

Physicochemical Analysis Of Virgin Coconut Oil Blended With Various Vegetable Oils: Implications For Quality And Stability

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ABSTRACT:

Virgin coconut oil produces medium-chain triglycerides, aids in heart health, and has many other health benefits. Its many functional qualities also serve to promote gut and digestive health. According to the study, it is possible to blend virgin coconut oil with various vegetable oils, including rice bran, soybean, ground nut, and sunflower oils. A variety of ratios, including 50:50, 60:40, 75:35, and 80:20, were used to combine the oils to enhance their physicochemical and sensory characteristics. The physicochemical characteristics of the blended oils were examined after three months of storage. The physicochemical characteristics include colour, iodine number, peroxide value, free fatty acid, smoke point, spread ability, and saponification number. Puri was prepared for sensory evaluation in order to evaluate the organoleptic and sensory attributes of the blended oils. According to the findings, mixed oils made from soybeans and sunflower have good quality and stability. The results showed significant differences in quality, stability, and sensory perception when compared to the combined groundnut and rice bran oils.

Key words: virgin coconut oil, blending of oils, smoke point, colour, sensory evaluation.

1.1 Introduction:

Dietary fats give food excellent organoleptic, nutritional, and physical qualities. Vegetable oils serve as the primary cooking medium in various food preparations and are the main source of fat in the diet. Triacylglycerol, which is made up of one glycerol molecule and three fatty acids, is essentially what fats and oils are. Solid fats are typically referred to as "fat," whereas liquid fats are referred to as "oil." In general, the fatty acid content of vegetable oils varies. By nature, no oil contains all of the fatty acids in the ideal amounts (Akriti Dhyani et al., 2018).

The fatty acid contents of several widely used vegetable oils show an imbalance and do not align with the expert committee's recommendations. It is not always possible to get the proper ratio of fatty acids in triacylglycerol (TG) of oils and fats from a single oil, as recommended by nutritionists. Making a physical mixture of several oils in the proper ratio or creating structural lipids (SLs) from various oils are two easy and diverse ways to do this. The Indian government has officially approved the mixing of edible oils. (Sumit Grover et al., 2021).

1.1.1 Virgin coconut oil:

Fresh coconut meat is used to extract virgin coconut oil. There are a number of methods that fall into the following general categories:

(1) press to extract the oil after drying the newly grated flesh of the coconut at low temperature (no more than 60°C).

(2) by mechanically removing the coconut milk from the freshly grated coconut meat, then adding an enzyme or letting it age for a few hours, or by employing a continuous centrifuge.

The lowest possible moisture content is crucial for the quality of virgin coconut oil (VCO). The maximum moisture and volatile matter content allowed by the Philippine National Standard for Virgin Coconut Oil is 0.2%. It also states that the oil is colourless, devoid of sediment, has a fresh coconut aroma, and doesn't taste or smell rancid. (Carandang 2008).

Virgin coconut oil, or VCO, has been consumed globally for a number of health-related reasons, some of which have been scientifically proven. Although medium chain fatty acids were discovered to be a possible antidepressant functional food, this impact had not been assessed in VCO, which is high in medium chain fatty acids and polyphenols. (swee keong yeap et al., 2014).

1.1.2 Rice bran oil:

High concentrations of useful components like oryzanol, phytosterols, tocopherols, tocotrienols, and other nutrients are found in rice bran oil (RBO), which also has a balanced fatty acid composition. It has been shown to have beneficial effects in controlling hypertension, hyper glycemia, sleeplessness, cholesterol, and other chronic illnesses. RBO's special qualities have made it applicable in a wide range of fields, such as industries, food, pharmaceuticals, and cosmetics. Many people around the world are currently interested in expanding the uses of RBO. (Yong Wang 2019).

Because of its superior cooking quality, longer shelf life, balanced fatty acid content, and plenty of antioxidant components, rice bran oil (RBO) is becoming more and more popular among other conventionally used cooking oils. RBO is a healthy cooking oil because it has a comparatively high smoke point and a reduced viscosity. Triterpene alcohols, γ -oryzanol, phytosterols, and squalene are among the bioactive phytonutrients found in RBO, along with vitamin E (both tocopherols and tocotrienols). These substances all have strong anti-inflammatory, hypocholesterolaemia, antidiabetic, antioxidant, and anticancer properties. In addition to lowering blood pressure, blood cholesterol, and blood glucose levels, RBO use in the diet has been shown to lessen inflammation and metabolic syndrome symptoms. (Amanat Ali et al., 2017).

1.1.3 Soyabean oil:

Since soybean oil is high in polyunsaturated acids, particularly linoleic acid, and low in saturated acids, it is generally regarded as a healthy oil. But these kinds of oils are also prone to oxidation, which can cause rancidity and a decline in quality. roughly 20% of soybeans are used to make high-quality oil, and roughly 40% are used to make protein. With substantial amounts of the majority of necessary amino acids, it has an excellent protein content. Structure, consistency, and plasticity are some of the variables that affect shortening's physical characteristics. The addition of hydrogen to double bonds in the chains of fatty acids in triacylglycerol causes lipids to harden. Because it enables the conversion of liquid oils into semisolid fats and produces materials with increased stability, this process is essential to the fats and oils. (Mulugojjam Gobie Belachew et al., 2023).

Foods containing soya and soya-derived products have been linked to improved heart disease risk factors, decreased osteoporosis, alleviation of menopausal symptoms, decreased risk of cancer, and in a few studies, decreased diabetes. They also help people maintain a low body weight and are cholesterol-free. The level of soya milling affects the

digestibility and palatability. Both texture preservation and a high protein yield are guaranteed at the end of processing. Increasing use and knowledge of its health advantages is necessary. (E.F. Fabiyi 2006).

1.1.4 Sunflower oil:

Polyunsaturated fatty acids (PUFA) are abundant in SFO (60.8 and 69%, respectively), and the ratio of PUFA to saturated fat is 6.4. 69% C18:2n-6 and less than 0.1% C18:3n-3 are present in SFO. Therefore, SFO supplies sufficient amounts of C18:2n-6, whereas SBO delivers C18:3n-3 with a ratio of C18:2n-6:C18:3n-3. Despite conflicting clinical results, epidemiological data has indicated a negative correlation between blood pressure and intake of diets heavy in vegetable fat. Saturated fat and cholesterol consumption should be reduced, according to recent dietary guidelines. This goal can be accomplished by replacing animal fats with oils like SFO (S N Meydani et al., 2013).

About 70% of sunflower oil is linoleic acid, and it is quite prone to lipid oxidation. By reducing the sensitivity of low density lipoprotein (LDL) cholesterol to oxidation, high oleic sunflower oil may lessen the risk of coronary heart disease. This is because heating accelerates the oxidative reaction, which is a major problem for deep fat frying operations. Genetically altering sunflower oil to produce more oleic acid and less linoleic acid could boost its health advantages and oxidative stability when stored and deep-fried. (Stephanie et al., 2007).

1.1.5 Groundnut oil:

The most significant legume in Ghana is groundnut. Every agroecologist in the nation grows the crop, from the lush forest zones to the arid savannah regions. Groundnut is used in a variety of culinary recipes to enhance flavour, taste, and protein content. The chemical makeup of the farmer-grown cultivars has not been examined in terms of their nutritional value, despite the crop's significance. To assess the nutritional content of 20 groundnut varieties cultivated in Ghana, researchers looked at their oil, fatty acids, protein, oleic/linoleic (O/L) acid ratio, iodine value, and free soluble sugars. This information let endorsers decide which type would be most beneficial (JY Asibuo et al., 2008).

