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Research Article

Soybean Oils Quality for Human consumption

Quality of Vegetable Oil in Rural Punjab: Study on Soybean Oils

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Abstract: Soybean oil is the second highest-produced vegetable oil in India. Due to the high unsaturated fatty acid content, this oil is highly susceptible to oxidation. Even though branded oils are supposed to adhere to BIS standards, the quality of this vast unbranded oil segment requires monitoring. Furthermore, in the branded category, quality assessment is required on the end-user side because monitoring is primarily done on the production side. Monitoring is especially important in rural markets, which are frequently overlooked. Thus the present work describes the physicochemical properties of different branded and non-branded soybean oil sold in the market of Talwandi Sabo, district Bathinda. Four samples are collected randomly. Their refractive index, specific gravity, surface tension, Viscosity, acid value and peroxide value were determined. The observed values were in the range 1.473 to 1.474 (refractive index), 0.9216 to 0.9237 g/ml (specific gravity), 37.479 to 40.945 mN/m (surface tension), 61.602 to 68.973 mPa.s (Viscosity), 0.140 to 0.477 mg of KOH/g (acid value) and 1.075 to 6.331 milliequivalent/Kg (peroxide value). Observed data showed that the samples were good in all parameters. However, Sample C has a high acid and peroxide value but is still good for consumption. There is a need to study the quality of vegetable oil sold in the rural market in India. Since all these markets are not regularly monitored, there is a possibility of adulteration in the supply chain.

Keywords: Acid Value, Peroxide Value, Refractive Index, Specific Gravity, Surface Tension, Vegetable Oil Analysis.

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1. INTRODUCTION

The word "Oil" is derived from the Latin term oleum, which originally referred to olive oil, but now refers to a wide range of flammable substances which are liquid at room temperature. The main distinction between oil and fat is; that oils are liquid at 25°C while fats are solid at that temperature. The oils produced by plants are known as vegetable oils. Since time immemorial, fat and oil have been used for food and many other purposes. They are the carriers of oil-soluble vitamins and contain many fatty acids, which are not produced by our body but are essential for us[1]. However, the fundamental reason for their use in cooking is the fact that they contribute to the flavour and texture of the food, making dishes tasty and giving them a good, smooth mouthfeel[2]. Chemically oils and fats are mixtures of lipids. They have triglycerides (generally >95%) as a major component, mixed with diacylglycerols, monoacylglycerols and free fatty acids. They may also contain phospholipids, tocols (tocopherols and tocotrienols), free sterols and sterol esters, hydrocarbons, triterpene alcohols and fat-soluble vitamins[3]. The triglycerides are triesters of glycerol with fatty acids. Based on the degree of unsaturation, fatty acids are classified into saturated fatty acids (SFA), monounsaturated fatty acids (MUFA) and polyunsaturated fatty acids (PUFA). Zahir E. et al. reported the density, Viscosity, boiling point, saponification value, iodine value and peroxide value of Corn and Mustard oils[4]. Fapeto, O. P. et al. studies refractive index, specific gravity, Viscosity, moisture content, flash point, smoke point, fire point, pour point, cloud point acid value, free fatty acid, saponification value, unsaponifiable matter, iodine value, ester value and peroxide value of both raw Raffia oil and transesterified raffia oil[5]. Awogbemi O. et al. showed that both degree of usage and the type of food items originally fried in the oil substantially affected its properties and FA composition of vegetable oil. Neat vegetable oils consist mainly of saturated FAs and polyunsaturated FAs, whereas waste cooking oils contain predominantly saturated FAs and monounsaturated FAs[6]. Ghaleshahi. A. Z. et al. studied the physicochemical, quality characteristics and thermal properties of flax, perilla, and basil seed oils cultivated in Iran[7]. Akpambang, V. O. analyzed acid value, iodine value, saponification value and trace metals of edible vegetable oil samples purchased in Akure, Nigeria[8]. According to the annual report of the Department of Food & Public Distribution Ministry of Consumer Affairs, Food & Public Distribution Government of India (2019-20), among the different varieties of vegetable produce in India, the production of soybean oil is second only at 20.2 % of total production after mustard oil with 26.5 % of total production. The major fatty acids in soybean oil are Linoleic (18:2) and Oleic (18:1)[9]. Due to high unsaturated fatty acids, soybean oil has stability problems. Partial hydrogenation, the addition of antioxidants and metal inactivation, along with natural selection and induced mutation breeding to reduce the linolenic acid content, were some strategies used to improve the oxidative stability of the oil[10]. According to a 2017 report market share of unbranded oil is 75%[11]. Though the branded oils are supposed to follow BIS standards, the quality of this huge unbranded oil segment needs monitoring. Also, in the branded category, quality assessment is needed on the end-user side since the monitoring is mostly on the production side. The analysis is especially needed in the rural markets as they are most often the most neglected. Thus, this study is aimed at monitoring some Physico-chemical parameters of the mustard oil available in the markets of Talwandi Sabo, district Bathinda, Punjab, India. In physical property refractive index, specific gravity, surface tension and Viscosity are investigated. These parameters will give an idea of the purity of the sample. In chemical parameters, acid value and peroxide value are studied. This will indicate the sample's storage and ageing condition as well as their stability.

