Estimation and comparison of physico-chemical properties of commercially available edible oils

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Abstract - The physical and chemical properties of six commercially available edible oils (sunflower oil, mustard oil, gingelly oil, rice bran oil, olive oil and groundnut oil) were procured from the local shops of Bengaluru and their quality was examined. All the oil samples were analyzed for specific gravity, refractive index, acid value, iodine value, saponification value and ester value using titrimetric methods. The specific gravity was determined in the temperature range of 31^0 C - 33^0 C. The parameters varied significantly depending upon the type of oil. The specific gravity varied from 0.9066 to 0.9132, refractive index varied from 1.4675 to 1.4727, acid value varied from 1.122 to 5.603 mg KOH/g, iodine value varied from 40.46 to 117.90 g I_2/g, saponification value varied from 161.31 to 251.09 mg KOH/g and ester value varied from 104.7 to 293.59 mg KOH/g. The results of this study will help the local people to find out the most economically feasible oils for cooking purpose, with more nutrition, good in terms of health as well as with desirable physical and chemical properties

Key words: Specific gravity, Refractive index, Acid value, Iodine value, Saponification value, Ester value

1. INTRODUCTION

Oils constitute one of the essential components of balanced diet as good source of energy. The chemical and physical properties of oils are among the most important properties that determine the quality and help to describe the present condition of oils. Lipid oxidation has harmful effects on both food quality and human health. Then efforts must be made to minimize oxidation and improve oxidative stability of lipid products. The reactions during the cooking process and storage conditions depend on factors such as the original quality of the oil, concentration of antioxidants, type of oil and oxygen. Edible oil, being obtained from vegetable sources, is primarily composed of fatty acids and used for cooking, medicinal and cosmetic purposes. It is estimated that about 90% of vegetable oils are used for edible purposes. [1]

Lipids and triacylglycerol naturally occur in oils and fats. Their chemical composition contains saturated and unsaturated fatty acids and glycerides. Edible oils are vital constituents of our daily diet, which provide energy, essential fatty acids and serve as a carrier of fat-soluble vitamins. Edible oils are mostly refined before their consumption so that the resulting taste is sensorially neutral. [8]

A physical property is a characteristic of a substance that can be observed or measured without changing the identity of the substance. Physical properties include color, density, refractive index, hardness, and melting and boiling points. A chemical property describes the ability of a substance to undergo a specific chemical change. A chemical change always produces one or more types of matter that differ from the matter present before the change.

Different physical and chemical parameters of edible oil were used to monitor the compositional quality of oils. These physicochemical parameters include iodine value (IV), saponification value (SV), viscosity, density and peroxide value (PV). Edible oils are one of the main constituents of the diet used for cooking purposes.

Specific Gravity is the ratio of the density of a substance to the density of a given reference material (typically that of water). Density of fluids changes with temperature, so it is important to specify the temperature requirements when requesting density measurement from the lab. Refractive index is the ratio of the velocity of the light in vacuum to its velocity in the substance. It generally varies with temperature and wavelength of light. It increases with the increase in unsaturation and also chain length of fatty acids in oils. [10] Acid value is the amount of free fatty acids that are present in a substance typically a fat or oil is measured by its acid value. It is expressed as the amount of potassium hydroxide (KOH) required to neutralize the free fatty acids present in one gram of the substance. Iodine value is the amount of iodine in grams consumed by 100 grams of a chemical compound. The relative degree of unsaturation in oil components is measured by the iodine value, which is obtained by halogen uptake. The more unsaturation and oxidation susceptibility, higher the iodine value. [6] Saponification is a chemical reaction in which aqueous alkali converts oil, fat, or lipid into soap and alcohol. Soaps are carboxylic acids with long carbon chains, which are salts of fatty acids. Saponified materials include vegetable oils and animal fats. Ester value is the number of milligrams of potassium hydroxide required to neutralize the acids resulting from the complete hydrolysis of 1 gram of the oil.

2. MATERIALS AND METHODS

2.1. CHEMICALS USED

Carbon tetra chloride (CCl4), Wij's solution, 10% potassium iodide (KI), sodium thiosulphate, distilled water, starch indicator, absolute alcohol, phenolphthalein indicator, 0.1 N potassium hydroxide (KOH), 0.5 N alcoholic KOH, 0.5 N Hydrochloric acid (HCl).