The oil (48–50%) and protein (25–28%) in the kernels of groundnuts add to their importance as a rich energy source. From 100g of kernels, they produce 564 kcal of energy. Additionally, the groundnut kernels are high in monounsaturated fatty acids and contain a variety of health-promoting elements, including vitamins, minerals, and antioxidants. Antioxidants such as resveratrol and p-coumaric acid, vitamin E, and numerous essential B-complex groups, including thiamine, pantothenic acid, vitamin B-6, folates, and niacin, are present in them. Flavonoids, iso flavones, and physiologically active polyphenols can all be found in groundnuts (Janila et al., 2013).

1.2 Blending of oils :

Hina Daud et al. (2023) investigated the mixed oils' thermos-oxidative stability. The ternary blend was made by mixing CO:POO:SO in a ratio of 35:30:35, while the binary blends of SO:POO and CO:POO were created in a ratio of 75:25. Pure oils and their mixtures were heated for four hours at 180°C to check their thermal stability. Free fatty acid (FFA), peroxide value (PV), p-anisidine value (p-AV), and saponification value (SV) all significantly increased as a result of the heating procedure, although iodine value (IV) and oxidative stability index (OSI) dropped. Additionally, the principal component analysis (PCA) was carried out. Compared to the pure oils, the binary and ternary blends

showed higher oxidative stability. However, compared to other blends, the ternary blend CO:POO:SO with a ratio of (35:30:35) was found to be superior in terms of stability and health.

In (2021, Sumit et al.) prepared and evaluated the quality of various oil blends. Blends were made with linseed oil (LO) in different ratios, such as 20:80, 30:70, 40:60, 50:50, 60:40, 70:30, and 80:20 (v/v), and with soybean (SBO), mustard (MO), coconut (CO), olive (OO), and sunflower oil (SFO). Of all the blends, the fatty acid ratios (SFA:MUFA:PUFA) of 1:1.4:4.6 for LO and SBO (20:80), 1.5:1:3.1 for LO and CO (80:20), and 1:1.9:3.4 for LO and OO (80:20) were determined to be near to the recommended intake (1:1.5:1) and to be of higher quality. As a result, any oil's nutritional, physical, and sensory qualities are enhanced by the mixing. The compositional difference in oils could be used to build a better blend with higher quality overall.

(Antonietta Baiano et al., 2016) Extra-virgin olive oils used in the production of flavoured oils can derive from a single cultivar or can be a blend of two or more mono-varietal oils. In order to investigate the effects of the characteristics of the oil blends on the quality of the deriving flavoured oils, three mono cultivar extra-virgin olive oils (Coratina, Peranzana, Ogliarola) were used to produce three blends, which were successively flavoured by infusion. From each blend, three types of flavoured olive oils were produced: basil, chilli pepper, and garlic + chilli pepper. Mono-varietal extra virgin olive oils, blends, and flavoured oils were submitted for routine analyses and for determination of polar compounds, phenolic profile, antioxidant activity, and volatile profiles. The panel and consumer tests were also carried out on the flavoured oils. Along with the undoubted influence of the flavouring agents, the quality parameters of each blend changed and their changes greatly depend on the starting blend. The parameters mostly affected by oil blend were: acidity, K232, peroxide values, diacylglycerols, polar compounds, total phenolics, antioxidant activity, and phenolics such as p-coumaric acid, tyrosol acetate, vanillic acid, tyrosol, hydroxytyrosol, hydroxytyrosol acetate, dialdehydic form of elenolic acid linked to tyrosol, and ligstroside aglycone, oleuropein aglycone. The effects of oil blending were rather limited on volatile profiles and sensory characteristics.

(Mobin Siddique et al., 2010) Palm oil (olein) was blended with other edible oils for the enhancement of its market acceptability in terms of melting point depression and shelf life. The physico-chemical properties like viscosity, density, melting behaviour, peroxide value (PV), saponification value (SV) and iodine value (IV) of four different binary blends with four vegetable oils were evaluated. Palm olein was found to be more stable against rancidity than the other oils. For the stability against oxidation and melting point depression the palm olein-canola (PO/CO) blend was found to be better than the others. The Differential Scanning Calorimeter (DSC) thermogram of the melting behaviour of the blends traces some new polymorphs of the triglyceride. This 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.

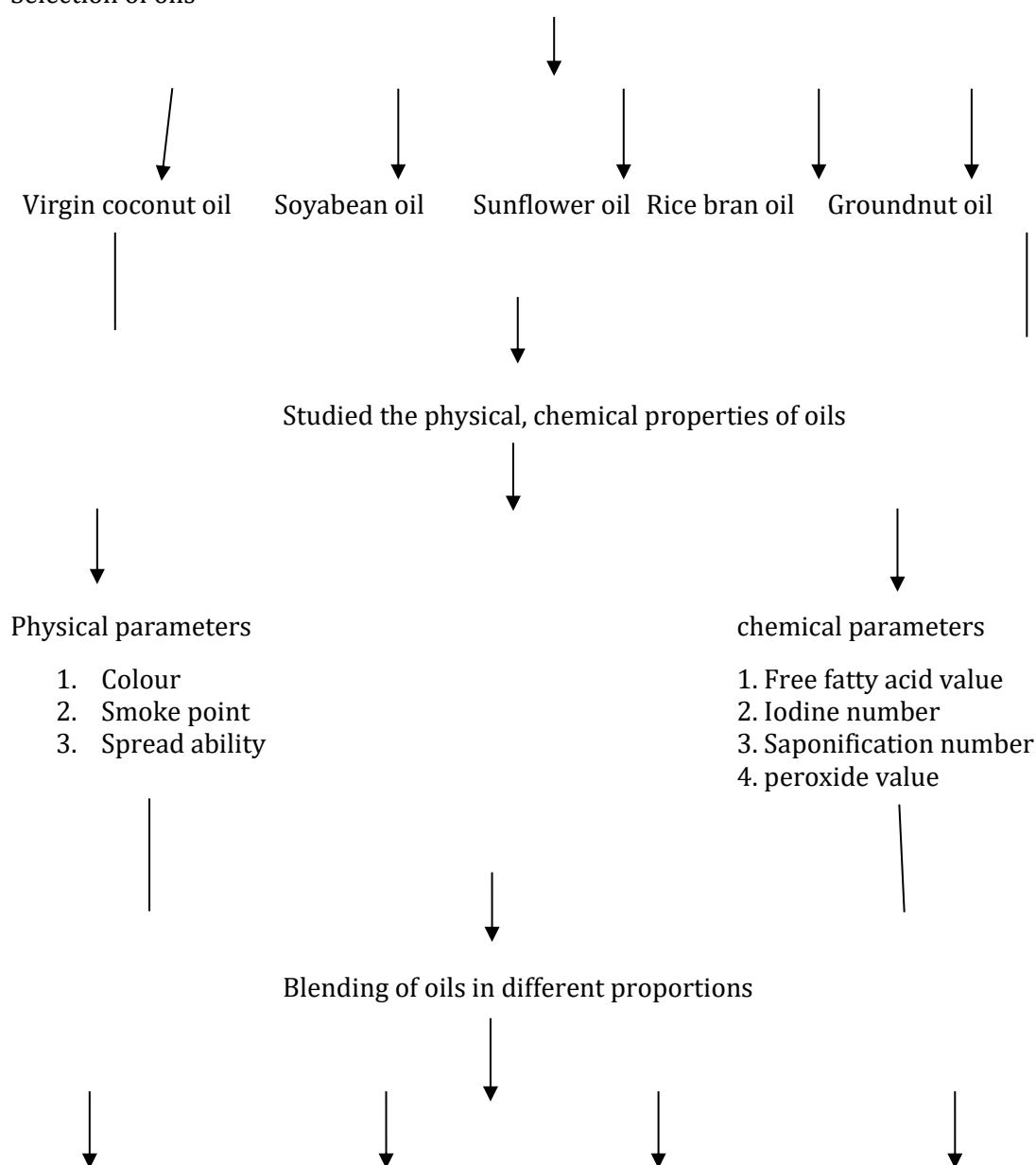
(Peeter Simon et al., 2017) Taking into consideration the regional preferences of the local population to sunflower oil, soybean oil and rice bran oil, the present study of nutritional evaluation of three different oil blends was conducted using sunflower oil, soybean oil, rice bran oils controls. The oil blends selected were sunflower oil, soybean oil, rice bran oil in the ratios of 50:50 with other oils. These oil blends were used for making a ready to eat (RTE) extruded snack. Shelf-life studies during storage for two months were examined for changes in chemical and sensory characteristics. Near significant changes were observed in the oil extracted from the fried product in comparison to control. Sensory

evaluation of the ready to eat (RTE) extruded snack indicated that it was chemically acceptable up to two months of storage.

