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Annexure - I

Institutional Human Ethics Committee Certificate

INSTITUTIONAL HUMAN ETHICS COMMITTEE

Avinashilingam

Institute for Home Science and Higher Education for Women
(Deemed to be University under Category 'A' by MHRD, Estd. u/s 3 of UGC Act 1956) Re-accredited with 'A+' Grade by NAAC.
Recognised by UGC Under Section 12 B
Coimbatore-641 043, Tamil Nadu, India

To
Ms. V.Vishali
Department of Food Service and Management
Avinashilingam Institute for Home Science and
Higher Education for Women
Coimbatore - 641 043

Dear Vishali,

Ref: Your proposal No. IHEC/19-20/FSMD/28 entitled "Development of Healthy Value-Added Cereal Products with blended omega-3 fatty acids and In vitro analysis of Dietary fats" submitted for approval of IHEC.

The Institutional Human Ethics Committee of our University hereby grants approval to your research proposal No. IHEC/19-20/FSMD/28 entitled "Development of Healthy Value-Added Cereal Products with blended omega-3 fatty acids and In vitro analysis of Dietary fats" submitted by you. The Approval number for the same is AUW/IHEC/FSMD-19-20/XPD-28.

We wish you all the best in your research endeavours.

Regards.

Dr.S.Uma Mageshwari
Member Secretary

Institutional Human Ethics Committee

3rd December 2020

Annexure - II

Interview Schedule Elicit Information on "Formulation of Blended Vegetable Oils and Investigation of their Fatty Acid Profile in Cooked Products"

A. BACKGROUND INFORMATION:

1. Name :

2. Age :

3. Address and phone no :

4. Gender
   a) Male b) Female

5. Monthly family income
   a) Rs ≤ 6326 b) Rs 6327-18,952
   c) Rs 18,953-31,590 d) Rs 31,591-47,265
   e) Rs 47,266-63,181 f) Rs 63,182-126,359
   g) Rs ≥ 126,360

6. Educational qualification
   a) Primary b) Secondary c) Higher Secondary
   d) Undergraduate e) Post graduate f) Illiterate

7. Occupation :

8. Tick the type of family and mention number of family members _____
   a) Nuclear family b) Joint family

9. Marital status
   a) Married b) Unmarried

Annexure - III

Dietary Assessment

10. Frequency consumption of fats and oils

Unsaturated fatty acids

S. No	Items	Frequency				
		Daily	**Weekly once**	**Fortnightly**	**Occasionally**	**Amount/ day**
a)	Canola oil					
b)	Flaxseed Oil					
c)	Soybean oil					
d)	Walnut oil					
e)	Salmon oil					
f)	Sardine oil					
g)	Rapeseed oil					
h)	Corn oil					
i)	Sunflower oil					
j)	Olive oil					
k)	Peanut oil					
l)	Groundnut oil					
m)	Gingelly oil					
n)	Refined Sunflower Oil					

Saturated fatty acids

S.no	Items	Frequency				
		Daily	**Weekly once**	**Fortnightly**	**Occasionally**	**Amount / day**
a)	Butter					
b)	Vanaspati					
c)	Cheese					
d)	Ghee					
e)	Palm oil					
f)	Coconut oil					

Annexure - IV

Inventory List

Daily Oil Usage

DAY-1

S.No.	Date	Name of oil	Quantity of oil in ml
1.	Breakfast		
2.	Lunch		
3.	Evening		
4.	Dinner		
	Total	**Consumed**	

Total no of person consumed =

DAY-2

S.NO	Date	Name of oil	Quantity of oil in ml
1.	Breakfast		
2.	Lunch		
3.	Evening		
4.	Dinner		
	Total	**Consumed**	

Total no of person consumed =

DAY-3

S.NO	Date	Name of oil	Quantity of oil in ml
1.	Breakfast		
2.	Lunch		
3.	Evening		
4.	Dinner		
	Total	**Consumed**	

Total no of person consumed =

DAY-4

S.NO	Date	Name of oil	Quantity of oil in ml
1.	Breakfast		
2.	Lunch		
3.	Evening		
4.	Dinner		
	Total	**Consumed**	

Total no of person consumed

DAY-5

S.NO	Date	Name of oil	Quantity of oil in ml
1.	Breakfast		
2.	Lunch		
3.	Evening		
4.	Dinner		
	Total	**Consumed**	

Total no of person consumed =

Annexure - V

Market Survey on Availability of Blended Vegetable Oil

Name of the shop:

Locality of the shop:

S.No.	Name of the Oil	Prize of the Oil	SFA	PUFA	Quantity /Amount	Manufacture Details	Ingredients	Nutrition	SFA	MUFA	PUFA

Annexure -VI

Sensory Evaluation Sheet

Name: Date:

You are requested to rate the given product for appearance, colour, texture, flavor, taste compared to the standard given.

S.No	Name of the Recipe	Appearance	Colour	Texture	Flavour	Taste	Overall acceptance	Standard
	Vadai							
1	BOGN-I							
2	BOGO-II							
3	BOSF-III							
4	BOSFO-IV							
5	BOFO-V							
6	BOEP-VI							
	Stand alone oil							
1	Sunflower oil							
2	Groundnut oil							
3	Gingelly oil							
	Chapatti							
1	BOGN-I							
2	BOGO-II							
3	BOSF-III							
4	BOSFO-IV							
5	BOFO-V							
6	BOEP-VI							
	Stand alone oil							
1	Sunflower oil							
2	Groundnut oil							
3	Gingelly oil							
	Potato Poriyal							
1	BOGN-I							
2	BOGO-II							
3	BOSF-III							
4	BOSFO-IV							
5	BOFO-V							
6	BOEP-VI							
	Potato Poriyal							
1	Sunflower oil							
2	Groundnut oil							
3	Gingelly oil							

Scores: 1-Dislike extremely 2-Dislike very much 3-Dislike moderately 4-Dislike slightly 5-Neither like nor Dislike 6-Like slightly 7-Like moderately 8-Like very much 9-Like extremely

Annexure - VII
Procedure for Colour

The proper functioning of the instrument was ensured and the power key was moved to “ON”. The instrument shows the starting page and transfers to the calibrate page, where in it was calibrated. The “black cavity” and “white board” mentioned in this manual matches the instrument used for calibration. The L,A,B,C,H mentioned in this manual is L*,a*,b*,C*,h.

The color values were displayed by lab, XYZ,RGB,ΔL*a*b, ΔL*C*h, the difference values of sample and tested item were displayed by ΔL*,Δa*,Δb*,ΔC*, Δh, besides Yxy, Yellowness index and Whiteness index, The bottom of the instrument was put into black cavity and placed evenly. Black calibration was done by pressing “Up”, “Down” to choose and “black calibration”.

White calibration was done by pressing the “Up”,“ Down” to choose and White calibrate” after putting the instrument on the white title.“Cancel” was pressed to exit the calibration page and enter the main page.

In order to guarantee the stability of the instrument, it is recommended that the “Black calibrate” and White calibrate” must be completed every time when the instrument is being switched on.

The instrument test aperture was placed on the sample and “test” was pressed where in the result could be viewed on the screen. The name of the sample and test condition were depicted in the title bar. The result displayed as L*, a*,b*was noted.

Formula: $\Delta Ea^*b=\sqrt{(\Delta L^*)^2+(\Delta a^*)^2+(\Delta b^*)^2}$

ΔL^+-White,ΔL^--Black,Δa^+-Red,Δa^--Green,Δb^+-Yellow,Δb^--Blue,L*-Black/White,a*-Red/Green, b*-Yellow/Blue (AOCS Official Method Cc 13e-92. (2017).Color of fats and oil. Lovibond (ISO Method).

Annexure - VIII

Procedure for Refractive Index

Measurement of the refractive index of the sample was done by means of a suitable refractometer.

Apparatus used:

Abbe's Refractometer

(i). Double prism was opened with the help of the screw head and a drop of oil was placed on the prism.

(ii).The prism was firmly closed by tightening the screw heads.

(iii). The temperature of the refractometer was controlled to be within ± 0.1 °C as the refractive index is greatly affected by temperature. To serve this purpose it was provided with a thermostatically controlled water bath and a motor driven pump to circulate water throughout the instrument.

Butyrorefractometer

(i) The reading displayed by the Butyrorefractometer was converted to a refractive index with the help of the table.

(ii) Light Source -If the refractometer is equipped with a compensator, a tungsten lamp or day light may be used or else a monochromatic light such as sodium vapour lamp (589.3 nm) may be used.

Reagent preparation:

The instrument is calibrated with a glass prism of known refractive index (an optical contact with the prism being made by a drop of a bromonaphthalene or by using distilled water which has refractive index of 1.3330 at 20.0°C and1.3306 at 40.0°C, which is the usual temperature of taking readings.

The Abbe's Refractometer was used to find out the refractive index of the oil. Sodiumsulphate in the proportion of one-two grams per 10 grams sample was heated in the oven at50^0 C to remove impurities and traces of moisture. It was ensured that the

sample was completely dry and a stream of water was circulated through the instrument. The temperature of the refractometer was adjusted to desired values and ensured that the prisms are clean anddry. A few drops of the oil was placed on the prism, the prisms were closed and allowed to stand for 1-2 mins. The instrument and lighting was adjusted to obtain the most distinct reading possible and the refractive index or butyro- refractometer number was determined. After recording the measurement, the prism was wiped with tissue to remove the oil. Isopropanol and Pet ether were used to clean the prism for next sample analysis (AOAC-921.08).

Formula:

Determine refractive index at the specified temperature. If temperature correction is necessary use following formula

$$R = R^1 + K\ (T^1T)$$

Where, R=Reading of there fractometer reduced to the specified temperatureT°CR^1 = Reading atT^{10} C

K=constant 0.000365 for fats and 0.000385 for oils (If Abbe Refractometer is used)

Or=0.55for fats and 0.58 for oils (if Butyro- refractometer is used)

T^1 = temperature at which the reading R1 is taken and T = specified temperature (generally40 °C.