2.2 SAMPLE COLLECTION

Six oils, Sunflower oil (Brand name: Sai power), Mustard oil (Brand name: Fortune), Gingelly oil (Brand name: Idhayam), Rice bran oil (Brand name: Fortune), Olive oil (Brand name: Figaro), Groundnut oil (Brand name: Fortune) were purchased from the local shops in Bengaluru**.**

2.3. DETERMINATION OF THE PHYSICAL AND CHEMICAL PARAMETERS

2.3.1. Specific gravity

Specific gravity bottle was used to measure the specific gravity of all the oil samples. The gravity bottle with the oil samples were weighed and the temperature was noted at 31^{0}C, 32^{0}C and 33^{0}C. Specific gravity of oil was determined as the ratio of the density of oil into the density of water at same temperature. Specific gravity of the oils was calculated by the formula:

$$= \frac{W2-W1}{W3-W1} \text{ (density of water at room temperature).}$$

Where, W1= Weight of empty specific gravity bottle

W2= Weight of sample + specific gravity bottle

W3= Weight of water + specific gravity bottle

Fig 1: Specific gravity of oils

2.3.2. Refractive Index (RI)

The light source was turned on. The oil sample to be tested was chosen. The refractometer scale knob was turned to get the clear interface between the illuminated and dark regions. The index of refraction was read using the telescope scale. The experiment was repeated with different liquids and the variation of refractive index with temperature and wavelength was studied.

Fig 2: Refractometer

2.3.3. Acid value (AV)

1.5 g of absolute oil was weighed accurately in a saponification flask to which 10 ml of absolute alcohol was added and surface heated for 2 min. Two drops of phenolphthalein indicator was added and titrated against 0.1 N alcoholic KOH with continuous agitation until the first appearance of pale pink colour. This was considered as the end point.

Fig 3: Acid value of oils

2.3.4. Iodine value (IV)

0.25 g of oil was taken in a conical flask, to which 10 ml of CCl4 was added. 25 ml of Wij's solution was added to the conical flask with the glass stopper smeared with KI and kept in dark for 30 minutes. 15 ml of 10% KI solution and 35 ml of distilled water was taken in the conical flask. The solution was titrated against sodium thiosulphate. 4-5 drops of starch indicator were added until the blue colour disappears.

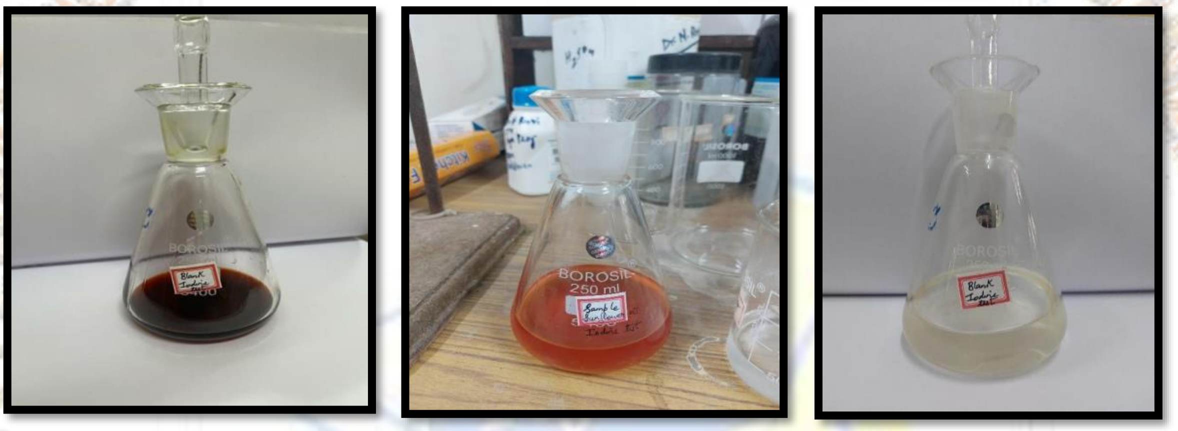


Fig 4: Iodine value of the oils

2.3.5 Saponification value

2 g of oil sample was taken in a joint conical flask to which 25 ml 0.5 N KOH was added and heated under a reserved condenser for 1 hour to ensure that the sample was fully dissolved. After this sample was cooled, phenolphthalein was added and titrated with 0.5 M of HCl until a pink endpoint was reached. A blank was determined with the same time conditions.