1.3 Materials and method:

The selected oils for the study have been bought in large quantities from the supermarket Tirupati, Andhra Pradesh, India. 16 blends were made and stored in PET bottles. The virgin coconut oil was used as the control sample and was mixed with soy, rice bran, sunflower, and pulverized nut oils in the following ratios: 50:50, 60:40, 70:30, and 80:20 in the lab using a magnetic stirrer at 40°C. For three months, the oils were kept at room temperature. Following the oils, the product's physical and chemical characteristics are assessed, and its sensory qualities are evaluated in order to compare the product's flavour, stability, and oil quality. Puri was deep-fat fried in each oil mix while the frying temperature was kept above 180°Celsius.

Selection of oils



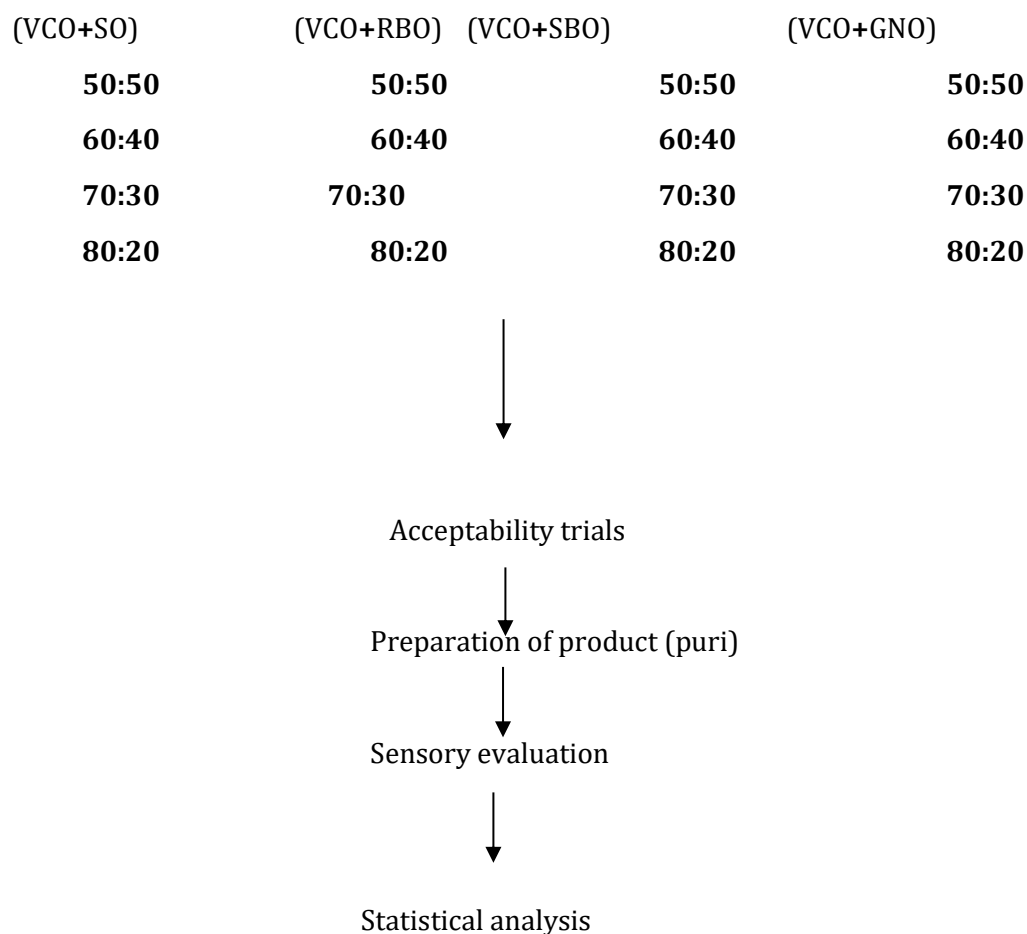


Fig: 1 study designed for blending of oils

1.4 Chemical analysis:

After three months of storage, the blended oils were tested using standardized techniques including the free fatty acid value, peroxide value, saponification number, and iodine number. Analysis of variance, significance tests, means, and standard deviation were performed on the tabulated data

Tab:1.4.1 Procedures for the chemical analysis

Name of the test	Procedure of the tests	Reference
Free fatty acid value	Pipette 3ml of oil into a clean conical flask. Dissolve oil in mixture of equal parts of alcohol and ether each about 10ml. Add a drop of phenolphthalein as indicator. Titrate the dissolved oil to prevent evaporation. Do blank titration with 20ml of alcohol ether mixture. Subtract the blank value from the titrate value of the sample. A blank is necessary to neutralize the impurities present in the alcohol-ether mixture. End point is a light pink colour which fades out on exposure to light. Repeat the experiment to get concurrent values	AOAC official method 965.33
Iodine number	Take a clear dry pipette transfer 1 ml of oil to each of the two 250 Erlenmeyer flasks. Weight accurately one ml samples of the oils. Take the average of the two weights as the weight of the sample of oil taken. (i.e. Wt gm s). Add 10 ml of chloroform and stopper with a cork stopper. When the oil is dissolved, add 25 ml of Hans iodine solution from a burette that of the solution adheres to the bank of the flask. Insert the stopper and agitate gently. After 30 min's add 10 ml of 15% potassium iodide solution. Allow to stand, Stoppard, in the dark for 1 hour. A blank titration must be carried out and the titrate value is subtracted. Titrate immediately with standard sodium thiosulphate ($\text{Na}_2\text{S}_2\text{O}_3$) solution. During titration run in the thiosulphate solution rapidly until a pale yellow or colourless is reached and then add to the flask contents 2ml of freshly prepared starch solution. Carefully continue the titration until the blue colour disappears. At the end point 1 drop of sodium thiosulphate will change colourless. Subtract the titrate value from that of blank and calculate the iodine	AOAC official method 965.33
Peroxide value:	Dissolve 5ml of oil in 25ml of solvent mixture. Add 5ml of a saturated solution of KI. In stopper flask and shake the contents of flask until clear by giving a rotator motion to the flask for 2 mins. After exactly 2 mins titrate the liberated I_2 with 0.1 N sodium thiosulphate using starch indicator about 1ml. shake vigorously at end to remove last traces I_2 from chloroform layer. Do blank. Weigh accurately two 5 ml samples of oil using the same pipette as for determination.	AOAC official method 965.33

Saponification number:	Introduce 1ml of oil into each of two Erlenmeyer flasks/iodine flasks of about 250ml capacity, with a clean dry pipette. Add exactly 15ml of alcoholic KOH to each flask. Boil gently on a water bath for 30 minutes. Repeat this step with the second sample of oil. The contents of the flasks are frequently mixed. Cool each flask, add two drops of phenolphthalein indicator, and titrate the excess of alkali with standard 0.5N HCL. Conduct a blank determination with 15ml of alcoholic KOH but without oil.	AOAC official method 965.33
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1.5 Sensory evaluation:

Panel members used a five-point hedonic scale to rate the samples in the bottles based on their perceptible sensory qualities, including colour, flavour, texture, taste, and overall acceptability. A sensory evaluation plan was created to evaluate the product's colour, flavour, texture, taste, and general acceptability.