2. MATERIALS AND METHODS

2.1 Material

2.2 List of chemicals

1. ethyl alcohol, 2. phenolphthalein indicator, 3. potassium hydroxide, 4. acetic acid, 5. Chloroform, 6. potassium iodide, 7. sodium thiosulphate, 8. starch. All the chemicals were purchased from Loba Chemie Mumbai, India, and used without purification. Distilled water was prepared in the laboratory by refluxing tap water with basic permanganate. Solvents were dried using standard procedures[12]. Solutions were prepared on the day of the experiment and were not stored for more than 24 hours. Four oil samples of different brands were collected from different retail outlets (both large and small shops) of Talwandi Sabo district Bathinda, Punjab. The samples were designated as A, B, C, and D. All the small samples except sample C are chemically refined, while sample C is physically refined. All the oil bottles were preserved in a dry, cool, dark place. Oil samples were taken directly from the container after inverting it several times. Samples were analyzed within three days of collection. All the analysis was performed in triplicate.

2.3 Methods

Analyses were performed according to the standard procedure of the Food Safety Standard Authority of India[13], whenever available. Briefly, the procedures were as follows.

2.4 Refractive index

Abbe's Refractometer determined the refractive index. The temperature of the Refractometer is controlled to be within ± 0.1°C by circulating water. Readings were taken at 18 °C, room temperature at that time. A sodium vapour lamp (589.3 nm) was used as the light source[13].

2.5 Specific Gravity

Samples were filtered through filter paper to remove any impurities and the last traces of moisture. A pycnometer of 25 mL capacity was cleaned with a chromic acid cleaning solution. Then it was filled with recently boiled water and placed in a constant temperature water bath at 19 °C, room temperature. The water level was adjusted to the proper point on the pycnometer and weighted (W_1). The instrument was then dried and weighed (W_2). The sample, maintained at 19 °C, was then filled in the dry pycnometer. The instrument was then weighed quickly (W_3)[13].

$$Specific\ gravity\ = \frac{W_3\ -\ W_2}{W_1\ -\ W_2}$$

Where W_3= weight in gm of specific gravity bottle with oil at 30°C, W_2= weight in gm of specific gravity bottle at 30°C, W_1= weight in gm of specific gravity bottle with water at 30°C.

2.6 Surface Tension

The chromic acid cleaning solution cleaned Stalagmometer wax used. The oil sample to be tested was sucked into the clean and dry Stalagmometer up to the upper mark. Then it was allowed to fall due to gravity. The number of drops was counted as n_1 when the oil passed from the upper to the lower mark. The procedure was repeated three times to obtain the mean value. Next, the Stalagmometer was again cleaned and sucked with distilled water. Again, the number of drops was counted as n_2. Then the surface tension was calculated using the equation.

$$\gamma_2 = \frac{\rho_2 n_1}{\rho_1 n_2}\gamma_1$$

Where γ_2= Surface tension of sample ρ_2 = Density of the sample, n_1= number drops for sample, ρ_1 = density of the reference water, n_2 = number of drops of reference water and γ_1 = surface tension of the reference water. Here liquid 1 is water, whose surface tension was taken from the literature[14].