Annexure - IX

Procedure for Density

Apparatus used:

- General glassware and apparatus
- Pycnometerfitted with a thermometer of suitable range (with0.1or0.2°Csubdivision) or a density bottle.
- Weighing Balance
- Waterbathmaintainedat30±2.0°C.

Preparation of reagents:

Pycnometerfitted with a thermometer of suitable range (with0.1or 0.2^0 C subdivision), weighing balance and water bath maintained at 30± 2.0^0 C were used to find out the density of oil. The reagents were prepared to find out the density of oil. Standardization of the pycnometer was done before using the equipment. The pycnometer was carefully cleaned by filling it with chronic acid and cleaning solution. It was allowed to stand for several hours, emptied, rinsed thoroughly with water, filled with readily boiled water that has been cooled to about 20^0 C and placed in a constant temperature water bath held at 30^0 C. After30 mins water level was adjusted to the proper point on the pycnometer and the stopper was removed from the bath, wiped and dried with clean wipes/clean cloth.

Finally for analysis, the dry pycnometer was filled with the prepared sample in such a manner that could prevent entrapment of air bubbles after removing the cap of the side arm. The stopper was inserted, immersed in a water bath at 30±2.0^0 C and held for 30 mins. Any trace of oil that has come out of the capillary opening was carefully wiped off. The bottle was removed from the bath, cleaned and dried thoroughly. The cap of the side arm was removed and quickly weighed ensuring that the temperature does not fall below 30^0 C (AOAC 185.19).

Formula:

Carotene content (mg/kg as beta-carotene) = 383E

Txc

Where,

E=Observed difference in absorption between sample solution

and cyclo hexane

t = path length of the cell

c = concentration used for absorption measurement

Annexure - X

Procedure for Viscosity

The specific details of operation vary for the different types of viscometers listed in Table 1. In all cases, however, proceed in accordance with maintain the bath at the test temperature within the limits.

- Apply, the necessary corrections, if any, to all thermometer readings.
- Ascertain that the ice-point of the thermometer has been determined recently and the corrections, if any, applied to the calibration values. The possible change in the ice-point reading of new thermometers may require a check every week.
- Select a clean dry, calibrated viscometer having a range covering the estimated viscosity (that is, a wide capillary for a very viscous liquid and a narrower capillary for a more fluid liquid). The flow time should not be less than 200 seconds.
- When the temperature of the test is below the dew point, fit loosely packed drying tubes on to the open ends of the viscometer to prevent water condensation. Drying tubes shall fit the design of the viscometer and not restrict the~ flow of the sample under test by pressure created in the instrument. At temperatures below OX, it may be advisable to charge the sample into the viscometer at ambient temperature; allow the viscometer to cool to bath temperature, keeping sample in the working capillary to prevent slight accumulation of frost on the walls of the capillary.
- Viscometers used for silicone fluids, fluoro-carbons, and other liquids which are difficult to r9move by the use of a cleaning agent, should be reserved for the exclusive use of those fluids except when calibrating. Such viscometers should be subjected to calibration checks at frequent intervals.
- Charge the viscometer in the manner dictated by the design of the instrument, this operation being in conformity with that employed

when the instrument was calibrated. Should the sample contain solid particles, filter during charging through a 75-micron IS Sieve.

- With certain products which exhibit ‘gel-like ’behaviour, take care that measurements are made at sufficiently high temperatures for such materials to flow freely so that similar results will be obtained in viscometers of different capillary diameters.
- The viscosity of steam refined cylinder oils, black lubricating oils, residual fuel oils, and similar waxy products can beaffected by the previous thermal history. The following preheating procedure should be followed to obtain uniform results for viscosities below 95°C. 6.X 2.1 To obtain a representative sample, heat in the original container to about 50°C with stirring and shaking. Probe the bottom of the container with a rod to be certain that all waxy materials are in solution. Pour 100 ml into a 125-ml flask. Stopper loosely with a cork or rubber stopper. Immerse the flask in a bath of boiling water for 30 minutes. Mix well, remove the sample from the bath, and strain it through a 75-micron IS sieve directly into the viscometer already in the thermostated bath. Complete the viscosity test within 1 hour after preheating.
- Allow the charged viscometer to remain in the bath long enough to reach the test temperature. Because this time will vary for the different instruments and for different temperatures, establish a safe temperature equilibrium time by trial (30 minutes should be sufficient). Where design of the viscometer requires it, adjust the volume of the test sample after the sample has reached temperature equilibrium. One bath is often used to accommodate several viscometers. Never add or withdraw a viscometer while any other viscometer is in use for measuring a flow time.
- Use suction (if the sample contains no volatile constituents) or pressure to adjust the head level of the test sample to a position in the capillary arm of the instrument about 5 mm ahead of the first timing mark. With the sample flowing freely, measure in seconds, to within O-2 seconds,

the time required for the meniscus to pass from the first timing mark to the second. If this flow time is less than the specified minimum, select a viscometer with a capillary of smaller diameter and repeat the operation.

- 6.5.1 For modified Ostwald and suspended level types, repeat the procedure described in -6.5 to make a second measurement of the flow time. For reverse-flow viscometers, use the same or another unit and begin at 6.3 to make the second measurement.
- If two measurements agree within 0.2 percent, use the average for calculating the reported kinematic viscosity. time should agree within~0*35 percent. For reverse-flow types, flow If these agreements axe not obtained, reject the test results.

Annexure - XI
Procedure for Peroxide Value

To test the oxidative stability of the blended oil, the peroxide value was analyzed by adding fives milliliters of oil sample to 12 ml of chloroform in 25 ml beaker. Potassium iodide KI solution (0.5-1.0 ml) was added to the beaker. The beaker was shaken for at least one minute and 30 ml distilled water was added. The mixture was titrated with sodium thiosulphate (0.01M) until the disappearance yellow color and the peroxide value (Annexure-XI) calculated using the formula

$$\text{Peroxide Value} = \frac{\text{Titre} \times N \times 1000}{\text{Wt of sample}}$$

Where,

Titre = mL of Sodium Thiosulphate used (blank corrected)

N = Normality of sodium thiosulphate solution (0.01M).

Where,

Titre = mL of Sodium Thiosulphate used (blank corrected)

N = Normality of sodium thiosulphate solution.

Annexure - XII

Procedure for Iodine value

To determine the iodine number using the Wijs method, weigh 0.3-0.5g of the oil sample into a conical flask. Add 25mL of chloroform and 25mL of Wijs solution (iodine monochloride solution in acetic acid). Stopper the flask and swirl gently for 30 minutes in the dark at room temperature. After 30 minutes, add 30mL of potassium iodide solution (15% w/v) and 100mL of water to the mixture. Titrate the liberated iodine with 0.1N sodium thiosulfate solution until the yellow color almost disappears. Add a few drops of starch solution as indicator and continue titrating until the blue color disappears. Record the volume of sodium thiosulfate used (Annexure-XII) Calculate the iodine number (Wijs) using the formula:

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

B = volume in ml of standard sodium thiosulphate solution required for the blank.

S = volume in ml of standard sodium thiosulphate solution required for the sample.

N = normality of the standard sodium thiosulphate solution.

W = weight in g of the sample.

Units: g of iodine per 100 g oil

Annexure - XIII

Procedure for Saponification Value

The saponification value is an important parameter used for the characterization and assessment of the quality of edible fats and oils. To understand the average molecular weight of the fatty acids present in the formulated blended vegetable oils the saponification value was estimated. For this two to five grams of oil sample was accurately weighed and transferred to the conical flask. Twenty five milliliters of 0.5M alcoholic potassium hydroxide (KOH) and a few anti-bumping granules were added to the conical flask. The conical flask was placed in a water bath and reflux gently for one hour. Care was taken to prevent loss of alcohol. After refluxing, the mixture was cooled and titratedagainst 0.5M hydrochloric acid (HCl) solution using phenolphthalein as an indicator. The quantum of hydrochloric acid used was noted. The saponification value of blended oil was calculated using the formula :(Annexure – XIII)

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

Where,

B = Volume in ml of standard hydrochloric acid required for the blank.

S = Volume in ml of standard hydrochloric acid required for the sample

N = Normality of the standard hydrochloric acid (0.5N) and

W = Weight in g of the oil taken for the test.

Units: mg of KOH/1 g oil or fat

Annexure - XIV

Procedure for Acid Value

Acid value (AV), which measures free fatty acid content, is a crucial component in determining how refined fats and oils and how their quality varies over time. The hydrolysis of triglycerides leads to the generation of free fatty acids, which is aggravated when moisture reacts with the oil. To measure the acid value, two to five grams of the oil sample was weighed and transferred into a conical flask. A few drops of phenolphthalein indicator was added along with 50 ml of neutralized isopropyl alcohol. Potassium hydroxide (KOH) solution (0.1M) was used to mixture until a steady pink hue developed(Annexure – XIV). The acid value was calculated using the formula

$$\text{Acid value} = \text{Where,} \quad \frac{56.1 \times V \times N}{W}$$

Where, V = Volume in ml of standard sodium hydroxide used

N = Normality of the Sodium hydroxide solution (0.1N) and

W = Weight in g of the sample Acid value = % fatty acid (as oleic) 1.99.