1.6 Results and discussion:

The production of deep-fat fried foods in India heavily relies on oils and fats. Such goods provide a significant portion of dietary fat. Evaluating the quality of frying oil that has been used for a long time is necessary in order to establish a threshold for determining its acceptability from a nutritional and health standpoint.

Fatty acid composition

Around the world, oils and fats are a staple of diet plans. In terms of chemistry, they are intricate blends of glycerol and fatty acid esters. Oil is the term for fat that is liquid. Fatty acids come in a variety of forms and can be either saturated or unsaturated. As a result, the types of fatty acids—stearic, oleic, palmitic, etc.—that are present determine the composition of the various fats and oils. Some edible fats and oils' fatty acid makeup is listed in a table.

Table :1.6.1 Fatty Acid Composition of Individual Blended Oils

Oils	Capric acid (C10:0)	Lauric acid (C12:0)	Palmitic acid (C16:0)	Stearic acid (C18:0)	Oleic acid C18:1n9c	Linoleic acid C18:2n6c	Linolenic acid C18:3n3c
Coconut oil	5.18±0.20	49.57±0.81	9.26±0.39	2.97±0.23	7.24±0.25	1.90±0.14	ND
Sunflower oil	ND	ND	6.43±0.36	3.69±0.22	25.92±2.23	62.69±2.2	ND

Rice bran oil	ND	ND	39.67±0.79	4.23±0.11	43.36±0.61	11.23±0.46	0.30±0.05
Ground nut oil	ND	ND	1.17 ± 0.06	0.98±0.03	10.16±0.75	15.58±0.43	11.70±0.57
Soyabean oil	ND	ND	11.67±0.48	3.87±0.82	24.77±2.41	54.17±1.72	5.16±0.77

1.7 Quality characteristics of individual oils:

To examine the physic-chemical properties of the oils, the qualitative attributes of each particular oil chosen for the experiment are covered in the next two sub headings.

1.7.1 Physical characteristics

The most crucial aspects of each oil's colour and spread ability in this section are

Fig:1.7.1. A7 Blended oils of a. sunflower and b. groundnut oils

Fig: 1.7.1.B. Blended oils of c. soyabean and d. rice bran oil**1.7.1.a Colour****Tab:1.7.1.a colour difference between the individual and blended oils**

Name of the oil	Colour of individual oils
Virgin coconut oil	pristine white colour
Sunflower oil	pale yellow
Ground nut oil	dark brown to light brown
Soyabean oil	Bright golden
Rice bran oil	dark yellow to yellow
Colour of the blended oils	
Name of the blended oil	Colour
VCO+SUN	Light yellow colour
VCO+RBO	Light pale-yellow colour
VCO+GUN	Pale light brown
VCO+SOB	Light golden colour

The individual and mixed oils' colours are depicted in the table. The colour of the individual oil is darker than that of the mixed oil. Because it is cold-pressed and pure, virgin coconut oil helps preserve each oil's colour. Soybean oil shifted from bright yellow to light golden, groundnut oil from dark brown to pale light brown, rice bran oil from dark yellow to light pale yellow, and sunflower oil from pale yellow to light yellow.

1.7.1.b Smoke point

The oil's quality and acidity content can be determined with the aid of its smoke point. Different oils have varying smoke point ranges; some have low smoke points, while others have high ones. The following figures represent the oil's smoke point, which aids in determining its quality and acidity content:

Table : 1.7.1.b Smoke point difference between individual and blended oils

Smoke point of individual oils	
Name of the oil	Smoke point
Virgin coconut oil	<177°C
Soyabean oil	234°C
Sunflower oil	227°C

Ground nut oil	299°C			
Rice bran oil	258°C			
Smoke point of blended oils				
Name of the oil	Smoke point			
	50:50	60:40	75:35	80:20
Virgin coconut oil+ SUN	171°C	183°C	180°C	180°C
Virgin coconut oil+ SOB	190°C	182°C	184°C	180°C
Virgin coconut oil+ RBO	182°C	180°C	180°C	164°C
Virgin coconut oil+ GNO	160°C	168°C	161°C	171°C

The smoke point variations between the separate and blended oils are shown in the table. According to the research, combined oils have a lower smoke point than individual oils. It contributes to the reduction of trans fatty acid production during cooling, which has an impact on heart health. The smoke point often drops as the percentage of VCO rises. Blends of VCO with sunflower oil have a smoke point that ranges from 171°C to 183°C, which is largely constant across ratios. With increasing amounts of soybean oil, the smoke point of VCO-soybean oil blends rises noticeably to 190°C. Blends of VCO with rice bran oil maintain a comparatively high smoke point, ranging from 180°C to 197°C. Higher groundnut oil proportions significantly lower the smoke point of VCO-groundnut oil blends, which ranges from 160°C to 230°C.

1.7.1.c Spread ability

Table: 1.7.1.c spread ability difference between individual and blended oils

Spread ability ranges for individual oils				
Name of the oil	Spread ability ranges			
sunflower oil	10 cm			
rice bran oil	6 cm			
soybean oil	7 cm			
Ground nut oil	5 cm			
Spread ability ranges for blended oils				
Name of the oil	Spread ability ranges in different variations			
	50:50	60:40	75:35	80:20
VCO+SUN	3.5cm	4.4cm	6cm	4.1cm
VCO+SOB	5.2cm	5cm	3.6cm	4.1 cm

VCO+RBO	4cm	4.4cm	3cm	3.8cm
VCO+GUN	2.4cm	2.8cm	3.5cm	4.5cm

Predicting the various oils is the primary goal of testing an oil's spread ability. A line spread chart is used to conduct the spread ability exam. Individual sunflower oil has a very high spread ability (10 cm), followed by rice bran oil (6 cm), soybean oil (7 cm), and ground oil (5 cm). Higher sunflower oil proportions during blending result in a greater spread ability, which can reach up to 6 cm at a 75:35 ratio. Blends of soybean oil: the spread ability ranges from 3.6 cm to 5.2 cm and is largely constant throughout ratios. The spread ability of rice bran oil blends declines as the amount of rice bran oil increases, reaching a minimum of 3 cm at a 75:35 ratio. The spread ability of groundnut oil blends increases as the quantity of groundnut oil increases, reaching a maximum of 4.5 cm at an 80:20 ratio



Fig: 1.7.1.d spread ability test for a. soyabean, b. sunflower, c. rice bran, d. groundnut oil

1.7.2 Chemical parameters for individual oils:

Free fatty acid value, peroxide value, iodine number, and saponification number are crucial chemical characteristics for evaluating the quality and stability of an oil's shelf life. For simplicity, these quality parameters are checked in the lab using standard protocols in the current study. Each parameter is graphically represented and described separately in the section:

1.7.2.1 Free fatty acid value:

The values of free fatty acids for each particular oil are plotted. It is possible to measure the amount of palmitic, lauric, and oleic acid present in various oils by using free fatty acid values. Ground nut oil has a high concentration of free fatty acids (0.1 mg). In respect to rice bran oil (0.05 mg), sunflower oil (0.05 mg), and soy bean oil (0.1 mg). The other oils have identical values.