Fig 5: Heating of conical flask under condenser

2.3.6 Ester value

About 1.5 g of absolute oil was taken in a saponification flask. To this 10 ml of neutral 95% alcohol was added and surface heated for about 2 minutes. 3 drops of phenolphthalein indicator was added and titrated with 0.1 N KOH until a pale pink colour appeared. After 25 ml of 0.5 N alcoholic KOH was added, a reflux condenser was connected and heated in a boiling water bath for 2 hours. After the completion of the time period, the flasks were cooled and excess alkali was titrated with 0.5 N HCl. Blank was also performed in a similar manner

3. RESULTS AND DISCUSSION

The physical and chemical properties of six different oils like sunflower oil, mustard oil, gingelly oil, rice bran oil, olive oil and groundnut oil are shown in Table 1.

Specific gravity: Specific Gravity or relative gravity is a dimensionless quantity that is defined as the ratio of the density of a substance to the density of the water at a specified temperature and it is expressed without units. Specific gravity of vegetable oils depends on the type of oil and temperature. The specific gravity obtained for all oil samples are less than 1.0 when measured at 31^0C, 32^0C, and 33^0 C.

The results tabulated in Table 1 shows the specific gravity values, varied between 0.9066 and 0.9132. The highest and the lowest values were recorded for mustard and groundnut oils, respectively. The highest specific gravity obtained in mustard oil may due to the presence of high linoleic acid and other unsaturated fatty acids. Different values of density may attribute to difference in fatty-acid composition, degree of unsaturation and total solid content (Tilahun *et al*, 2018) and solid contents (Belsare GW and SG. Badne).

Refractive index (RI): The refractive index is the ratio of the speed of light in a vacuum to the speed of light through a given material (Tilahun et al 2018). The refractive indices of oils increase with increase in the number of double bonds. The refractive indices of oil decreases with increase in temperature and influenced by oxidative damage of the soil (Panduranga *et al*, 2014). RI of oils depends on their molecular weight, fatty acid chain length, degree of unsaturation and degree of conjugation (Nichols and Sanderson, 2003).

The results of the refractive indices of the investigated oils at 20 ^{0}C are depicted in the Table 2. The refractive indices were between 1.4675 to 1.4727. Of the 6 different oils evaluated, the RI value of all the oils were within the recommended values by FSSAI (1.466-1.470) (Suzanne, 2010). A high RI was seen in Olive oil This indicates that the oil samples contain highly unsaturated or long chain fatty-acids in their triglycerides. Low refractive index was found in sunflower oil. This could be attributed to the nature of fatty-acids present since refractive index decreases with molecular weight of the fatty acids.

Acid value (AV): It is an indicator of vegetable oil quality and the age of the oil. It is a measure of decomposition of glycerides by lipase and other physical factors such as light and heat in the oil (Panduranga *et al*, 2014), since acid content increases in oil with time due to hydrolysis with moisture. Acid value shall be not more than 6.0 as per FSS Regulations.

Acid values of 0.6 and 4.0 have been recommended by each of FDA/WHO to be the upper limit for refined and virgin oil sample (Belsare *et al*, 2017). The results of acid value of Table 1 show that, in none of the oils AV exceeded 6.0, as required by the FSS Regulations. Groundnut oil and sunflower oil were found to have the lowest acid value. The acid value of all the oils is below 6 which proves that all the oils are less rancid and can be used in soap manufacturing as they will be good cleansers. Free fatty acid and the acid values are used to indicate the rancidity and edibility of oils (Tilahun *et al*, 2018). Low acid value indicates good cleansing by soap. The results indicate that the AV of different oils corresponds to the low levels of free fatty acids present in the oils, suggesting low levels of hydrolytic and lipolytic activities in the oils (Panduranga *et al*, 2014) and resistance to rancidity. The acid values also reveal the resistance of oil to gum formation and corrosion and hence the shelf life is increased (Belsare *et al*, 2017).