Annexure - XV

Procedure for Free Fatty Acids

Fifty milliliters of alcohol were taken in a clean, dry 150 ml flask. A few drops of the oil was added along with 2 ml of phenolphthalein. The flask was placed in water at 60-65℃ until it turned warm and enoughof0.1MNaOHwas added to produce faint permanent pink colour. Then, 56.4g oil was weighed into the neutralized alcohol and titrated against 0.1MNaOH, with occasional warming and vigorous shaking of the mixture until the appearance of faint permanent pink in supernatant alcohol. The volume of 0.1MNaOH used was multiplied by 0.05 and reported as percent of free fatty acids and was expressed in terms of oleic acid (Annexure – XV).

Free fatty acids may also be expressed in terms of acid value (mgKOH necessary to neutralize 1g oil) (AOAC-940.28).

$$\text{Free fatty acids (as oleic acid \%)} = \frac{\text{Titre Volume x Strength of NaOH x28.2}}{\text{Sample Weight}}$$

Here, strength of NaOH =0.1N

Annexure - XVI

Procedure for Alpha Tocopherols

To describe method for determination of Vitamin A&E in food and feed products by HPLC – UV/PDA/FLD

Scope:

To determine Vitamin A&E in Food, Feed and Premix products using High performance Liquid Chromatography – UV/PDA/FLD

Abbreviation:

HPLC-UV- High Performance Liquid Chromatography with UV Detector/PDA/FLD

Principle:

Sample is Saponified using KOH and neutralized with acetic acid. Ethanol: Tetrahydrofuran mixture is added and vitamin E is extracted and quantified using HPLC-. UV/PDA/FLD

Equipment:

HPLC with UV Detector and Column/PDA/FLD

Analytical Balance

Sonicator and Vortex Mixer

Micropipettes

Volumetric Flasks

Water bath with chiller

Reagents:

Tetra Hydro Furan – HPLC Grade

50 % Potassium hydroxide: 250g (KOH) is dissolved in 500ml water.

Methanol – HPLC grade

Ethanol – HPLC Grade 95 %

Antioxidant-BHA or BHT or Pyrogallic acid

Standard – Vitamin A

Milli- Q Water

Glacial Acetic Acid – HPLC grade

Sample Preparation and Extraction:

Take 5-10 g of finely homogenized grounded sample, Food or Feed in a 250 ml round bottom flask.

- Add 40 ml 95 % Ethanol and 10 ml of 50 % KOH.
- Add a Pinch of BHT or BHA or Pyrogallic acid for antioxidant.
- Reflux the solution in boiling water bath up to 45-60 minutes.
- After Saponification, Cool the content and add 10ml of glacial acetic acid.
- Make up the content to 100 ml with THF: Ethanol (50:50) Mixture.
- Shake the sample well and Keep it refrigeration for 16 hours.
- Filter the sample through 0.45 µm filter unit and inject in HPLC for analysis.

Standards Preparation:

Preparation of Stock Standard Solution:

- Prepare stock solution of 1000ppm (approximately) by dissolving 10mg of standard (Vitamin A Retinol Acetate) in 10 ml of Methanol.
- Preparation of Working Standard Solution:
- Prepare working standards at 100ppm from the stock solution. The required linearity range standards (0.5, 1.0, 3, 5.0 10.0and 20mg/kg) by appropriate dilutions from working standard solution. Diluent Methanol.

Instrument Condition:

HPLC Conditions:

Mobile Phase : Methanol

Flow rate : 1.0 mL/minute

Column : C18, 4.6X250 mm, 5 micron or equivalent

Injection Volume : 25 µl

UV Detector : 328nm

Runtime : 30 minutes

Calculation:

$$\text{Vitamin E (µg/Kg) by mass} = \frac{\text{Area of Sample X Standard Weight X Sample dilution}}{\text{Area of Standard X Sample Weight X Standard dilution}} \times \text{Purity}$$

Quality Control data and Acceptance Criteria:

Item	Concentration (ppm)	Acceptance Criteria	Frequency
Calibration Curve	0.5,1.0,3.0,5.0, 10, 20,	r>0.995	Every day
Calibration Standard check	3 ppm	Recovery 90-110%	Every day
Method Blank	< 0.1		Every day
Sample Spike / Duplicate	10 ppm	Recovery 80-120%	Every day

Appendices / Forms: Nil

References:

- Commission Directive 2000/45/EC of July 2000 establishing the community methods of analysis for the determination of Vitamin A, Vitamin E and Tryptophan in feeding Stuff.
- AOAC Official method – 2012.09 Vitamin A and Vitamin E in Infant Formula and adult/Pediatric Nutritional Formula.
- AOAC Official method – Int.85.424 (2002).

Annexure - XVII

Procedure for Fatty acids Profile of Blended Oil

This SOP describes the procedure for the determination of fatty acid profile of oils .

Procedure

Reagents

- NaOH
- Na2SO4
- Methanol
- Hexane

Preparation of standard

FAME standard (1 ml in DCM) of varied conc. is purchased from Accu standard. Make up the volume to 10 ml with the same solvent. Label it with name of the standard. Label expiry date and store the solution in a refrigerator at 2-8°C.

Sample Preparation

- Take 100 ul of fat sample extracted from foods, pipet 2 ml of 8% (w/v)

Methanolic sodium methoxide solution (2M).

- The transesterification time starts with the addition of the first drop. Close the tube and shake well for 10s using a vortex mixture.
- After 2 min open the tube and add 2 ml of hexane. Shake gently using a vortex mixture. The trans esterification time should not exceed 4 min.
- Collect the hexane layer and transfer to an expend or of tube with 50 mg of sodium sulphate. Vortex well and centrifuge at 1500 rpm for 3 min.
- Collect the hexane layer and filter through 0.22 um filter and inject in GC-FID.

Fatty acid Identification

- Identify the fatty acids in the sample solution chromatogram and by comparing their retention times with those of the corresponding peaks

Calculation

- Calculate the percentage of the MUFA, PUFA and saturated fatty acids from the total area of the fatty acids.

Annexure - XVIII

Procedure for Oil Extraction from Cooked Products

First of all, rinse all the glass apparatus by petroleum ether and dry it in the oven at 102°c and after removing it keep in the desiccator.

2. Weigh 5 gram of grounded and dried sample and place it in the thimble.

3. Place the thimble in the soxhlet extractor.

4. Take a 150ml round bottom ask and clean it and ll the ask with 90 ml petroleum ether.

5. Place the whole setting on a heating mantle and allow the petroleum ether to boil.

6. Continue the extraction process for several hours, almost 6 hours.

7. Remove the condensing unit from extraction unit and allow the sample to cool down. Finally, it removes all the lipid.

8. Collect almost all the solvent after distillation.

9. Place the sample in the oven and after removing it place in the desiccator.

10. Take the weight of the sample.

11. As a result, we get a defat sample.

Calculation:

Empty thimble= w1

Thimble with sample= w2

Weight of sample= p

Fat percentage = $\frac{\text{Weight of flask with extracted fat- weight of empty Flask x 100}}{\text{Sample weight}}$

This method is ancient method to extract all the fat present in the food. Hence it is used in oil extraction units for better recovery of oil. This method is also applied to the deoiled cake which is collected from screw impellers rather than high-pressure expression. It is also used in the analysis of fat present in the sample.

Annexure- XIX

Consent Letter

Informed Consent

If you are uncomfortable in answering any of our questions during the course of the interview / biological sample collection, you have the right to withdraw from the interview / study at any time. You have the freedom to withdraw from the study at any point of time. You will NOT be paid any remuneration for the time you spend with us for this interview / study. The information provided by you will be kept in strict confidence. Under no circumstances shall we reveal the identity of the respondent or their families to anyone. The information that we collect shall be used for approved research purposespurposes only. You will be informed about any significant new findings – including adverse events, if any – whether directly or indirectly related to you or to other participants of this study, developed during the course of this research which may relate to your willingness to continue participation

Consent: The above information regarding the study, has been read by me/ read to me, and has been explained to me by the investigator(s). Having understood the same, I hereby give my consent to them to interview me. P. Chitra affixing my signature / left thumb impression to indicate my consent and willingness to participate in this study (i.e., willingly abide by the project requirements)

P. Chitra

Signature / Left thumb impression of the Study Volunteer / Legal Representative

V Vishali 23.10.2020

Signature of the Interviewer with date

P. Sangeetha

Signature of the Witness with name

Annexure - XX

Dr. T.S.Avinashilingam Fellowship (Circular)

Avinashilingam Ins...
and Higher Educ...
(University Estd u/s 3 of UGC Act 1956)
Coimbatore - 641 043.

19.04.2021

No. AIHS&HE/FS/2021-22//6

CIRCULAR

We are pleased to announce the selection of students for getting Endowment scholarships for UG/PG students and Dr.T.S. Avinashilingam Fellowship for Research Scholars for the year 2020-21 as detailed in the enclosed annexure III & IV.

The concerned beneficiary students are requested to upload the first page of the bank passbook in the link https://tinyurl.com/4artdupc so that, the amount of scholarship/fellowship can be credited to their account on or before 30.04.2021 positively without fail.

S. Ramadas
REGISTRAR

The circular may be also hosted in our Institute website.

