical rotation
The rotation technique is used as a tool to analyze oil quality and also sort out types of oils. In the present study, there is no optical rotation in groundnut oil blends with palm oil and rice bran oil (Tables.1, 2). The key results rotation angle of various samples of vegetable oils was recorded. The comparison of the rotation angle of the vibration plane in rice bran oil and their blends, show the greatest reduction in rotation angle was found in sesame oil. It can be argued that temperature changes affect the spring constant of the material through which polarized light is propagated. A rise in temperature weakens the spring constant and lowering temperature results in a strong spring constant. Since rotation, depends on the constant of propagation, it is necessary to investigate the contribution of temperature on rotation of the vibration plane. Vegetable oils (edible oils), which are hydrocarbons with long and complex molecules capable of resonating at a particular frequency. This particular frequency at which resonancy occurs depends upon the nature of the oil.

3.7 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 has been decomposed by lipase and other physical factors such as light and heat. From the results, it's clear that the acid value of groundnut oil blend with rice bran oil in 95:5, 90:10 and 85:15 is markedly low which indicate good lubricating properties as compare to other vegetable oils (Tables.1, 2). Low acid value, prevents the oxidation of oil which ultimately prevent 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.

Acid value increases with days of storage under ambient conditions. The results indicate that the acid value which is an index of free fatty acid content due to enzymatic activity in the samples was found to be very low, below the minimum acceptable value of 4.0% for sesame recommended by the Codex Alimentarius Commission for oil seeds (Abayeh *et al.,* 1998).

3.8 Saponification value

In the present study saponification value of groundnut oil and their blends in palm oil and rice bran oil, were found to be higher than other vegetable oils and their blends (Tables.1, 2). This represent percentage of fixed oil in ground nut oil and their blends in palm oil and rice bran oil is higher than other vegetable oils and their blends.

The higher the saponification numbers of the oil, the more soluble the soap that can be made from it (Alyas *et al.*, 2006). The lower value of saponification value in the oil suggest that the mean molecular weight of fatty acids is lower than that of other vegetable oil or that the number of ester bonds is less when compared to that of other vegetable oil. The saponification value for the various oil samples decreased with increased temperature, this implies that soaps are formed easily with increase in temperature. Thus from above data, saponification value of groundnut oil and their blends in palm oil and rice bran oil, is similar to this. Thus above blends act as good lubricants than other cited blends.

Table.1 Physico-chemical characteristic features of groundnut oil and palm oil

Parameters	Adultrant-1				
	Ground nut oil (Virgin)	Palm oil (Virgin)	Groundnut oil : Palm oil (95:5%)	Groundnut oil : Palm oil (90:10%)	Groundnut oil : Palm oil (85:15%)
Viscosity	53.14 ± 0.01^{g}	77.50 ± 0.01^{h}	55.79 ± 0.15^{h}	59.46 ± 0.02^{h}	61.12 ± 0.02^{h}
Density	0.732 ± 0.00^{c}	0.908 ± 0.01^{c}	0.768 ± 0.00^{c}	0.805 ± 0.00^{c}	0.880 ± 0.00^{c}
Specific gravity	0.911 ± 0.00^{c}	0.934 ± 0.00^{c}	0.956 ± 0.00^{d}	1.012 ± 0.00^{d}	1.018 ± 0.00^{d}
Refractive indices	1.4673 ± 0.00^{d}	1.464 ± 0.01^{d}	1.4675 ± 0.00^{e}	1.4670 ± 0.00^{e}	1.4675 ± 0.00^{e}
Conductivity	0.4407 ± 0.00^{b}	0.374 ± 0.01^{b}	0.421 ± 0.00^{b}	0.434 ± 0.00^{b}	0.438 ± 0.00^{b}
Optical rotation	0.000 ± 0.00^{a}	$0.000 \pm .00^{a}$	$0.000 \pm .00^{a}$	0.000 ± 0.00^{a}	$0.000 \pm .00^{a}$
Acid value	4.40 ± 0.10^{f}	5.466 ± 0.15^{e}	4.02 ± 0.01^{g}	4.40 ± 0.10^{f}	4.8 ± 0.10^{f}
Saponification value	189.90 ± 0.10^{c}	197.50 ± 0.15^{c}	195.20 ± 0.15^{f}	202.40 ± 0.15^{j}	203.57 ± 0.05^{j}
Iodine value	95.300 ± 0.43^{h}	55.11 ± 0.01^{g}	63.88 ± 0.01^{c}	$1.147E2 \pm 0.00^{i}$	98.25 ± 0.01^{i}
Peroxide Value	1.9733 ± 0.01e	7.48 ± 0.02^{f}	2.81 ± 0.01^{f}	4.40 ± 0.100^{g}	7.51 ± 0.01^{g}
P-Value	0.0000	0.0000	0.0000	0.0000	0.0000
F-Value	574900	2541000	4827000	3243000	9512000

Table.2 Physico-chemical characteristic features of groundnut oil and rice bran oil