2.7 Viscosity

The viscometer was washed with a chromic acid cleaning solution. The viscometer was then mounted vertically on a stand with a clamp. The oil was introduced in the lower reservoir of the viscometer and drawn up into the higher reservoir using a pipet bulb and allowed to return to the lower reservoir under gravity through capillary. An electronic timer was started as the oil level passed the first reference mark and stopped when the oil passed the second reference mark. At least three readings were taken in each experiment and the average reading was reported[15]. Next, the instrument was washed again, and the process was repeated with water as a reference liquid, whose viscosity coefficient value was taken from the literature[14]. Finally, the Viscosity was calculated according to the equation:

$$\frac{\eta}{\eta_0} = \frac{\rho t}{\rho_0 t_0}$$

Where η= viscosity coefficient of sample η_0 = viscosity coefficient water, ρ= density of the sample, ρ_0 = density of the reference water, t = flow time with the sample and t_0 = flow time reference water.

2.8 Acid value

20 mL of ethyl alcohol and 1 mL of phenolphthalein indicator were taken in a 250 mL conical flask, and then 1 gram of oil sample was added. The mixture is boiled for about five minutes and titrated while hot against a standard alkali solution with vigorous shaking. At the endpoint, the pink colour persisted for thirty seconds[13]. The acid value was calculated by the equation given below.

$$Acid\ value\ = \frac{56.1 \times V \times N}{W}$$

Where V = volume in mL of standard potassium hydroxide used, N = normality of the potassium hydroxide solution and W= weight in gm of the sample.

2.9 Peroxide value

A 5 gm sample was weighed into a 250 mL stoppered conical flask. 30 mL acetic acid chloroform solvent mixture (3:2 vol: vol) was added, and the mixture was swirled to dissolve. Now 0.5 mL of saturated potassium iodide solution was added to the flask. The mixture was allowed to stand for a minute in the dark with occasional shaking. Then about 30 mL of water was added to the flask. The liberated iodine then slowly titrate with 0.1 N sodium thiosulphate solution with vigorous shaking until the yellow colour is almost gone. About 0.5 mL starch solution as an indicator was added, and titration was continued till all I2 was released from the chloroform layer and the blue colour disappeared. A blank titration was also performed[13]. Peroxide value expressed as milliequivalent of peroxide oxygen per kg sample (meq/kg):

$$Peroxide\ value\ = \frac{Titre \times N \times 1000}{Weight\ of\ sample}$$

Where, Titer = mL of sodium thiosulphate used (blank corrected) and N = Normality of sodium thiosulphate solution.

3. STATICAL ANALYSIS

All experiments were conducted three times, and the average values were used for modelling. The significant difference was evaluated by one-way ANOVA using MS Excel 2019. Quantitative indicators are presented as continuous quantitative values expressed as mean ± SD. Differences were considered significant at $p < 0.05$. Graphs are plotted using MS Excel 2019.

4. RESULT AND DISCUSSION

4.1 Composition of Soybeans oil

According to the published report, triglycerols comprise 94.5 % of soyabean oil. Among the different fatty acids present in triglycerols amount of linoleate is reported to be the highest (~54.5%), followed by oleate (~23%). So, it has a very high polyunsaturated fatty acid content[16]. After triglycerols next important component in soyabean oil is phospholipids which constitute around 4% of the oil[17]. The amount of unsaponifiable matter in soyabean oil hovers around 1.3 to 1.6%. Among this unsaponifiable matter, around 26% is hydrocarbons. Another important component of the unsaponifiable matter is sterols and tocopherols[16].