To

1. All Deans
2. HoDs
3. Director, Campus II
4. Dean, Engineering
5. Computer Centre

Annexure - XXI

Certificate of Accreditation

National Accreditation Board for Testing and Calibration Laboratories

NABL

CERTIFICATE OF ACCREDITATION

SRI SHAKTHI FOOD TESTING LABORATORY

has been assessed and accredited in accordance with the standard

ISO/IEC 17025:2017

"General Requirements for the Competence of Testing & Calibration Laboratories"

for its facilities at

9/1, V.K.L.NAGAR, THUDIYALUR, COIMBATORE NORTH, COIMBATORE, TAMIL NADU, INDIA

in the field of

TESTING

Certificate Number: TC-10001

Issue Date: 18/10/2021 Valid Until: 17/10/2023

This certificate remains valid for the Scope of Accreditation as specified in the annexure subject to continued satisfactory compliance to the above standard & the relevant requirements of NABL.
(To see the scope of accreditation of this laboratory, you may also visit NABL website www.nabl-india.org)

Name of Legal Identity : SRI SHAKTHI FOOD TESTING LABORATORY

Signed for and on behalf of NABL

N. Venkateswaran
Chief Executive Officer

Annexure - XXII

List of UGC Care Publications

Avinashilingam Institute for HomeScience and Higher Education for Women
(Deemed to be University Estd. u/s 3 of UGC Act 1956, Category 'A' by MHRD
Re-accredited with A++ Grade by NAAC. CGPA 3.65/4, Category I by UGC
Coimbatore - 641 043, Tamil Nadu, India

Appendix L2 (Item No 5 of Check List) Details of Research Publications

S.No	Article	Journal	Other Details Vol/No/Page No/ Year	Published in UGC-CARE / Scopus Indexed/ Web of Science
1	Physio chemical Properties and Fatty Acid Profile of Blended Vegetable Oil	The Indian Journal of Nutrition and Dietetics	Vol 60 (4), October-December 2023, Page number- 558-571	UGC CARE-I Journal
2	Fatty Acid Profiling Of Blended Vegetable Oil For Diversified Dietary Needs	The Indian Journal of Home Science	Vol.36, No. 1, January 2024, Page number-396-403	UGC CARE-I Journal

*Proof of list of Journals from Internet to be attached along with copies of reprints.

Scholar : V.Vishali

Supervisor : Dr.V. Premala Priyadharsini

The scholar Miss. Vishali, V (19PHFDF001) has published her research article in the following journals:

1. The Indian Journal of Nutrition and Dietetics - indexed & active in UGC Care List Group I from January 2021 to present and
2. The Indian Journal of Home Science - indexed and active in UGC Care List Group I from July 2020 to present.

This may be considered.

3/7/24

Checked By:

HoD/Dean of Respective School

03.07.2024

The Indian Journal of Nutrition and Dietetics
ISSN: 0022-3174; eISSN: 2348-621X
www.ijndonline.org

DOI:10.21048/IJND.2023.60.4.35556

Physico Chemical Properties and Fatty Acid Profile of Blended Vegetable Oil

Vishali, V. and Premala Priyadharsini, V.

(Department of Food Service Management and Dietetics)
Avinashilingam Institute for Home Science and Higher Education for Women, Coimbatore - 641 043)

email: vishalilekha97@gmail.com

(Received 4th January, 2023)

Abstract

Modifying dietary fat intake is essential for reducing and preventing cardiovascular disease risk. In recent years, blending oil has shown to be a more commercially viable method of improving the nutrient profile of oil while preserving a balanced fatty acid composition. The present study aims at designing blended oil and analysing its physicochemical properties and fatty acids profile. Flaxseed, groundnut, safflower, gingelly, and sunflower oil were acquired from retail outlets in Coimbatore. All five vegetable oils were combined into two blends: blended oil - I (Sunflower - 50 ml: Flaxseed-12.5 ml: Groundnut-12.5 ml: Gingelly-12.5 ml: Safflower-12.5 ml) and blended oil - II (Safflower -50 ml: Flaxseed-12.5 ml: Sunflower-12.5 ml: Groundnut-12.5 ml: Gingelly -12.5 ml). The physical and chemical properties of the blended vegetable oil. Fatty acids profiling of blended oil was carried out using the standard procedure using Gas Chromatography Flame Ionization Detector. Modified oil was equally beneficial in terms of fatty acid composition. The peroxide values of blended oil-I and II was found to be 0.1 Meq/kg and 0.1 Meq/kg, respectively. The saturated fatty acid content of blended oil I and II were found to be 26.67±2.08 and 16.67±2.08, respectively, whereas the monounsaturated fatty acid content of both blended oil I and II was reported to be 28.67±2.08. The polyunsaturated fatty acid content of blended oil I and II were observed to be 39.67±2.08 and 39.33± 2.08, respectively. Thus the formulated blended oil with the combination of different types of oil was suggested to be superior compared to common cooking oil like sunflower and safflower oil.

Keywords: *Vegetable oils, polyunsaturated fatty acids, saturated fatty acids, monounsaturated fatty acids, trans fatty acids and blended oil*

Introduction

Cardiovascular disease has become more prevalent and a great challenge in recent years, particularly among young adults[1]. Clinical and observational data suggest that the quantity and type of dietary fat should be the main dietary recommendations for lowering cardiovascular disease-related morbidity and mortality[2-4].

Unsaturated fatty acids such as monounsaturated and polyunsaturated fatty acids, play a prominent role in the development of numerous cell membranes and regulate hormones relating to the clotting of blood, vaso-constriction, and vasodilation of arterial walls. Studies show that shortages in these fatty acids can raise the risk for cardiovascular and inflammatory illnesses[5]. As rightly pointed out by Simakova *et al*[6] the body's requirement for polyunsaturated fatty acids is not constant; it varies with age, type of work, lifestyle situations, particularly climatic conditions, health, and other factors.

Omega-3 and omega-6 fatty acids are two main components in polyunsaturated fats that are quite beneficial in decreasing cholesterol levels thereby diminishing the production of thromboxane in our bodies[7]. Usage of single vegetable oil, alone do not provide a good balance of all necessary nutritional and therapeutic components, as they may lack some of the essential fatty acids namely n-6 and n-3, which are extremely beneficial in lipid metabolism, and in preventing cardiac illnesses[8]. Recent reviews show that using the right oil mixes can lower cholesterol and triacylglycerol levels in the blood and liver[9].

Blending of oil can improve the quantum of the essential fatty acids and physicochemical properties of vegetable oils and decrease the rate of oxidation and viscosity of oil to make more functional[10]. The rate of oxidation and viscosity can be reduced by blending oils with high stability and good functional qualities[11]. Since blending of oil with multiple vegetable oil is less attempted this study aims at blending of multiple vegetable oil and to test their organoleptic quality, physical and chemical characteristic and their fatty acid profile on different methods of cooking.

Materials and Methods

Selection and procurement of the vegetable oil

For the present study, five different types of cooking oils were used for blending. The oils were selected based on the fatty acids quality. Sunflower oil is India's most popular cooking oils and it contains desirable polyunsaturated (62.65), monounsaturated (25.96) and saturated fatty acids (11.39). Safflower oil contains a high linoleic acid (omega-6) and oleic acid (omega-9). Safflower oil is rich in polyunsaturated (76.78), monounsaturated fatty acids (14.04) and saturated fatty acids

(9.19). Flaxseed oil contributes a high amount of linolenic acid, oleic, linoleic, stearic and palmitic acid[12].

Groundnut oil otherwise called as peanut oil is widely used in cooking in many parts of India and is also rich in monounsaturated (53.89), polyunsaturated (27.17) and saturated fatty acids (18.94).

Gingelly oil (or) sesame oil is the most popular among south Indian population. Gingelly oil contains cooking oil and equal proportion of polyunsaturated (42.34), monounsaturated (41.41) and saturated (16.25) fatty acids.

Thus, the above vegetable oils were selected for blending based on their polyunsaturated fatty acids content. The selected vegetable oils were purchased from retail shops in Coimbatore and were stored in clean air tight container.

TABLE I

Formulation of Blended oil

Variation	Cooking oil, used for blending	Quantity used (ml)
BOSF01	Safflower oil	50
	Flaxseed oil	12.5
	Groundnut oil	12.5
	Gingelly oil	12.5
	Sunflower oil	12.5
	Total	100
BOSN02	Sunflower oil	50
	Safflower oil	12.5
	Flaxseed oil	12.5
	Groundnut oil	12.5
	Gingelly oil	12.5
	Total	100

The purchased vegetable oils were formulated into two variation of blends and were coded as given in Table I. The formulated oils for blending were taken in a conical flask and shaken for 90 rpm using an orbital shaker at 37ºC for 24 hours and was kept in the sonicator for two seconds. The blended oil was then transferred into an airtight container[13].

Organoleptic evaluation of recipes fried in blended oil

The organoleptic evaluation of the recipes fried in blended oils was carried out for three methods of frying namely, deep frying (vadai), pan frying (chapati) and sautéing (potato poriyal).

Vadai (deep fat frying), chapati (pan frying) and potato poriyal (sautéing) were fried using the blended oils and were subjected for sensory evaluation by a panel of 20 semi-trained members. The members were asked to rate each sensory characteristic namely colour, appearance, texture, flavour, and taste of the selected recipes on a scale of nine point hedonic scale ranging from, like extremely to dislike extremely, with a maximum score of 45 and a minimum score of 5. The mean acceptability score for each sensory attributes and overall acceptability score was calculated

and compared with same recipes cooked in common cooking oils namely sunflower oil, groundnut oil and gingelly oil. The difference in the acceptability score was evaluated statistically using t-test.

Chemical parameters of blended oils

Using standard procedure (AOAC 996.06)- (AOAC, 2019) the chemical characteristics such as peroxide value, iodine value, saponification value, and acid value were analyzed[14]. The color of the blended oil was measured using colour reader (Gowegroup Mutitesters). The smoking temperature of blended oil was measured using digital food thermometer (Thermopro).

Quantitative analysis of fatty acid profile of recipes fried in blended oil

Quantitative analysis for the fatty acids profile of blended oils I and II was carried out using the Gas Chromatography-Flame Ionization detection method[13]. The fat samples (100 µl) were taken in a test tube. The mouth of the test tube was closed and shaken well for 10 seconds using a vortex mixer. The test tube was made to rest for two minutes and 2 ml of hexane was added and shaken well for four minutes. To the sample, 50 ml of sodium sulfate was added and centrifuged at 1500 rpm for three minutes. The hexane layer was collected through a 0.22 µm filter and injected into Gas Chromatography - Flame Ionization for detection. The fatty acids profile of the blended oils was recognized in a chromatogram by comparing their retention time to that of the corresponding peak. The samples were analysed in triplicate for reliability. The quantitative analysis of fatty acids in cooked products was carried out by extracting the oil from the cooked products (potato poriyal) using soxhlet extraction. The extracted oil was analyzed for its fatty acid profile using Gas Chromatography Flame Ionization Detector (GC-FID- AOAC 996.06) - (AOAC, 2019).