Iodine value (IV): Iodine value and refractive index are important characteristics which determine the degree of saturation or unsaturation of fats and oils (Sadoudi and Ali Ahmed 2017) as well as an indicator of their susceptibility to oxidation (Knothe, 2006). The iodine value was determined mainly to determine which oil types are more saturated. Unsaturated fatty-acids is recommended for healthy consumption over highly saturated fatty-acids containing oil (Yonnas *et al*, 2019). The greater value of IV indicates that the oil is prone to oxidation (Seria Chimie, 2013).

In the present study, iodine value varied from 40.46 to 117.90 g I_2/g. Iodine value of groundnut oil showed the highest and the lowest IV was seen in olive oil, suggesting the amount of unsaturated fatty acids. The observed higher iodine value in the oil indicated that they are likely to be healthier of a consumption (Yonnas *et al*, 2019). The studies have recommended to switch from saturated to unsaturated fats because of risk of cardiovascular disease associated with high consumption of saturated fatty-acids (German JB 2004). For the maintenance and preservation of oil quality, it is advisable to keep it in cool places in airtight, dark containers flushed with nitrogen and glass containers (Kaul et al 2009).

Saponification value: Saponification value is a measure of oxidation during storage and also indicates deterioration of the oils. Saponification measures the average chain length of the fatty acids that makes up the oil. Saponification values are useful in providing information, such as type of glycerides, quantity and mean weight of the acids in a given oil sample. (Fazal *et al*,2010). The lower the saponification value, the larger the molecular weight of fatty acids in the glycerides or the number of ester bonds is less and vice versa (Muse et al 2012).

Among the six oil samples studied, all the oils except sunflower oil are relatively in line with the recommended value (185-195 mg KOH/g). Sunflower oil gave the highest saponification value (251.092 ml KOH/g) which can be used as a raw material for cosmetics and soaps (Nangbes *et al*, 2013), characterized by the presence of relatively high concentration of low molecular weight free fatty acid in their triglycerides (Ngaasapa and Othman, 2001, Nangbes *et al*, 2013). The lower value of saponification indicates the short chain unsaturated fatty acids and suggests that the number of ester bonds is less when compared to that of other vegetable oils (Panduranga et al 2014).

Ester Value: Ester value is the number of milligrams of potassium hydroxide required to support the esters present in 1 g of the substance. The high ester values of oil indicate the presence of high amount of ester and low molecular weight of the fatty acid content (Belsare et al 2017). There will be a greater amount of ester in the oil sample if the number is greater.

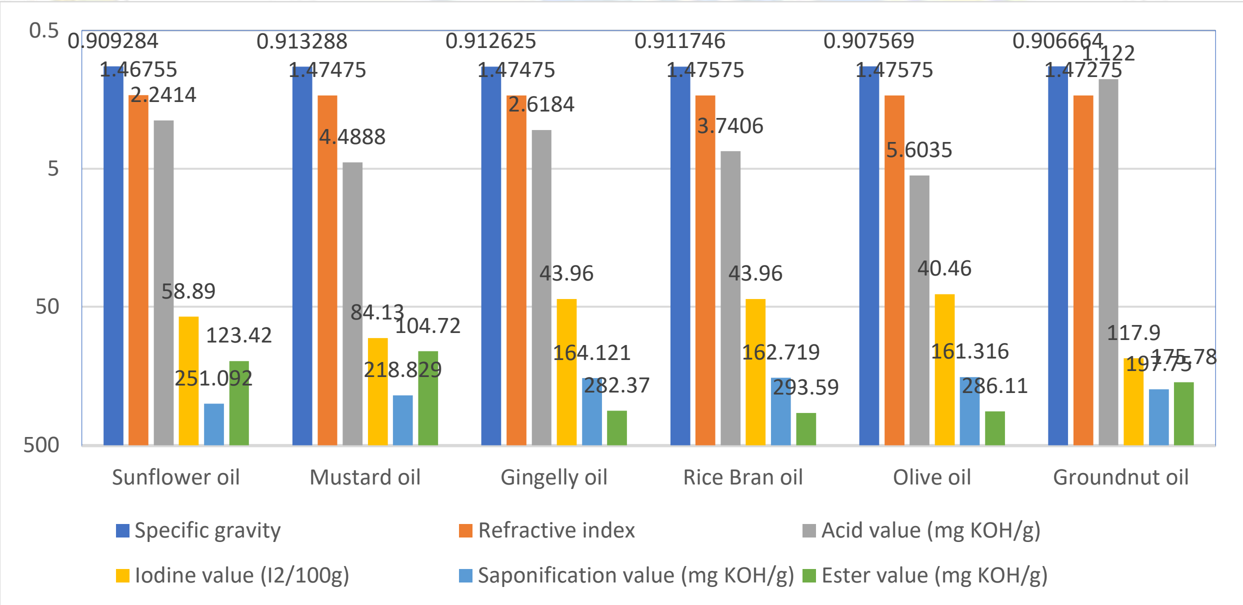
Among the six oil samples studied, ester value varied from 104.7 to 293.59 mg KOH/g. Mustard oil had less ester value i.e.104.72 KOH/g and olive oil had the highest ester value i.e. 293.59 KOH/g.