Fig: 1.7.2.1 Free Fatty Acid values for individual oils

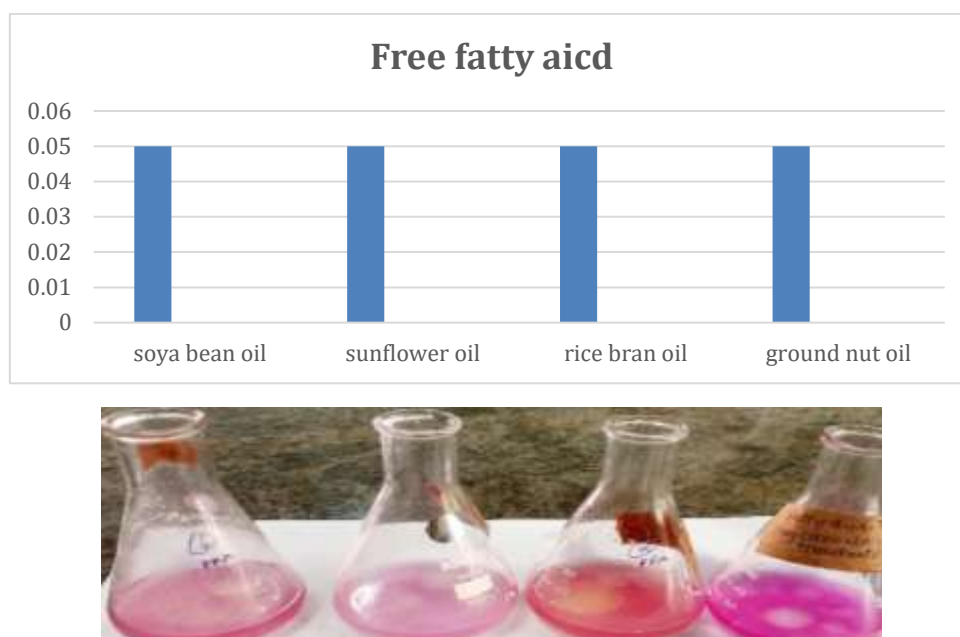


Fig: 1.7.2.2 Free fatty acid test a. soyabeen, b. sunflower, c. rice bran, d. groundnut oils

1.7.3 Peroxide value:

The first indication of rancidity in unsaturated fats and oils is provided by the detection of the peroxide value. Although there are several approaches, peroxide value is the most frequently employed. It provides an indication of the degree of initial oxidation, secondary oxidation, and further rancidity of the oil sample. Soy bean oil has a high peroxide value of 0.25 meq, followed by ground nut oil at 0.2 meq. Sunflower oil and rice bran oil have the same levels of peroxide value (0.1 meq).

Fig: 1.7.3.1 Peroxide value for individual oils

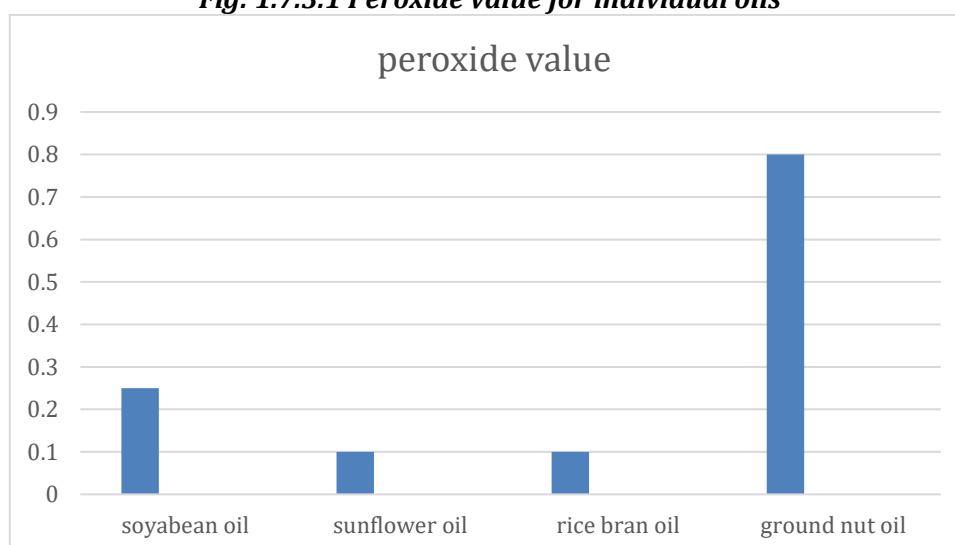




Fig: 1.7.3.2. Peroxide value test a. soyabean, b. sunflower, c. rice bran, d. groundnut oils

1.7.4 Iodine number:

In chemistry, the mass of iodine in grams that is eaten by 100 grams of a chemical material is known as the iodine value (also known as the "iodine adsorption value," "iodine number," or "iodine index"). To ascertain the degree of unsaturation in fatty acids, iodine numbers are frequently employed. Double bonds that react with iodine compounds are the result of this unsaturation. There are more C-C bonds in fat with a higher iodine value. However, because they are highly unsaturated, rice bran oil and sunflower oil are drying oils that work well for oil plant production. When compared to sunflower oil and rice bran oil (0.7 mg), ground nut oil has a higher iodine number (0.9 mg) and is second only to soy bean oil (0.8 m).

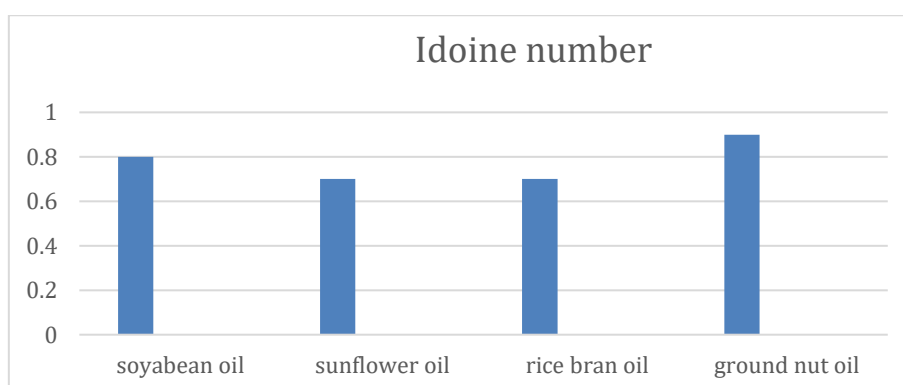
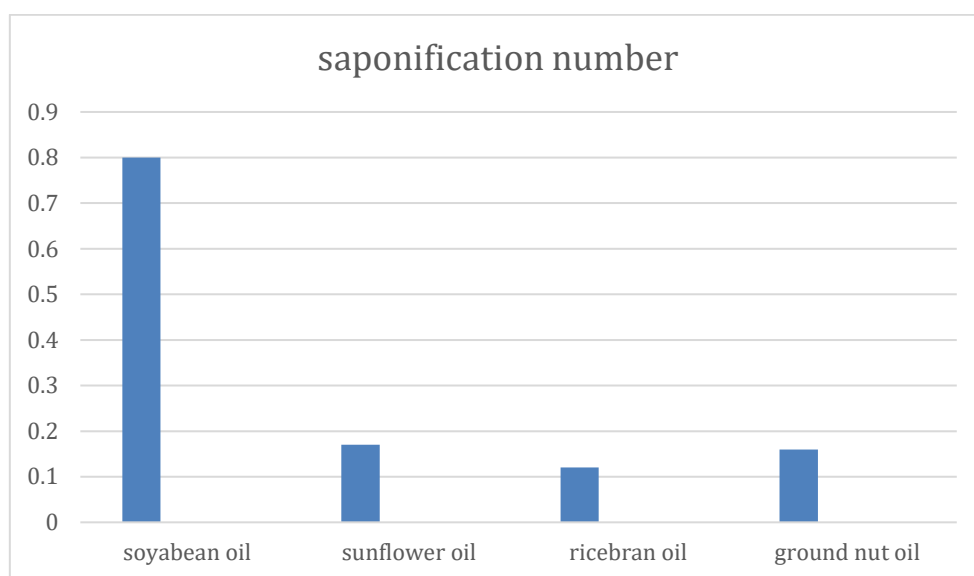