Table I. Physical properties of the samples

Physical properties	Samples			
	A	B	C	D
Refractive Index of the samples at 18 °C	1.473±0.0005	1.474±0.0005	1.474±0.0005	1.473±0.0005
The specific gravity of the samples at 19 °C	$0.9202\pm10^{-5}\pm10^{-5}$	$0.9237\pm9.4\times10^{-5}$	$0.922\pm9.4\times10^{-5}$	$0.9216\pm8.2\times10^{-5}$
The surface tension of the samples at 16 °C at mN/m	40.017±0.333	39.716±0.766	40.945±0.307	37.479±0.257
The Viscosity of the samples at 20 °C in mPa.s.	68.973±0.052	65.178±0.3193	67.131±0.101	61.602±0.3884

4.1 Refractive index

The refractive index of the samples was recorded at 18 °C. The results are summarized in Table I and Fig. 1. The refractive index of the samples was found inside a very narrow range of ±0.001. The Bureau of Indian Standards set the requirement of refraction index for soybean oil in the range of 1.465 0 to 1.471 0 at 40 °C[18]. American Oil Chemists' Society19, in its Method Cc 7-25, recommended the following formula to estimate the refractive index of oil at a temperature other than the temperature used for the measurement.

$$n_D^{T'} = n_D^T + 0.000385(T - T') \cdots (1)$$

Where$n_D^{T'}$ $n_D^{T'}$ is the refractive index at $T'T'$K, and $n_D^T n_D^T$is the refractive index at TK. Using this formula, the observed values, when converted to 40 °C, give values between 1.464 to 1.465. Thus, the observed values are on the lower side. Gonzalez, C. et. Al. reported the refractive index of soybean oil as 1.47260 at 298.15K[20]. The observed refractive indexes when the temperature is corrected to 298.15 K by equation (1) give 1.470 and 1.471. Again, the observed values are slightly less than that reported by Gonzalez, C. et al. The refractive index of vegetable oil is related to its iodine number. Majors and Milner[21]developed a reverse relationship for estimating the iodine value of soybean oil when the refractive index is known:

$$IV = 8661.723(n_D^{25}) - 12.626.174 \cdots (2)$$

Where IV= is the iodine number and $n_D^{25} n_D^{25}$is the refractive index, when observed values are put into equation (2) after correcting for temperature by using (1) iodine numbers 109 and 117 results,, these values are lower than the Bureau of Indian Standards limit 125-140. But any immediate inference should not be drawn from this since it is only an approximate method to estimate iodine values.

4.2 Specific gravity

The refractive index of the samples was recorded at 19 °C. The results are summarized in Table I and Fig. 1. Magne and Skau reported a value of 0.9175 g/ml for Commercial, edible.