The ethical clearance for the present study was obtained from Avinashilingam Institute for Home Science and Higher Education for Women's Institutional Human Ethics Committee (AUW/IHEC-17-18/FSMD/FHP-02).

Results and Discussion

The organoleptic characteristics of vadai prepared by deep fat frying using blended oils I and II were analysed and compared with that of the vadai cooked in sunflower oil, gingelly oil and groundnut oil (Table II).

No significant difference in the overall acceptability of vadai was observed between the blended oil-I 38.34±0.28 and blended oil- II 38.31±0.17 and commonly used cooking oil (sunflower oil- 38.34±0.26, gingelly oil- 38.48±0.12 and groundnut

TABLE II
Organoleptic Evaluation of Blended oil I and II Deep Fried Food Products (Vadai)

Method of frying	Blended oils and Commonly cooking oils	Organoleptic evaluation						
		Colour	Flavour	Texture	Taste	Appearance	Overall Acceptability	P value
Deep frying	Blended oil-I	7.29±0.21	8.1±0.04	7.69±0.65	7.61±0.32	7.76±0.43	38.34±0.28	BOSF01 *Vs* Sunflower oil -0.1583^{ns}:
	Blended oil-II	7.52±0.31	7.22±0.24	7.44±0.19	7.4±0.13	7.31±0.48	38.31±0.17	BOSF01 *Vs* Gingelly oil- 0.2106^{ns}:
	Sunflower oil	7.34±0.13	7.67±0.60	7.42±0.41	7.48±0.43	7.4±0.13	38.34±0.26	BOSF01 *Vs* Groundnut oil- 0.1149^{ns}:
	Gingelly oil	7.74±0.28	7.34±0.36	7.44±0.42	7.29±0.30	7.52±0.2	38.48±0.12	BOSN02 *Vs* Sunflower oil- 0.1682^{ns}
	Groundnut oil	7.54±0.09	7.13±0.17	7.52±0.31	7.35±0.095	7.61±0.24	38.50±0.07	BOSN02 *Vs* Groundnut oil-.02239^{ns}
								BOSN02 *Vs* Gingelly oil- 0.1083^{ns}

** 1 per cent level of significance, * 5 per cent level of significance, ns- Not significant

TABLE III
Organoleptic Evaluation of Blended oil I and II Pan Fried Food Product (Chapati)

Method of frying	Blended oils and Commonly cooking oils	Organoleptic evaluation						
		Colour	Flavour	Texture	Taste	Appearance	Overall Acceptability	P value
Deep frying	Blended oil-I	7.42±0.06	7.59±0.25	7.29±0.2	7.75±0.08	7.41±0.15	38.27±0.13	BOSF01 Vs Sunflower oil -0.0279*
	Blended oil-II	8.31±0.14	7.45±0.06	7.31±0.22	7.27±0.56	8.46±0.16	38.45±0.15	BOSF01 *Vs* Gingelly oil- 0.0220*
	Sunflower oil	7.47±0.259	7.62±0.19	7.61±0.31	7.5±0.47	7.59±0.12	39.23±0.18	BOSF01 *Vs* Groundnut oil- 0.0142*
	Gingelly oil	8.18±0.17	8.18±0.22	8.20±0.18	7.41±0.29	7.41±0.19	39.37±0.11	BOSN02 *Vs* Sunflower oil- 0.0368*
	Groundnut oil	8.22±0.16	8.20±0.13	8.23±0.29	8.30±0.43	8.14±0.29	39.67±0.24	BOSN02 *Vs* Groundnut oil- 0.0257*
								BOSN02 *Vs* Gingelly oil- 0.184*

** 1 per cent level of significance, * 5 per cent level of significance, ns- Not significant

TABLE IV

Organoleptic Evaluation of Blended oil I and II Sauted Food Product (Potato Poriyal)

Method of frying	Blended oils and Commonly cooking oils	Organoleptic evaluation						
		Colour	Flavour	Texture	Taste	Appearance	Overall Acceptability	P value
Deep frying	Blended oil-I	7.31±0.04	7.57±0.08	7.72±0.25	7.56±0.13	7.46±0.16	38.02±0.28	BOSF01 *Vs* Sunflower oil -0.0050**
	Blended oil-II	6.31±0.13	6.24±0.10	6.95±0.49	5.33±0.12	6.24±0.10	30.4±0.10	BOSF01 *Vs* Gingelly oil- 0.0072**
	Sunflower oil	7.65±0.21	7.52±0.31	7.46±0.19	7.68±0.43	7.46±0.215	39.3±0.19	BOSF01 *Vs* Groundnut oil- 0.0142*
	Gingelly oil	7.37±0.33	7.58±0.26	7.38±0.32	7.48±0.37	7.44±0.30	39.22±0.36	BOSN02 *Vs* Sunflower oil- 0.0001**
	Groundnut oil	8.08±0.075	8.31±0.22	7.58±0.26	7.67±0.21	7.39±0.049	39.68±0.20	BOSN02 *Vs* Groundnut oil- 0.0001**
								BOSN02 *Vs* Gingelly oil- 0.0001**

** 1 per cent level of significance, * 5 per cent level of significance, ns- Not significant

TABLE V

Physical Properties of Blended Oils with Common Cooking Oils

Parameters	Sunflower oil	Groundnut oil	Gingelly oil	Blended oil-I	Blended oil-II
Colour (groove/mm)	White 11.71	Reddish yellow 10.61	Yellowish red 10.51	Intense Yellow 13.51	Pale Yellow 20.06
Viscosity (CPS)	60	79	55	55	62
Odour	Bland odour	Nutty smell	Nutty smell	Flaxseed oil smell dominating	Slight flaxseed oil smell
Texture	Viscous liquid	Viscous liquid	Viscous liquid	Viscous liquid	Viscous liquid

TABLE VI

Chemical Characteristics of the Blended Oil

Chemical properties	Safflower oil	Blended oil-I	t-value	Sunflower oil	Blended oil-II	t-value
Peroxide value (Meq/kg)	5.99	<0.1	-	4.36	<0.1	-
Iodine value (g)	151.29 ± 2.08	145.02± 2.08	3.6889*	120.21±2.08	136.86 ± 2.08	9.1488**
Saponification value (Mg/KOH)	193.66 ± 3	183.18 ± 2	5.5775**	193.06 ± 2	185.167 ± 2	4.6480**
Acid value (Mg/KOH/g) oil	2.14 ± 2.08	2.59 ± 2.08	0.2648^{ns}	1.32 ± 2.08	2.85 ± 2.08	0.9002*
Smoking Point	232.66 ± 2.08	185.5 ± 2.08	27.122**	238.67 ± 2.08	181.67 ± 2.08	33.5359**

**1 per cent level of significance: * 5 per cent level of significance: ns not significant

oil- 38.50±0.07). Thus it can be inferred that the blended oil I and II was in par with commonly consumed oil in terms of its organoleptic quality. It was observed that the colour of blended oil II to be more appealing than that of sunflower oil and the texture in par with that of gingelly oil. It was also observed that the taste of the vadai fried in blended oil- II to be more appealing on comparison with that of all the commonly used cooking oils (Table II).

The organoleptic characteristics of chapati prepared by pan frying using blended oils I and II was analysed and compared with that of the chapati cooked in sunflower oil, gingelly oil and groundnut oil (Table III).

Whereas a five per cent significant difference in the organoleptic score was observed among the chapati pan fried in blended oil and common cooking oil (Table III). The difference in score can be attributed to the after taste and flavour of safflower oil[15].

The organoleptic characteristics of potato poriyal prepared by sauted using blended oils I and II was analysed and compared with that of the potato poriyal cooked in sunflower oil, gingelly oil and groundnut oil (Table IV).

Organoleptic evaluation of blended oils for sauted food product

For sautéing a significant difference in the overall sensory quality of potato poriyal sauted in blended oils I and II were observed at one per cent level of significance. The overall acceptability score of blended oil-I (38.02±0.8) was slightly lower than the oils (sunflower oil- 39.3±0.19, gingelly oil- 39.22±0.36 and groundnut oil- 39.68 ±0.20) and the difference in score was statistically significant at one per cent level (Table IV).

Comparison of physical properties of blended oils with common oils

The colour of the blended oil-I a* is positive and b* is positive and it denotes intense yellow colour. Whereas the blended oil-II (20.06) a* and b* is positive it denotes pale yellow colour. Thus it can be inferred that the appearance of the formulated blended oil is in par with commonly consumed cooking oil namely gingelly and groundnut oil. The viscosity of the blended oil-I and II was found to be 55 and 62 Centipoise (CPS). From the study it was observed that the viscosity of blended oil-I to be similar to that of the gingelly oil [55 Centipoise (CPS)], similarly the viscosity of the blended oil-II was more or less similar to that of the sunflower oil [60 Centipoise (CPS)]. The texture of the blended oil was non-greasy and had a pleasant mouth feel texture, and it had a distinct nutty aroma that could be is due to the acetic acid that was present in flaxseed oil (Table V).