Fig: 1.7.4.1 Iodine number for individual oils



Fig: 1.7.4.2 Iodine test for a. soyabean, b. sunflower, c. rice bran, d. groundnut oils**1.7.5 Saponification number:**

The average molecular weight (or chain length) of all the fatty acids in the mixture is measured. The average fatty acid chain length can be compared because the three fatty acids make up the majority of a fat or tri-ester's bulk. Because they contain comparatively fewer carboxylic functional groups per unit mass of the fat than short chain fatty acids, the long chain fatty acids present in fats have a low saponification value. According to the figure, soy bean oil has the highest saponification number (0.8 mg), followed by sunflower oil, ground nut oil, and rice bran oil (0.17 mg, 0.16 mg, and 0.12 mg, respectively).

**Fig: 1.7.5.1 Saponification number for individual oils****1.8 Chemical parameters for blended oils:**

It is crucial to evaluate the chemical properties of blended oils in order to determine their quality and shelf life.

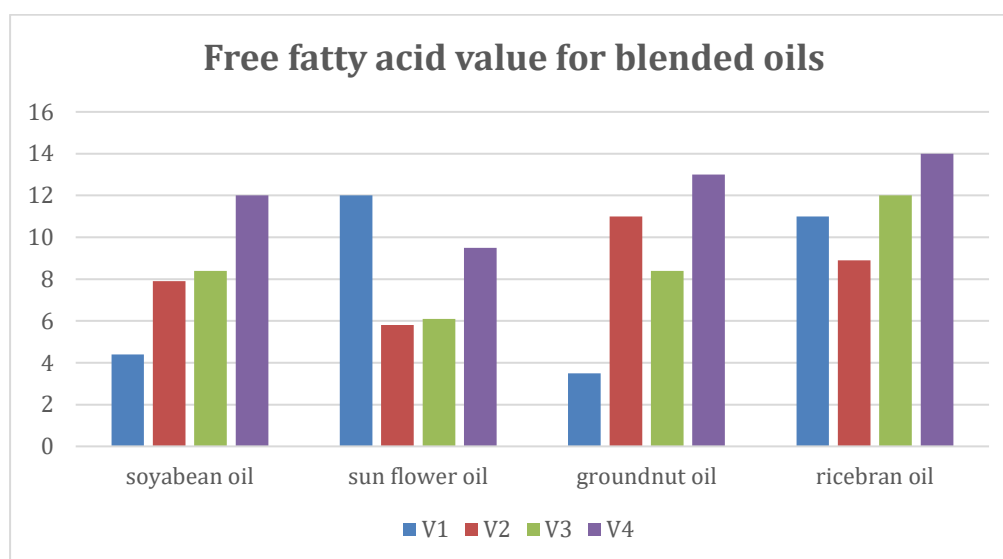
Table: 1.8.1 Chemical analysis of blended oils

NAME OF THE BLENDED OIL	FFA VALUE (MGKOH/G) OIL				PEROXIDE VALUE (MEQ)				IODINE NUMBER (MGKOH/G) OIL				SPN VALUE (MGKOH/G) OIL			
	V1	V2	V3	V4	V1	V2	V3	V4	V1	V2	V3	V4	V1	V2	V3	V4
VCO+SB O	4.4	7.9	8.4	12	19	2.9	8.5	2.1	9.7	0.5	1.0	0.4	1.6	1.9	5.7	2
VCO+SUN	12	5.8	6.1	9.5	16	2.3	3.9	1.8	3.4	0.4	0.6	0.5	2.0	1.8	2.0	2

VCO+GU N	3. 5	1 1	8. 4	1 3	1 0	3. 8	8	1. 7	6. 3	0. 5	3. 4	0. 5	6. 7	2	1 7	2. 3
VCO+RB O	1 1	8. 9	1 2	1 4	3. 8	3. 2	1 6	1. 8	1. 1	0. 5	1. 9	0. 5	1. 1	3. 2	2 0	1. 8

1.8.1 Free fatty acid:

Fig:1.8.1 Bar graph representation of free fatty acid value for blended oils

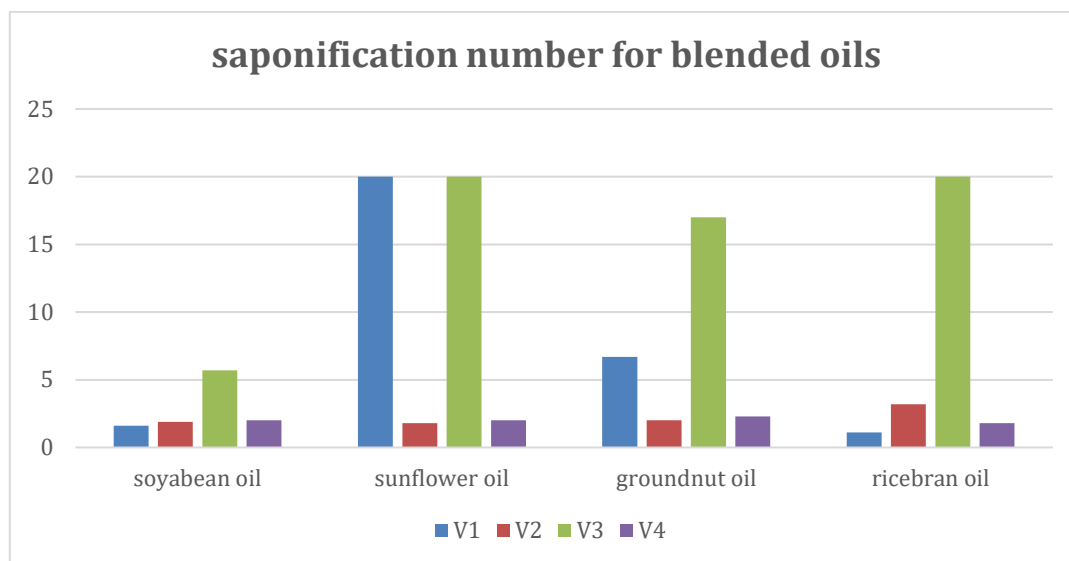


The amount of palmitic, lauric, and oleic acids present in various oils can be estimated using the free fatty acid value. According to the findings, the rice bran oil (11.62), sunflower oil (8.22), soy oil (8.05), and groundnut oil (9.12)

- Out of all the oils, V4 consistently has the highest FFA readings. With the exception of sunflower oil, which has the highest values, V1 typically has the lowest values.
- The FFA levels of rice bran and groundnut oils are often greater than those of sunflower and soybean oils.
- The discrepancy in FFA readings implies that various blending methods or oil compositions may have a substantial impact on FFA levels.