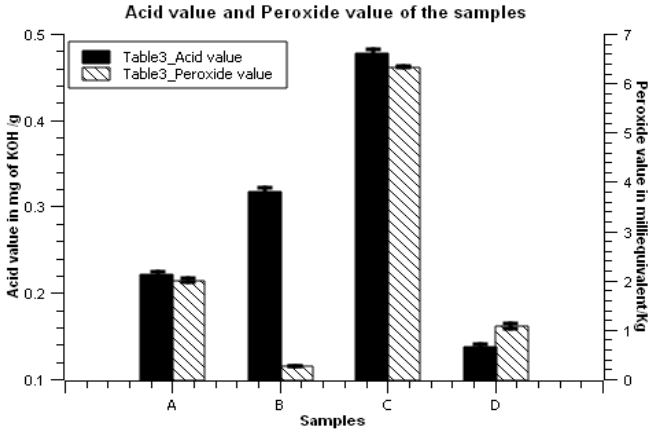

Fig. 1. Acid value and Peroxide value of the samples

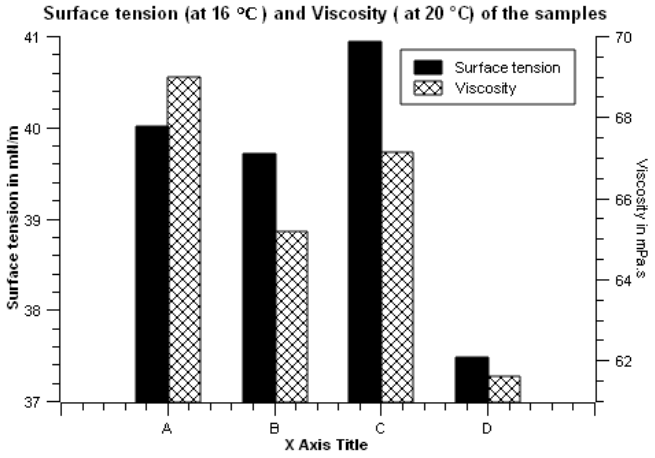

Fig. 2. Surface tension and Viscosity of the samples

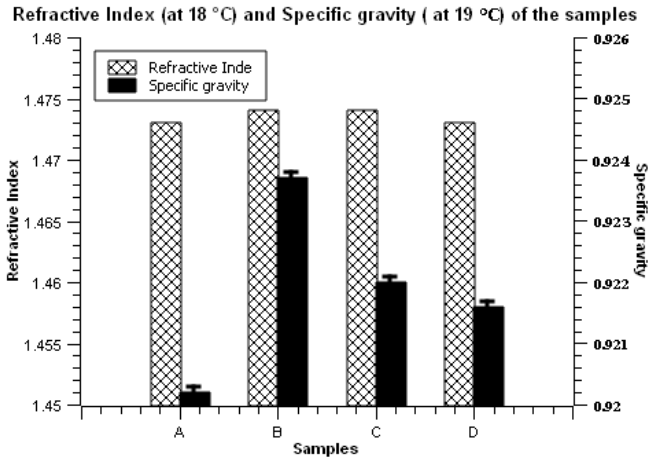

Fig. 3. Refractive index and specific gravity of the samples

Table II. Chemical properties of the samples					
The acid value of the samples in mg of KOH /g.					
Sample	**Value 1**	**Value 2**	**Value 3**	**Mean**	**Standard deviation**
A	0.225	0.220	0.219	0.221	0.0026
B	0.315	0.324	0.313	0.317	0.0048
C	0.483	0.471	0.477	0.477	0.0052
D	0.140	0.135	0.139	0.138	0.0022
Peroxide value of the samples in milliequivalent/Kg.					
Sample	**Value 1**	**Value 2**	**Value 3**	**Mean**	**Standard deviation**
A	1.975	1.990	2.050	2.005	0.032
B	0.2501	0.599*	0.2495	0.250	0.0003
C	6.312	6.350	6.331	6.331	0.016
D	1.15	1.075	1.00	1.075	0.061

Standard Deviation

Soybean oil has an iodine value of 132.6 and contains 0.10% free fatty acid[22]. On the other hand, Johnstone et al. reported a value of 0.9171 for a soybean oil that had been refined, bleached, and deodorized and that had the following characteristics: iodine value, 130.1; peroxide number, 5.1; acid number, 0.11; thiocyanogen number, 80.0; and phosphorus content, 0.00095%[23]. Both these data are recorded at 25 °C. Noureddini H. et al. reported the value of the density of soybean oil as 0.9193 g/ml at 23.9 °C[24]. Gonzalez, C. et al. describe the value of 0.91596 g.cm-3 at 298.15 K[20]. Thus, the observed values are consistent with the previously reported values.

4.3 Surface tension

The measured surface tension of the samples at 16 °C is shown in Table I and Fig. 2. Both the length of the fatty acid hydrocarbon chain and the number of unsaturation affect the surface tension. Also, the surface tension is increased with an increase in the chain length. Sample C has the highest values (40.945 mN/m), while D has the lowest values (37.479 mN/m). A and B have comparable values (40.017 and 39.716 mN/m, respectively). Unlike the refractive index and specific gravity, the surface tension values are not almost identical. This is expected as surface tension is not linearly related to the mole fraction of the component; rather, a very small variation in the composition can produce large variations in surface tension due to surface accumulation of components with low surface tension. Here it is interesting to note that sample C is physically refined while others are chemically refined. Esteban, B. et. al. reported a value of 34.0 mN/m at 20 °C[25]. This value is quite low compared to the one found in this report. This fact again indicates that surface tensions are much more susceptible to variation than other properties.