Parameters	Adultrant-2				
	Ground nut oil (Virgin)	Rice bran oil (Virgin)	Groundnut oil : Rice bran oil (95:5%)	Groundnut oil : Rice bran oil (90:10%)	Groundnut oil : Rice bran oil (85:15%)
Viscosity	53.14 ± 0.01^{g}	46.32 ± 0.01^{h}	55.796 ± 0.00^{f}	56.46 ± 0.0100^{f}	56.96 ± 0.01^{e}
Density	0.732 ± 0.00^{c}	1.13 ± 0.01^{d}	0.76 ± 0.00^{bc}	0.780 ± 0.00153^{bc}	0.789 ± 0.00^{abc}
Specific gravity	0.911 ± 0.00^{c}	0.914 ± 0.00^{c}	0.955 ± 0.00^{cd}	0.961 ± 0.00^{cd}	0.969 ± 0.00^{bc}
Refractive indices	1.4673 ± 0.00^{d}	1.471 ± 0.00^{e}	1.466 ± 0.00^{d}	1.4672 ± 0.00^{d}	1.468 ± 0.00^{c}
Conductivity	0.4407 ± 0.00^{b}	0.374 ± 0.00^{a}	0.255 ± 0.00^{ab}	0.277 ± 0.00^{abd}	0.294 ± 0.00^{ab}
Optical rotation	0.000 ± 0.00^{a}	4.40 ± 0.10^{f}	0.000 ± 0.00^{a}	0.000 ± 0.00^{a}	0.000 ± 0.00^{a}
Acid value	4.40 ± 0.10^{f}	8.00 ± 1.00^{g}	5.20 ± 0.10^{e}	5.01 ± 0.010^{e}	5.300 ± 0.10^{d}
Saponification value	189.90 ± 0.10^{c}	191.33 ± 0.00^{j}	189.00 ± 1.00^{h}	191.00 ± 1.00^{h}	193.00 ± 1.00^{g}
Iodine value	95.300 ± 0.43^{h}	96.04 ± 0.01^{i}	75.33 ± 0.57^{g}	78.36 ± 0.15^{g}	70.00 ± 1.00^{f}
Peroxide Value	1.9733 ± 0.01e	0.706 ± 0.015^{b}	0.92 ± 0.00^{cd}	1.010 ± 0.01^{cd}	1.17 ± 0.10^{c}
P-Value	0.0000	0.0000	0.0000	0.0000	0.0000
F-Value	3529000	118000	83550	112700	57270

Values are expressed as Mean ± SEM, n=3 as Anova test $p<0.05$% level.

3.9 Iodine value

The iodine value is a measurement of the total unsaturation of vegetable oils, as well as an indicator of their susceptibility to oxidation (Knothe, 2006). Vegetable oils can be divided into four major categories depending on their iodine value: saturated oils (iodine value between 5 and 50), so-called semi-siccative mono-unsaturated oils (50 and 100), di-unsaturated oils, also called semi-siccative (100 and 150) and tri-unsaturated oils called siccative (over 150).

In the present study, iodine value of groundnut oil blends in palm oil shows increase in iodine value hence this blends act as a good lubricant than other blenders (Tables.1, 2). This shows that, drying quality of groundnut oil and their blends in palm oil is more than other vegetable oils and their blends. Furthermore, the lower iodine value of the groundnut oil blends with rice bran oil, sesame oil blends with groundnut oil suggests that the amount of unsaturated fatty acids. For the other blends the iodine value also increased with the time. For the same reason, to maintain and preserve oil quality, it is advisable to keep it in cool places in airtight, dark containers flushed with nitrogen and the container should be glass, which is better than PVC or simpler container (Kaul *et al.*, 2009).

3.10 Peroxide value

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). A freshly refined oil should have nil peroxide value.

In the present study groundnut oil blends with palm oil and rice bran oil shows higher peroxide value (Tables.1, 2) indicated a more susceptibility to oxidation than the other vegetable oil (Atasie *et al*.,2009). Therefore, it is likely that storage for a long time may lead to rancidity of the oil. In the present study groundnut oil blends with rice bran oil shows low peroxidative values. The low values of peroxidative value are indicative of low levels of oxidative rancidity of the oils and also suggest strong presence or high levels of antioxidant. A rancid taste often begins to be noticeable when the peroxidative value is above 20 meq/kg (Adelaja, 2006). The peroxide values are low and point to the fact that the oils may not be easily susceptible to deterioration. Since, peroxide value correlates with the extent to which oxidative rancidity has taken place in oils, and thus a measure of the shelf life of oils, the almond oil is not rancid but good for consumption when fresh and considered stable (Ajayi and Oderinde, 2002).

The peroxide value was also found to increase with the storage time, temperature and contact with air of the oil samples. Oils exposed to both atmospheric oxygen and light showed a much larger increase in peroxide value during storage. Increase of peroxide value with storage time has also been reported by Kamau and Nanua (2008).

CONCLUSION

Scientific information and knowledge on less familiar or under-utilized oils encourage the utilization of both nutritional and industrial potential. The result of physico-chemical properties further confirmed the quality of the extracted oil for cooking and industrial potentials.

Thus blending is a good choice by which we can manufacture edible oils of good characteristics and ensure their quality. The food value of the oils and blends can also be predetermined to provide the safest food to consumers. The blend of oils that results from the combination has a good frying and acceptable sensory qualities. The advantages of using blending as a means of modifying oils is that it is easy and costs less. More importantly blending oils serves to improve and enhance the nutritional and functional qualities of the oils by combining the good attributes of the two oils into one, by this therefore improving commercial viability.

The physical, chemical, and functional properties of groundnut that relate to specific end products have to be determined and refined to facilitate screening breeding material for such properties. Also, methods have to be developed so that hulls and other by-products can be better utilized.

So, this study will help the oil producing industry to find the most economically viable oil blends for cooking purposes, with maximum nutrition as well as desirable physic-chemical properties. As India is the second largest producer of vegetable oils, blending of traditional oils with this nonconventional oil is a good choice by which we can manufacture edible oils of good characteristics and ensure their quality. The food value of the oils and blends can also be predetermined to provide the safest food for consumers.

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