Chemical characteristics of blended oils

On studying the physicochemical characteristic of blended oils I and II, it was observed that the peroxide values of both the blended oils I and II to be <0.1 Meq/kg which is lesser than the peroxide value of sunflower 4.36 and safflower oil 5.99. The peroxide value can be used to track the production of peroxides during the initial stages of oxidation and thereafter its likeliness of becoming rancid[14,18]. A harmful peroxide value was one greater than 10 to 20 meq/kg[15]. From the table, it is clear that both I and II have less peroxide value indicating a good oxidative stability of oil compared to sunflower and safflower oil. A high iodine value indicates that the oil has a significant proportion of unsaturated fatty acids[16,19]. In the present study, the iodine value of blended oils-I and II was 145.02±2.08 and 136.86±2.08 respectively, which is greater than that of sunflower oil (120.21±2.08). The table values indicate that blended oil-I to be superior to sunflower oil at five per cent level of significant and also rich in unsaturated fatty acids which can be claimed to be heart friendly (Table VI).

Saponification value of oil indicates the average chain length of fatty acids and a parameter for oxidation that occurs during storage and an indicator for oil breakdown. The volatility of oils rises as their saponification value rises. A high saponification value indicates a large proportion of fatty acids with lower molecular weight and chain length. Low saponification values indicate the presence of a longer fatty acid chain and a higher molecular weight[16,20]. The saponification value of blended oils-I and II were noted as 183.18±2 and 185.16±2 which was significantly lesser than sunflower and safflower oil at one per cent level of significance (193.66±3 and 193.66±2). However the saponification value has no nutritional significance and used as a reasonable means of characterizing the fat.

TABLE VII (a)

Comparison of Fatty Acid Profile of Blended Oil-I with Common Cooking Oils

Oil	SFA	t-value	MUFA	t- value	PUFA	t-value
Blended oil-I	28.06 ± 3.23	-	29.33 ± 3.21	-	39.50 ± 2.94	-
Safflower oil	10.39 ± 3.21	6.7437**	14.74 ± 3.21	5.5585**	78.60 ± 3.21	14.0033**
Sunflower oil	12.35 ± 3.21	5.9969**	30.82 ± 3.21	0.4518^{ns}	60.37 ± 3.21	7.8067**
Rice bran oil	25.09 ± 3.21	1.1430^{ns}	45.45 ± 3.21	6.1417**	33.45 ± 3.21	2.4498^{ns}
Palm oil	46.31 ± 3.21	6.9418**	44.86 ± 3.21	5.9169**	12.82 ± 3.21	9.5833**
Coconut oil	92.19 ± 3.21	24.4221**	8.57 ± 3.21	7.9096**	3.23 ± 3.21	13.0220**
Groundnut oil	24.56 ± 3.21	1.3449^{ns}	43.50 ± 3.21	5.3988**	35.56 ± 3.21	1.6459^{ns}
Mustard oil	7.05 ± 3.21	8.0162**	68.42 ± 3.21	14.8933**	28.52 ± 3.21	3.9538**

**1 per cent level of significance: * 5 per cent level of significance: ns not significant

Footnote: Blended I 50% of safflower oil blended with 12.5 ml of sunflower oil, 12.5 ml of gingelly oil, 12.5 ml of groundnut oil, and 12.5 ml of flaxseed oil.

As acid value is the indicator of free fatty acids content due to enzymatic reaction and indicates the level of spoilage of oil, and analysed the same for the blended oils I and II and found the value to be 2.59±2.08 and 2.85±2.08 respectively. The maximum acceptable level of acid value as per the recommendation of the Codex Alimentations Commission[17] for edible oil is 4mg KOH/g oil[16]. Also, the acid value of both blended oils I and II observed had more or less equal compared to safflower oil (2.14±2.08). A high acid value denotes oil degradation, which reduces the oil's nutritious value.

The smoking temperature of the blended oils I and II was found to be 185.5±2.08 and 181.67±2.08 respectively, which was 20% less than the smoking temperature of sunflower oil (232.66±2.08) and safflower oil (238.67±2.08) the difference in smoking temperature of blended oil was statistically significant at one per cent level of significance.

Fatty acid profile of blended oils with common cooking oils - a comparison

Table VII (a and b) shows that fatty acid profile of blended oil-I and II with common cooking oil.

Although the percentage of polyunsaturated fatty acids present in blended oils I and II was higher than rice bran oil, palm oil, coconut oil, groundnut oil and mustard oil, no significant difference in the t-value was noted in the current study. It was observed that the percentage of polyunsaturated fatty acids of the blended oils I and II (39%) to be superior compared to groundnut oil (35%), palm oil (12%), coconut oil (3%) and mustard oil

TABLE VII (b)

Comparison of Fatty Acid Profile of Blended oil-II with Common Cooking Oils

Oil	SFA	t-value	MUFA	t- value	PUFA	t-value
Blended oil-II	18.10 ± 2.10	-	29.33 ± 3.21	-	39.50 ± 2.94	-
Safflower oil	10.39 ± 3.21	3.2394*	14.74 ± 3.21	5.5585**	78.60 ± 3.21	15.000**
Sunflower oil	12.35 ± 3.21	1.9660*	30.82 ± 3.21	1.5040^{ns}	60.37 ± 3.21	8.0543**
Rice bran oil	25.09 ± 3.21	2.8880^{ns}	45.45 ± 3.21	5.7988**	33.45 ± 3.21	2.2022^{ns}
Palm oil	46.04 ± 3.21	10.3632**	44.86 ± 3.21	8.7276**	12.82 ± 3.21	10.0622**
Coconut oil	92.13 ± 3.21	28.453**	8.57 ± 3.21	9.9435**	3.23 ± 3.21	13.7160^{ns}
Groundnut oil	24.56 ± 3.21	2.6861^{ns}	43.50 ± 3.21	5.0559**	35.56 ± 3.21	1.3983^{ns}
Mustard oil	7.053 ± 3.21	3.9853**	68.42 ± 3.21	13.5510**	28.52 ± 3.21	4.0805*

**1 per cent level of significance: * 5 per cent level of significance: ns not significant

Footnote: Blended I 50% of safflower oil blended with 12.5 ml of sunflower oil, 12.5 ml of gingelly oil, 12.5 ml of groundnut oil, and 12.5 ml of flaxseed oil.

(28%) at one per cent level of significance. Thus the blended oils can be suggested as cooking oil to replace rice bran oil, palm oil, coconut oil and mustard oil. Monounsaturated fatty acids of blended oil-I was superior compared to safflower oil (14%) and sunflower at one per cent level of significance. It was also observed that the amount of saturated fatty acids present in blended oil-I was lesser compared to palm oil and coconut oil. Furthermore, the quantum of saturated fatty acids present in blended oil-II was lesser compared to rice bran oil, palm oil, coconut oil and groundnut oil.

Quantum of oil absorption in blended oils

The quality and quantity of polyunsaturated fatty acid (PUFA) absorption in blended oil II (22.56) was found to be superior when compared to commonly used groundnut and gingelly oil, despite the fact that the amount of oil

TABLE VIII

Quantum of Oil Absorption in Blended Oils-I and II

Type of cooking	Standard oil	Fat absorbed (%)	Saturated fatty acids (%)	Monounsaturated fatty acids (%)	Polyunsaturated fatty acids (%)
Shallow	Blended oil-I	26.33	3.33	8.30	14.70
frying	Blended oil-II	22.56	3.00	7.00	12.00
(Potato	Groundnut oil	21.72	5.21	9.09	7.42
Poriyal)	Gingelly oil	22.41	4.09	9.81	8.51
	Sunflower oil	17.86	2.05	5.58	10.22

TABLE IX

Fatty Acids Profile of Food Products (Sautéing) Blended Oils I and II

Fatty acids profile of blended oil-I	Peak area %	Fatty acids profile of blended oil-II	Peak area %
Saturated fatty acids			
Methyl palmitate (C16:0)	7.556	Methyl palmitate (C16:0)	7.403
Methyl stearate (C18:0)	3.960	Methyl stearate (C28:0)	4.021
Methyl arachidate (C20:0)	0.476	Methyl arachidate (C20:0)	0.547
Methyl behenate (C22:0)	0.665	Methyl behenate (C22:0)	0.862
		Methyl lignocerate (C24:0)	0.282
Monounsaturated fatty acids			
Methyl oleate (C18:1 [cis-10]	24.600	Methyl oleate (C18:1[cis-9])	32.066
Methyl eicosenoate (C20:1 [cis-11,14]	6.931	Methyl eicosenoate (C20:1[cis-11])	0.192
Polyunsaturated fatty acids			
Methyl linolenate (C18:2 [cis-9,12])	55.812	Methyl linolenate (C18:2 [cis-9,12])	47.860
		Methyl linolenate (C18:3[cis-9,12,15])	6.767

absorption of blended oil II (22.56) in cooked products was observed to be more or less similar to that of groundnut oil (21.72). Therefore, it can be concluded that the blended oil II can be used as an effective, healthy substitute for regular cooking oil.

Fatty acids profile of food products (Sauteing)

Peak values for polyunsaturated fatty acids present in blended oil-I methyl linoleate 55.81 and monounsaturated fatty acids are methyl oleate 24.60 and methyl eicosenoate 6.931. Blended oil II shows highest peak of polyunsaturated fatty acids for methyl linoleate 47.860 and methyl linolenate 6.767. Monounsaturated fatty acids are methyl oleate 32.036 and methyl eicosenoate 0.192 was observed (Table X).

Fatty acids profile of blended oils

Peak values for polyunsaturated fatty acids of cis form of 8, 11, and 14 eicosatrienoic were observed to be 49.44 for both blended oil I and II. Also, the peak retention time of cis 11,14,17 eicosatrienoic (omega-9) was found to be 1.312 and 0.356 for blended oil I and II respectively.

Similarly, a peak value of monounsaturated fatty acids such as the cis form of 9 oleic acids was observed at the retention time of 29.412 for blended oils I and II, indicating the presence of cis-9 oleic acid (n-9) claim, cis-9 oleic acids and the n-9 acid as a modulate inflammatory markers that reduces the synthesis of the pro-inflammatory mediator[20,21] (Table X).