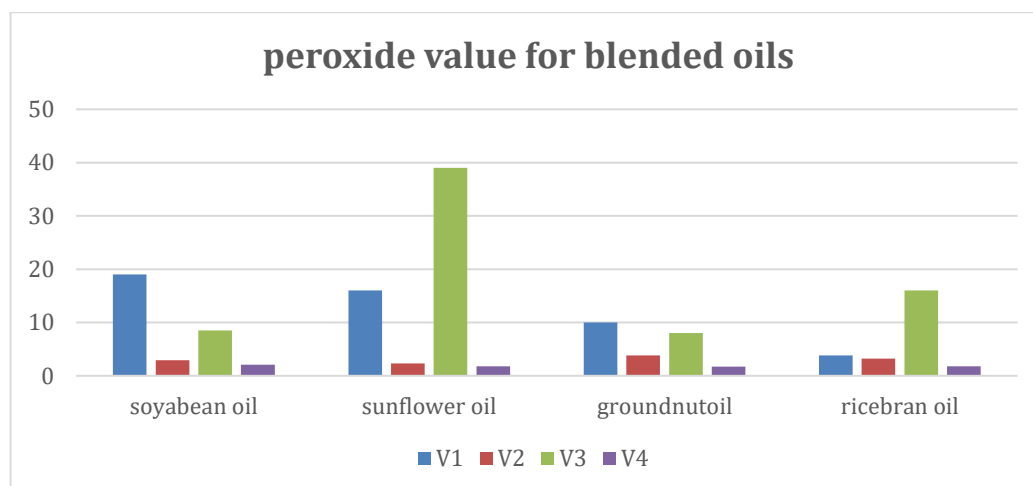
1.8.2 Saponification number:

The average molecular weight of all the fatty acids present is measured by this. Having a lengthy fatty acid chain and a low saponification number makes it less likely to oxidize and produce dangerous free radicals. Sunflower oil (11), groundnut oil (7), rice bran oil (6.5), and soybean oil (3).

Fig:1.8.2 Bar graph representation of saponification number for blended oils

- Out of all the oils, V3 regularly
- has the highest saponification numbers. Across all oil types, V2 and V4 have consistently lower values.
- When compared to soybean and rice bran oil, sunflower and groundnut oils typically have higher saponification qualities.
- A higher saponification number indicates a larger percentage of short-chain fatty acids in the oil, which may affect the oil's quality and ability to make soap.

1.8.3 Peroxide value:

Fig:1.8.3 Bar graph representation of peroxide value for blended oils

Peroxide value detection provides the first indication of rancidity in unsaturated fats and oils. The most commonly used is peroxide value. The amount of primary oxidation, secondary oxidation, and further rancidity levels of the oil sample are measured. Rice bran oil

(6.25), groundnut oil (5.75), sunflower oil (15.5), and soybean oil (8).

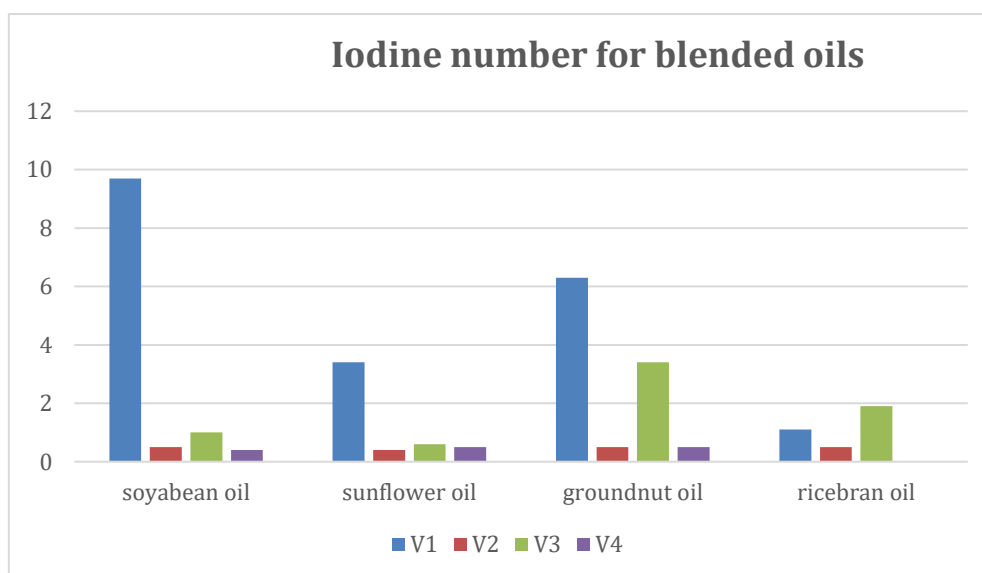
- V1 contains high levels of peroxide in groundnut, sunflower, and soybean oils.

- In general, V3 has the greatest peroxide values, particularly in rice bran and sunflower oils.
- The lowest peroxide levels are regularly displayed by V2 and V4, suggesting that they may be more resistant to oxidation.
- The greatest peroxide levels, especially in V3, are found in sunflower oil, indicating that it is more susceptible to oxidation than other oils.

1.8.4 Iodine number:

The mass of iodine in grams that is consumed by 100 grams of chemical substance is known as the iodine value. To ascertain the degree of unsaturation in fatty acids, iodine numbers are frequently employed. Double bonds, which react with iodine compounds, are the form of unsaturation. Rice bran oil (1.0), groundnut oil (2.75), sunflower oil (1.375), and soybean oil (3.625)

Fig:1.8.4 Bar graph representant of iodine number test for blended oils



- Among all oils, V1 typically has the highest iodine number, which suggests a higher level of unsaturation.
- Out of all the oils, soybean oil has the greatest iodine value, indicating that it contains more unsaturated fatty acids.
- Since V2 and V4 have the lowest iodine values, they may be more saturated and contain fewer unsaturated fats.
- The iodine value of groundnut oil is moderate, especially in V1 and V3.
- In comparison to the other oils, rice bran oil has the lowest total iodine values, suggesting that it is more saturated.

1.9 Sensory evaluation:

The suitability of each of the chosen oils is evaluated by sensory analysis. Puri made with 16 individual samples was created for sensory evaluation on the day of 85th day of storage period. The quality aspects of look, colour, texture, and taste were noted during the sensory evaluation process.

1.9.a Appearance of the product with blended oils:

Table: 1.9.a Appearance comparison of product between the oils

Name of the oils	Variation 1	Variation 2	Variation 3	Variation 4
Soyabean oil	4.4	4.75	3.95	4.15
Rice bran oil	4.1	4.25	4.3	4.2
Ground nut oil	4.35	4.7	4.5	4
Sunflower oil	4.7	4.5	4.55	4.35

The product made using soyabean oil (4.31%), ground nut oil (4.38%), sunflower oil (4.5%), and rice bran oil (4.21%) exhibits average ranges in appearance, according to the able sensory score mean values. There isn't any discernible difference in appearance between the individual oils.

1.9.b Taste of the product with blended oils:

Table: 1.9.b Taste comparison of product between the oils

Name of the oil	Variation 1	Variation 2	Variation 3	Variation 4
Soyabean oil	4.2	4.65	3.5	4.15
Sunflower oil	4	4.55	4.25	4.05
Ground nut oil	4.3	4.35	4.45	4.3
Rice bran oil	4	4.4	3.85	4.1

The table shows that there is a minor variation in the product's flavour and rice bran oil (4.08%), but no discernible difference between the products made with soyabean, sunflower, and groundnut oils (4.1%, 4.21%, and 4.35%).

1.9.c Texture of the product with blended oils:

Table: 1.9.c Texture comparison of product between the oils

Name of the oil	Variation 1	Variation 2	Variation 3	Variation 4
Soyabean oil	4.35	4.5	3.45	4.15
Sunflower oil	4.2	4.45	4.3	4.3
Ground nut oil	4.35	4.3	4.5	4.2
Rice bran oil	4.25	4.3	3.9	4.15

When compared to soyabean (4.11%) and rice bran (4.15%) oils, the texture of the product made with sunflower (4.31%) and groundnut (4.31%) oils is comparable, according to the sensory score data.