Table 1: PHYSICO-CHEMICAL MEASUREMENTS OF DIFFERENT OIL SAMPLES AS PER FSSAI

OIL SAMPLES	SPECIFIC GRAVITY	REFRACTIVE INDEX	ACID VALUE	IODINE VALUE	SAPONIFICATION VALUE	ESTER VALUE
Sunflower oil	0.9145 – 0.9182	1.4640 – 1.4691	Not more than 6	100-145	188-194	123.42
Mustard oil	0.907 – 0.910	1.4646 – 1.4662	Not more than 6	96-112	168-177	104.72
Gingelly oil	0.912 – 0.921	1.4662 – 1.4694	Not more than 6	115-120	185-190	282.37
Rice bran oil	0.910 – 0.920	1.4600 – 1.4700	Not more than 6	90-105	180-195	293.59
Olive oil		1.4677 – 1.4705	Not more than 6	75-94	184-196	286.11
Groundnut oil	0.881 – 0.901	1.4620 – 1.4640	Not more than 6	85-99	188-196	175.78

Table 2: COMPARISON OF PHYSICO-CHEMICAL MEASUREMENTS OF DIFFERENT OILS

PARAMETERS	OIL SAMPLES					
	Sunflower oil	**Mustard oil**	**Gingelly oil**	**Rice Bran oil**	**Olive oil**	**Groundnut oil**
Specific gravity	0.909284	0913288	0.912625	0.911746	0.907569	0.906664
Refractive index	1.46755	1.47475	1.47475	1.47575	1.47575	1.47275
Acid value (mg KOH/g)	2.2414	4.4888	2.6184	3.7406	5.6035	1.122
Iodine value (I_2/100g)	58.89	84.13	43.96	43.96	40.46	117.90
Saponification value (mg KOH/g)	251.092	218.829	164.121	162.719	161.316	197.75
Ester value (mg KOH/g)	123.42	104.72	282.37	293.59	286.11	175.78



COMPARISON OF PHYSICO-CHEMICAL MEASUREMENTS OF DIFFERENT OILS

CONCLUSIONS

In this study various physico-chemical characteristics of six fresh vegetable oil samples were estimated and compared with each other. Results obtained indicated that there was remarkable difference in all the physical and chemical properties analysed between the oils but had acceptable physicochemical parameters. The acid value of all the oils was below 6 (recommended by FSSAI) which proves that all the oils are less rancid. Groundnut oil showed the highest iodine value, suggesting the amount of unsaturated fatty acids indicating that they are likely to be healthier for consumption. Except sunflower oil, the rest of the oils were relatively in line with the recommended value

Natural oils are the mixtures of different types of tryglycerols containing different proportions of fatty acid moieties. Each oil has its characteristic fatty acid composition and tryglyceride molecules. The different proportion of saturated, monounsaturated and polyunsaturated fatty acid in a tryglyceride molecule play an important role in physico-chemical properties. The desired combination of fatty acids in the triglyceride molecule of fats and oils cannot always be met from a single native oil. Consumption of oil containing higher amount of saturated fatty acids could increase health hazards. It would be necessary among producers and retailers to become aware of the extraction, storage processes which influence the stability of the oils.

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