TABLE X

Fatty Acids Profile of Blended oils-I and II

Fatty acids profile of blended oil-I	Peak area %	Fatty acids profile of blended oil-II	Peak area %
Saturated fatty acids			
Methyl butyrate (C4:0)	14.255	Methyl butyrate (C4:0)	2.714
Methyl palmitate (C16:0)	8.571	Methyl palmitate (C16:0)	9.089
Methyl stearate (C18:0)	4.011	Methyl stearate (C28:0)	3.677
Methyl arachidate (C20:0)	1.183	Methyl arachidate (C20:0)	0.824
		Methyl lignocerate (C24:0)	0.438
Monounsaturated fatty acids			
Methyl oleate (C18:1 [cis-10]	29.412	Methyl eicosenoate (C20:1[cis-11])	0.036
Polyunsaturated fatty acids			
Methyl linolenate (C18:2 [cis-9,12])	32.449	Methyl linolenate (C18.3)	6.226
Methyl linolenate (C18.3)	5.375	Methyl eicosatrienoate (C20:3 [cis-8,11,14)]	1.061
Methyl eicosatrienoate (C20:3 [cis-8,11,14)]	1.227	Methyl eicosatrienoate C20.3 cis11,14,17	0.356
Methyl eicosatrienoate C20.3 cis11,14,17	1.312		

Conclusion

The human body fulfils their essential fatty acids requirements from dietary sources. The quantum and quality of essential fatty acids which are required for lipid metabolism and the prevention of dietary fat related disorders are becoming a cause of concern when choosing oil as a cooking medium. The attempt of blending two or more oils from various plant sources in the present study, not only alters the fatty acid composition and physicochemical properties of the blended oil but, also provides a more affordable healthy sources for cooking. The presence of beneficial polyunsaturated fatty acids especially methyl linoleate, methyl linolenate, methyl eicosatrionate, and cis-8,1,14-eicosatrienoic acid and cis-5,8,11,14 eicosatetraenate acid, in the blended oil can act as a heart-friendly cooking medium.

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FATTY ACID PROFILING OF BLENDED VEGETABLE OIL FOR DIVERSIFIED DIETARY NEEDS

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ABSTRACT

Dietary variations play a crucial role in determining a country's health and well-being. The onset of diet-related disorders is closely associated with food intake specifically oil intake. Blending of oils has become a more financially successful technique to improve the nutrient profile of oil while maintaining a balanced fatty acid profile in recent years. Combining vegetable oils increases the concentration of antioxidants and bioactive lipids which in turn improves the stability of vegetable oils besides improving the quality of life. Thus, blending oils to create an alternate cooking medium with desired health advantages is the need of the day. The present investigation aims at designing blended oil and to study its fatty acid profile. Vegetable oil namely flaxseed, groundnut, safflower, gingelly, and sunflower oil were purchased from retail shops in Coimbatore. All the selected five vegetable oils were blended into two different combinations, blended oil– I and II. The blended vegetable oils were stored at room temperature and were analyzed for physical and chemical properties. Fatty acids profiling of blended oil was carried out using standard procedure (Gas Chromatography – Flame Ionization Detector). The Peroxide value of blended oil- I and -II were found to be <0.1 Meq/Kg. The saturated fatty acids content of blended oil I and II was found to be 15g/100g and 40g/100g respectively, similarly monounsaturated fatty acids content of blended oil- I and II was found to be 24.11g/100g and 26.01g/100g respectively. The polyunsaturated fatty acid present in blended oil-I and II was found to be 60g/100g and 32g/100g. The blended oil can serve as a healthy alternative for cooking medium.

Keywords Cardiovascular Disease, Modified Vegetable Oil, blended oil, Omega-3 Fatty Acids, Polyunsaturated Fatty Acids, Unsaturated Fatty Acids

INTRODUCTION

Oil has long been an important staple of people's daily diets around the world, and its use has increased multiple times over the decades. Vegetable oils are considered as a main ingredient in our dietary practices. Bioactive substances, sterols, polyunsaturated fatty acids (PUFA), polyphenols, carotenoids, and other important elements all contribute to the health (Chatzopoulou*et al*., 2020; Sodeifian*et al*., 2019).The nutritional quality of fats and oils has recently acquired prominence due to their strong association with the onset of non-communicable diseases mainly obesity and cardiovascular diseases. Estruch*et al*., (2020) predict a global incidence of 39.7% of cardiovascular disease with further escalation to 40.5 per cent in 2030.As a consequence of significant rise in cardiovascular diseases, much attention has been paid to consumption of fat and oil.

Choosing the right cooking oil significantly contributes to cardiac health. The body's requirement for Polyunsaturated Fatty Acids (PUFA) is not constant; it varies with age, type of work, lifestyle behaviour particularly climatic conditions, health, and other factors.(Simakova *et al*., 2019).Several studies have associated increased omega-3 PUFA intakes, particularly eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), to a lower risk of chronic inflammatory ailments including cardiovascular disease (CVD). (Djuricic*et al*., 2021). Also, antioxidants in oil, such as phytosterols, phytoestrogens, flavonols, carotenes, and tocopherols, prevent cardiac diseases and contribute significantly to nutrition (Cabezas-Zábala*et al*., 2016). No pure oil is with enough oxidative stability, good functional and nutritional qualities. One of the simplest ways to boost nutrient value, fatty acid profiles and storage stability is to combine several vegetable oils with different qualities. (Chopra, 2018).

Thus, blending oils has grown more commercially viable in recent years. Indian culinary practice widely used gingelly, groundnut, sunflower and safflower oil for different recipes and are commonly consumed among Asian population. Gingelly oil (sesame) is abundant in unsaturated fatty acids and antioxidants. When ingested, it reduces the risk for heart disease, due to its antihypertensive and lipid-lowering properties when mixed with other oils (Devarajan*et al*., 2016).Groundnut oil is a good source of antioxidants and polyunsaturated fatty acids and is proved to lowers blood cholesterol and low-density lipoprotein content (Pourrajab*et al*.,2021). Flaxseed contains high omega-3 fatty acid (n-3 and n-6) and nutraceuticals compound that prevents various diseases like cancer, coronary heart disease, diabetes, obesity, gastrointestinal disease, renal disease, and other bone disorders. Sunflower oil, which is high in vitamin E, helps to prevent atherosclerosis, artery disease and stroke. The presence of linolenic and linolenic acids in safflower oil aid in the prevention of thickening of arteries. Functional components (neutraceutical) present in safflower oil is proved to dilute blood, vasodilate blood vessels and reduces blood pressure.

JUSTIFICATION FOR THE STUDY

- Vegetable oils come in a variety of forms, but there is no single edible oil that possesses the appropriate fatty acid composition, oxidative stability and functional characteristics.
- Blending besides enhancing the storage quality of fat by increasing the shelf life of oil, also reduces oxidative damages and improves omega 3 fatty acids that are cardiac friendly and helps in the prevention of disease such as cardiovascular diseases, hypertension and diabetes mellitus.

OBJECTIVE

The objective of the study is to

- To select vegetable oil with high polyunsaturated fatty acids content.
- To design a heart friendly blended vegetable oil.
- To examine the physiochemical characteristic of the blended oil and to study the fatty acid profile of the blended oil.

MATERIAL AND METHODS

Designing a Heart friendly blended Vegetable oil

Vegetable oil namely flaxseed oil, groundnut oil, safflower oil, gingelly oil, and sunflower oil were selected for blending based on their polyunsaturated fatty acids content. The selected oils were purchased from retail shops in Coimbatore. The purchased vegetable oils were blended into two variation - blended oil I (BOGN01) and II (BOGO02) (Table-I). Blending was done in conical flasks using a orbital shaker (90rpm) at 37ºC for 24 hrs. The blended oils were treated with ultrasonic waves in a Bath sonicator. The waves were delivered for 1 minute at 37°C.

Table- I Designing of heart friendly blended vegetable oil

Variation	Vegetable oil	Quality used (ml)
Blended oil-I BOGN01	Groundnut oil	50
	Safflower oil	12.5
	Sunflower oil	12.5
	Gingelly oil	12.5
	Flaxseed oil	12.5
	Total	100
Blended oil-II BOGO02	Gingelly oil	50
	Safflower oil	12.5
	Sunflower oil	12.5
	Groundnut oil	12.5
	Flaxseed oil	12.5
	Total	100

Physical and chemical properties of blended oil

The physical properties such as colour of the blended oil was measured using colour reader (Gowegroup Multitesters). The smoking temperature of blended oil was measured using digital food thermometer (Thermopro).The standard (AOAC-996.06)- (AOAC, 2019) analytical method was used to determine chemical properties such as peroxide value (mohr's method – AOAC 995.33), iodine value (Wijs method – AOAC 920.159), saponification value (AOAC 920.160), and acid value (AOAC 940.28). (AOAC 995.33) were analyzed.

Quantitative analysis of the fatty acid profile of Blended oils (GC-FID)

Quantitative analysis for fatty acids profile of blended oil was carried out using Gas Chromatography – Flame Ionization detection method (AOAC 996.06) - AOAC, 2019.Fat samples (100µl) were taken in a test tube. The mouth of the test tube was closed and shaken well for 10 seconds using a vortex mixture. The tube was made to rest for two minutes and 2ml of hexane was added and shaken well for four minutes. To the sample,50 ml of sodium sulphate was added and centrifuge at 1500 rpm for three minutes. The hexane layer was collected through a 0.22um filter

and injected in Gas Chromatography – Flame Ionization for detection. The fatty acids were then identified in a chromatogram by comparing their retention time to that of the corresponding peak.