1.9.d Odour of the product with blended oils:

The product's flavour varies depending on the type of oil and how long it is stored.

Table: 1.9.d Odour comparison of product between the oils

Name of the oil	Variation 1	Variation 2	Variation 3	Variation 4
Soyabean oil	4.2	4.75	3.65	4.05
Sunflower oil	4.5	4.45	4.7	4.1
Ground nut oil	4.15	4.35	4.55	4.35
Rice bran oil	4.35	4.3	4.15	4.2

When compared to rice bran oil (4.25%) and ground nut oil (4.35%), the produce made with soyabean oil (4.16%) and sunflower oil (4.43%) exhibits acceptable acceptability of the items without any differences.

1.9.e Overall acceptability of the product with blended oils:

Table: 1.9.e Overall Acceptability of product between the oils

Name of the oil	Variation 1	Variation 2	Variation 3	Variation 4
Soyabean oil	4.15	4.75	3.65	4.25
Sunflower oil	4.35	4.65	4.45	4.2
Ground nut oil	4.65	4.4	4.6	4.35
Rice bran oil	4.4	4.4	4.2	4.5

When compared to groundnut oil (4.5%) and rice bran oil (4.37%), the product made with soyabean oil (4.2%) and sunflower oil (4.4%) has a similar taste, according to the table. This is because the blending of the oils alters the puri's flavour and results in a minor variation in its physicochemical characteristics.

1.10 Absorption of oil:

Tab: 1.10.a The amount oil absorption during cooking

Name of the oil	Variations			
	V1	V2	V3	V4
Soyabean oil	4	4	3	5
Rice bran oil	3	5	4	3

Ground nut oil	3	5	7	4
Sunflower oil	2	4	6	3

The table shows that whereas groundnut and sunflower oils absorb a slightly larger range of oil during cooking, soybean and rice bran oils absorb a similar range of oil during product preparation.



Fig: 1.10.b. Puri preparation of individual blended oils a. soyabeen, b. sunflower, c. rice bran, d. groundnut oil

1.11 Statistical analysis:

Tab: 1.11 One Way ANOVA between the different variations of oil blends for sensory evaluation

Attributes	product	Mean ± standard deviation				F-value	p-value
		V1	V2	V3	V4		
Virgin coconut oil blended with soyabeen oil							
Appearance	VCO+SBO	4.4±0.59	4.75±0.44	3.89±0.65	4.15±0.74	6.7666	0.000423
Taste	VCO+SBO	4.2±0.52	4.65±0.58	3.5±0.59	4.15±0.48	15.2412	7.08E-08
Texture	VCO+SBO	4.35±0.48	4.5±0.68	3.45±0.6	4.15±0.67	11.2823	3.34E-06
Odour	VCO+SBO	4.2±0.41	4.75±0.44	3.65±0.67	4.05±0.6	14.0349	2.28E-07
Overall acceptability	VCO+SBO	4.15±0.36	4.75±0.44	3.65±0.48	4.25±0.44	21.1689	4.56E-10
Virgin coconut oil blended with sunflower oil							
Appearance	VCO+SUN	4.7±0.47	4.5±0.68	4.52±0.61	4.35±0.48	1.2606	0.2941
Taste	VCO+SUN	4±0.45	4.55±0.51	4.26±0.56	4.05±0.6	4.3522	0.006997
Texture	VCO+SUN	4.2±0.61	4.45±0.68	4.3±0.47	4.3±0.86	0.4674	0.7059

Odour	VCO+SUN	4.5±0.6	4.45±0.68	4.7±0.47	4.1±0.71	3.1614	0.02935
Overall acceptability	VCO+SUN	4.35±0.87	4.65±0.48	4.45±0.51	4.2±0.61	1.7328	0.1674
Virgin coconut oil blended with groundnut oil							
Appearance	VCO+GUN	4.35±0.48	4.7±0.47	4.5±0.6	4±0.56	6.1004	0.000894
Taste	VCO+GUN	4.3±0.47	4.35±0.81	4.45±0.6	4.3±0.73	0.2242	0.8793
Texture	VCO+GUN	4.35±0.58	4.3±0.73	4.5±0.68	4.2±0.52	0.7674	0.5158
Odour	VCO+GUN	4.15±0.48	4.35±0.67	4.55±0.51	4.35±0.58	1.6477	0.1854
Overall acceptability	VCO+GUN	4.65±0.58	4.4±0.59	4.63±0.49	4.31±0.58	1.6774	0.1792
Virgin coconut oil blended with rice bran oil							
Appearance	VCO+RBO	4.1±0.64	4.25±0.44	4.3±0.65	4.2±0.61	0.4113	0.7454
Taste	VCO+RBO	4±0.72	4.4±0.59	3.85±0.74	4.1±0.78	2.0949	0.10709
Texture	VCO+RBO	4.25±0.63	4.25±0.63	3.9±0.64	4.15±0.93	1.041	0.3794
Odour	VCO+RBO	4.35±0.48	4.3±0.57	4.15±0.74	4.2±0.83	0.3671	0.7769
Overall acceptability	VCO+RBO	4.4±0.5	4.42±0.6	4.2±0.52	4.5±0.6	1.0325	0.3832

NOTE: **Significant at 1% level ($p < 0.01$), * Significant at 5% level ($p < 0.05$), Not Significant at ($> p 0.05$)

There were notable variations in VCO + SBO, especially across all qualities ($p < 0.05$). This indicates that participants had a strong preference for some versions over others. For VCO + SUN, only taste and odour showed statistical significance, suggesting these attributes influenced perception the most. The oils were visibly different for VCO + GUN, but other sensory characteristics were similar. This was the only significant difference. There were no discernible differences between VCO and RBO, suggesting that blending did not provide a noticeable sensory difference.

The sensory preferences of VCO + SBO (Soybean Oil) varied the greatest, with V2 being the most preferred. Moderate differences existed between VCO + SUN and VCO + GUN, but they were not as noticeable outside of certain features. With no significant statistical differences, VCO + RBO was the most stable mix in terms of sensory perception. Generally speaking, the more significant the difference in sensory perception across variables, the higher the F-value and the lower the p-value. According to this investigation, different blended oils have varying effects on sensory qualities; certain blends, like SBO, exhibit more pronounced fluctuations, while others, like RBO, stay constant throughout formulations.

1.12 Conclusion:

Based on the preceding data, it can be concluded that, generally speaking, mixes containing sunflower and soybean oils provide promising outcomes. Therefore, based on the findings of this study, it may be recommended that soy oil be used as a good frying medium oil by the product from a health perspective and that oil blending be done to achieve better outcomes. Adding soybean, sunflower, rice bran, and groundnut oils to

virgin coconut oil creates a special blend of nutritional advantages and improved functional qualities.

Rich in antioxidants and medium-chain triglycerides (MCTs), virgin coconut oil offers a unique flavour along with other health advantages, such as boosted immunity and metabolism. A balanced profile of omega-3 and omega-6 fatty acids is achieved by adding extra polyunsaturated fats, vitamin E, and essential fatty acids to the mixture when it is blended with oils such as soybean, sunflower, rice bran, and peanut.

Having a well-rounded nutritional composition, enhanced stability, and a longer shelf life, this synergy produces a cooking oil mix that may be used in a variety of culinary applications. Such a combination can, all things considered, provide both improved cooking performance and health benefits, making it appealing to consumers who are health-conscious and looking for variety in their cooking oils.

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