4.4 Viscosity

The Viscosity of the samples were recorded at 20 °C. The results are summarized in Table I and Fig. 2. Sample **A** and **C** are the most vicious (68.973 and 67.131 mPa.s., respectively), while sample **D** was the least viscous (61.602mPa.s.) at 20 °C. Sahasrabudhe, S. N et. al. reported a value of 57.1 ± 1.1 mPa.s at 22.1 °C[26]. Noureddini, H. describes the value of 54.3 mPa.s at 23.9 °C[27]. No report was found of Viscosity at the experimental temperature of 20 °C. However, the literature values are lower than those found in this report.

4.5 Acid value

The results are shown in Table II and Fig. 3. Sample **C** has the highest acid value of 0.477, indicating that it contains the maximum amount of FFAs. Interestingly this sample is physically refined and has the highest surface tension. This is followed by samples B, and A. D has the least acid value. All the values are within the maximum value of 0.5 for refined soybean oil prescribed by the Bureau of Indian Standards[18]. U K Prodhan et. al. reported acid values of soybean in the range 0.374 to 0.748[28]. Park, J.M and Kim, J. M obtained a value of 0.36 to 5.37 in their analysis[29]. Considering these values sample, A and D show exceptionally good acid values, whereas sample C just passed the Indian standard, closely followed by sample B. Now the high acid value can be due to inefficient refining or due to degradation of refined oil. Sample C also has a high peroxide value. Thus, degradation may be the cause of high acid value. On the other hand, Sample B has a very low peroxide value. Thus, the high acid value may be due to an inefficient refining process.

4.6 Peroxide value

The results are shown in Table II and Fig. 3. Sample C has the highest peroxide value, and sample B has the lowest value. For comparison, Park, J.M and Kim, J. M reported a peroxide value of 1.46 for soybean oil[29]. A peroxide value of 1 or less is considered an indication of freshness for soybean oil. When the value is between 1 to 5, soybean oil is expected to undergo low oxidation. A peroxide value of 5 to 10 indicates moderate oxidation for soybean oil[1]. By this standard, only sample B can be considered fresh. Samples A and D underwent low oxidation, while samples C underwent moderate oxidation. Sample C also shows high acid.

5. CONCLUSION

The present work was undertaken to investigate some physicochemical properties of different branded and non-branded soybean oil sold in the retail market of Talwandi Sabo, district Bathinda. Four samples are collected randomly. In physical property refractive index, specific gravity, surface tension and Viscosity are investigated. In chemical parameters, acid value and peroxide value are studied. The observed data indicate that all the samples are good in all parameters. Though, Sample C has a high acid value and peroxide value. But, these values in no way indicate that this sample could be better for consumption. There are few papers published with this type of study. According to a 2017 report market share of unbranded oil is 75%[11]. Though the branded oils are supposed to follow BIS standards, the quality of this huge unbranded oil segment needs monitoring. Also, in the branded category, quality assessment is needed on the end-user side since the monitoring is mostly on the production side. The analysis is especially needed in the rural markets as they are most often the most neglected. Thus, this study is aimed at monitoring some physico-chemical parameters of the mustard oil available in the markets of Talwandi Sabo, district Bathinda.

6. AUTHOR CONTRIBUTION STATEMENT

Rupinderjit Kaur performed the experiments, and Tirtha Mukherjee and Vajinder Kumar devised the project, the main conceptual ideas and proof outline, Vajinder Kumar, Tirtha Mukherjee, Anupama Diwan, Narender Yadav provided critical feedback and helped shape the research; analysis and manuscript.

7. CONFLICT OF INTEREST

Conflict of interest declared none.

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