The ethical clearance for the present study was obtained for the Avinashilingm Institute for Home Science and Higher Education for Women's Institutional Human Ethics Committee (AUW/IHEC-17-18/FSMD/FHP-02).

RESULT AND DISCUSSION

Table –II: Physical Characteristics of the blended oil

Parameters	Blended oil-I (BOGN01)	Blended oil-II (BOGO02)	Gingelly oil	Groundnut oil
Colour (groove/mm)	Dark Yellow 16.25	Brownish Yellow 19.39	Yellowish red 10.51	Reddish yellow 10.61
Viscosity (CPS)	54	70	55	79
Odour	Nutty smell	Nutty smell	Nutty smell	Nutty smell
Texture	Viscous liquid	Viscous liquid	Viscous liquid	Viscous liquid

Blended oil-I (BOGNO1)- 50ml of groundnut oil, 12.5 ml of sunflower oil, 12.5 ml of safflower oil, 12.5 ml of gingelly oil, 12.5 ml of flaxseed oil.
Blended oil –II (BOGO02)- 50ml of gingelly oil, 12.5 ml of sunflower oil, 12.5 ml of safflower oil, 12.5 ml of groundnut oil, 12.5 ml of flaxseed oil.

The colour of the blended oil-I and II was found to be dark yellow (a*and b*is positive) and brownish yellow colour (a*and b* is positive) respectively. From that it was inferred that in par with commonly consumed cooking oil namely gingelly and groundnut oil. The viscosity of the blended oil-I and II was found to be 54 and 70 Centipoise (CPS). From the study it was observed that the viscosity of blended oil- I to be similar to that of the gingelly oil [55 Centipoise CPS], similarly the viscosity of the blended oil-II was more or less similar to that of the groundnut oil [79 Centipoise CPS]. The texture of the blended oil was non-greasy and had a pleasant mouth feel texture, and it had a distinct nutty aroma that could be is due to the acetic acid that was present in flaxseed oil.

Table –III: Chemical Characteristics of the blended oil

Chemical properties	**Blended oil-I** (BOGN01)	**Blended oil-II** (BOGO02)	**Gingelly oil**	**Groundnut oil**
Peroxide value Meq/kg	<0.1	<0.1	1.40	9.99
Iodine value	15.60	16.63	104-120	77-107
Saponification value Mg/KOH	5.6	7.6	186-195	187-196
Acid value Mg/KOH	1.70	2.23	2.84	3.98

Smoking Point	181ºC	132ºC	140.4ºC	170ºC

Blended oil-I (BOGNO1)- 50ml of groundnut oil, 12.5 ml of sunflower oil, 12.5 ml of safflower oil, 12.5 ml of gingelly oil, 12.5 ml of flaxseed oil.

Blended oil –II (BOGO02)- 50ml of gingelly oil, 12.5 ml of sunflower oil, 12.5 ml of safflower oil, 12.5 ml of groundnut oil, 12.5 ml of flaxseed oil..

The peroxide values blended oil-I and II were found to be less than 0.1 Meq/kg of oil. A peroxide value is a measure of lipid matrix freshness and oxidation during storage. Also, more the peroxide in the oil, the more it oxidized (Sikorska *et al*., 2019). Thus, from the above observation, it can be inferred that the blended oil is superior to the gingelly and groundnut oil in terms of storage quality.

The saponification value of blended oil was observed to be blended oil-I and II to be 5.6 and 7.6 Mg/KOH respectively. According to (Muhammad *et al*., 2011) the molecular mass of fatty acids is inversely related to saponification value, indicating that there is a substantial fraction of fatty acids with lower molecular weight or chain length. The saponification score indicates the presence of more long-chain beneficial fatty acids in the blended oil, such as Eicosapentaenoic acid (EPA) and Docosahexaenoic acid (DHA).

The acid value is a measure of quantum of free fatty acids present in a specific amount of oil. Oil with a higher acid value has more free fatty acids, resulting in poorer quality of oil (Katkade *et al*.,2018)The acid value of blended oil-I and II was found to be 1.70 and 2.23 Mg/KOH which is lesser than groundnut and gingelly oil [(2.84Mg/KOH, 3.98 Mg/KOH) Longvah et al.,2017].

The higher the acid number, more is the free fatty acid value indicating poor quality of oil. Thus, it can be inferred that both the blended oil is superior in terms of quality compared to gingelly and groundnut oil.

A high iodine value indicates that the oil has a significant proportion of unsaturated fatty acids. The blended oil– I (15.60) and II (16.63) were compared to gingelly oil (104-120) and groundnut oil (77-107) According to Dim., 2013the existence of unsaturation is shown by the iodine value. Iodine value of blended oil-I and II was less compared gingelly oil and groundnut oil

The smoking temperature of blended oil-I and II was reported as 181ºC and 132ºC respectively.

Table –IV: Comparison of Fatty acids profile of Blended oil with Gingelly oil and groundnut oil

Type of fatty acids	Blended oil-I (%) (BOGN01)	Blended oil-II (%) (BOGO02)	Gingelly oil (%)	Groundnut oil (%)
Saturated Fatty Acids (SFA)	15	40	16	19
Monounsaturated Fatty acids (MUFA)	25	26	41	54
Polyunsaturated Fatty Acids (PUFA)	**60**	32	42	27
Trans fatty acids (TF)	<0.1	0.081	1.3	0.9
Total fat	97.32	98.52	100	100

Blended oil-I (BOGNO1)- 50ml of groundnut oil, 12.5 ml of sunflower oil, 12.5 ml of safflower oil, 12.5 ml of gingelly oil, 12.5 ml of flaxseed oil.
Blended oil –II (BOGO02)- 50ml of gingelly oil, 12.5 ml of sunflower oil, 12.5 ml of safflower oil, 12.5 ml of groundnut oil, 12.5 ml of flaxseed oil.

Though saturated oils are stable and less prone to oxidation compared to unsaturated oil, consumption of these oils leads to cardiovascular risk. Oil's that are stable with low saturated fatty acids at frying temperature can be designed by blending oil judiciously. In blended oil-I (15), we observed a reduction in the quantum of saturated fatty acid one to four percentage compared single use oil namely gingelly oil (16) and groundnut oil (19). However, the blended oil II showed a greater reduction in the quantum of saturated fatty acid (21-24%) compared to gingelly oil and groundnut oil. Thus, it is evident that blended oil-I is more stable and healthier compared to blended oil-II.

In contrary the percentage of polyunsaturated fatty acids in blended oil I was found to be 18-33 percentage higher compared to gingelly oil and groundnut oil and blended oil-II was found to be five percentage higher than groundnut oil. Since omega-3 polyunsaturated fatty acids aids in the reduction of cholesterol levels in heart patients and a variety of inflammatory illnesses Ghani *et al*., (2019), the higher percentage of Polyunsaturated Fatty Acids (PUFA) in the blended oils can help to lower cholesterol levels and can prevent thrombosis.

Table- V Fatty acids profile of blended oil I and II

Fatty acids Profile of Blended oil-I (BOGN01)	Peak area %	Fatty acids Profile of Blended oil-II (BOGO02)	Peak area %
Saturated fatty acids			
Methyl Palmitate C16:0	11.96	Methyl Palmitate	9.48
Methyl Stearate C18:0	4.33	Methyl Stearate	5.52
Methyl arachidate C20	1.03	Methyl arachidate	0.66
Methyl behenate C22	1.8	Methyl behenate	0.56
Methyl Ligocerate C4	0.68	Methyl Ligocerate	0.28
Monounsaturated fatty acids			
Methyl Oleate C18:1C	35.303	Methyl Oleate C18:1C	35.470
Methyl eicosenoate C20:1C	5.01	Methyl eicosenoate C20:1C	7.239
		Methyl erucate C22:1C	0.439
Polyunsaturated fatty acids			
Methyl linoleate C18:2C	39.208	Methyl linoleate C18:2C	40.340
Methyl linolenate C18:3C	0.648		

Blended oil-I (BOGNO1)- 50ml of groundnut oil, 12.5 ml of sunflower oil, 12.5 ml of safflower oil, 12.5 ml of gingelly oil, 12.5 ml of flaxseed oil.
Blended oil –II (BOGO02)- 50ml of gingelly oil, 12.5 ml of sunflower oil, 12.5 ml of safflower oil, 12.5 ml of groundnut oil, 12.5 ml of flaxseed oil.

Peak values for polyunsaturated fatty acids was observed in blended oil-I and II at the peak area of 39.2 and 40.34 respectively indicating the presence of methyl linoleate a n-6 fatty acid. Marangoni et al., (2020), claims methyl linolenate- a n-6 fatty acid as an oxidative stress marker, with functional properties to decrease blood cholesterol, blood pressure and inflammation.

Similarly, a peak value in blended oil-I for monounsaturated fatty acids was observed at the peak area of 35.303, indicating the presence of Cis -9 oleic acid (n-9). Mauger et al., (2021) claims Cis 9 oleic acid to modulate inflammatory marker by reducing the synthesis of pro-inflammatory mediators.

CONCLUSION

To conclude the present study throw's light on the health benefits of blending one or more vegetable oils. The blended oil-I (BOGN01) formulated using 50 percentage of gingelly oil and 12.5 percentage of each sunflower, safflower, groundnut and flaxseed oil was found to be more stable and functionally superior in quality due to the presence of 18-33% of polyunsaturated fatty acid. Also, the presence of n-6 methyl linolenate and cis form of n-9 methyl oleic acid in the blended oil (BOGN01)-I makes it as a good cardiac friendly alternate cooking source as it helps to modulate the inflammatory markers, by reducing the synthesis of pro inflammatory markers.

SUGGESTION FOR FUTURE RESEARCH

- The fatty acid profile of foods cooked using the blended oil can be studied in future.

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