International Journal of Science and Research (IJSR)
ISSN: 2319-7064
SJIF (2022): 7.942

SUNPURE study: A Real World Retrospective Study of Sunflower Oil, Flaxseed Oil, and Rice Bran Oil Combination for Prevention or Cure of Dyslipidemia

Rajagopal Jambunathan[1], Arjun Adnaik[2], Vanita Bhat [3], Divya Kumari Nityanandan[4]

[1]Consultant Cardiologist, Cauvery Heart & Multispecialty Hospital, Siddaratha Layout, Near Teresian College, Mysore – 570011, Karnataka, India
Email: *rajagopalj[at]gmail.com*

[2]Consultant Cardiologist, Swastik Hospital, Infront of Sayaji Hotel, Shivaji Park, Kolhapur– 416008, Maharashtra, India
Email: *dradnaik[at]gmail.com*

[3]Clinical Cardiologist, Cauvery Heart & Multispecialty Hospital, Siddaratha Layout, Near Teresian College, Mysore – 570011, Karnataka, India
Email: *drvanita73[at]gmail.com*

[4]Clinical Research Coordinator, Cauvery Heart & Multispecialty Hospital, Siddaratha Layout, Near Teresian College, Mysore – 570011, Karnataka, India
Email: *divyaprakash.pa[at]gmail.com*

Abstract: ***Background: Unhealthy dietary habits play a crucial role in the development of heart disease. Blending of vegetable oils has been shown to improve lipid profile and inflammatory parameters. Method: This was a retrospective, observational, single center real-world study. Anonymized medical records with follow up visits(1 month) for subjects above 18 years were included in the study. This study aimed at determining the effect of a blend of rice bran oil, flaxseed oil and sunflower oil on the glycemic and lipid parameters. Results: A total of 73 records were included in the study, of which 56.16% subjects were female.The mean age was 45.67 ± 15.38 years. Atone month follow up, significant reductions in total cholesterol(TC) (p<0.001), non-high-density lipoprotein cholesterol (p<0.001), TC/ high density lipoprotein (HDL) ratio (p=0.048), low density lipoprotein (LDL)/HDL (p=0.041), total bilirubin (p=0.001), gamma-glutamyl transferase (p=0.021), alkaline phosphatase(p=0.025), creatinine(p<0.001), calcium (p=0.020), triiodothyronine (T3) (p<0.001), thyroxine (T4) (p<0.001) andthyroid stimulating hormone (TSH) (p=0.051) were observed. Conclusion: The blend of rice bran oil, flaxseed oil, and sunflower oil was found to bebeneficial in lowering the lipids levels, renal, hepatic, thyroid, and inflammatory markers in Indian population.***

Keywords: Rice bran oil, flaxseed oil, sunflower oil, lipid parameters, inflammatory markers

1. Introduction

In developing countries, cardiovascular disease (CVD) continues to be the leading cause of death. India'sage-standardized CVD death rate was estimated to be 272 per 100000 population [1]. Obesity, hypertension, family history and dyslipidemia are the common risk factors for the early onset of CVD [2]. Dyslipidemia is the most prevalent and most modifiable risk factor among the common CV risk factors [1].According to an INTERHEART study, dyslipidemia appears to be the main cause of myocardial infarction in South Asians [3].

Unhealthy lifestyles, particularly dietary habits, play a crucial role in the development of heart disease. Many studies have investigated dietary changes that lower serum lipid levels and reduce CVD [4].The American Heart Association (AHA) have emphasized on progressive reduction in total body fat, saturated fatty acids, and cholesterolas the primary steps in treating hypercholesterolemia [5]. The lipid profile can be improved through dietary substitutionthat consists ofhigh saturated fatty acids (SFA),monounsaturated fatty acid (MUFA) and poly unsaturated fatty acid (PUFA) [6].

Recent studies have explored the hypolipidemic effect of vegetable oils which are rich in plantsterols and other unsaponifiable such as tocotrienols and oryzanol.Oryzanol acts as a hypolipidemic agent by preventing cholesterol absorption, increasing fecal excretion, and inhibiting hepatic cholesterol synthesis [7], [8].

Rice bran oil (RBO) has been investigated for its nutritional, chemical, and toxicological properties and was found to be safe for human consumption. The RBO consists of 35% PUFA, 43% MUFA, and 22% SFA. RBO containsoleic acid (38.4%), linoleic acids (34.4%),linolenic acid (2.2%),palmitic acid (21.5%) and stearic acid (2.9%) [9]-[11]. As a result of its high MUFA content, oxidative stability, anti-hypercholesterolemic, antioxidative, and anti-inflammatory properties, RBO is an excellent example of an antiatherogenic functional food [12], [13].

Flaxseed oil is a major source of alpha linolenic acid (ALA) which has a higher bioavailability than the whole seed.

Flaxseed oil is shown to possess antioxidant, anti-platelet adhesion, and other bioactive properties [14]. It is a rich source of omega-3 and has 55% α-Linolenic with significant amounts of soluble and insoluble fiber with a protective effect on the heart. Flaxseed oil contains 73% PUFA and 18% MUFA [15], [16]. Several studies have shown that flaxseed oil is effective in lowering cholesterol levels and treating chronic inflammatory diseases [17], [18].

Another important edible oil is sunflower oil which contains a high amount of PUFA. It contains approximately 15% saturated, 85% unsaturated fatty acid and consists of 14–43% oleic and 44–75% linoleic acids[19], [20].

Recent studies reported that blending vegetable oils (RBO, flaxseed oil, and sunflower oil) can enhance blood lipid profiles, glycemic levels, and inflammatory parameters [21], [23]. The present study was aimed to evaluate the effect of a blend of rice bran oil, flaxseed oil, and sunflower oil on the glycemic and lipid parameters in general population.

2. Methodology

This was a retrospective, observational, longitudinal, single center real-world study, to analyze the data from outpatient and inpatient settings. Anonymized medical records with follow-upvisits for subjects above 18 years included in the study.Subjects less than 18 years of age and pregnant women were excluded.The records of 73 subjects were included in the study.During the followup period (1 month), blood samples were collected for assessing the changes in glycemic parameters and lipid profiles.

The study was approved by the Royal Pune Independent Ethics Committee (RPIEC), located in Pune, India (Ethics Approval Number: RPIEC250523; dated 25 May 2023).

The aggregated data extracted from the EMRs was used for statistical analysis. Descriptive analysis was conducted on all variables. Categorical variables, such as dietary habits, were expressed in terms of frequencies and their respective percentages. Continuous variables, including lipid profile (TC, HDL, Non-HDL, LDL, triglycerides, apolipoprotein A, apolipoprotein B, apolipoprotein B/A1 ratio, very low density lipoprotein, lipoproteinA, hs-CRP, TC/HDL ratio, LDL/HDL ratio), liver function test (total bilirubin, gamma glutamyl transferase (GGT), serum glutamic oxaloacetic transaminase (SGOT), serum glutamic pyruvic transaminase (SGPT), alkaline phosphatase), renal function test (estimated glomerular filtration rate (EGFR), urea, creatinine, calcium, uric acid), thyroid function test (T3, T4, TSH), and glycated hemoglobin (HbA1C), were expressed as mean ± SD (variables distributed normally) and median (IQR) (variables not distributed normally) based on their statistical distributions. To assess the effect of a blend of rice bran oil, flaxseed oil, and sunflower oil from baseline to one month of use in the aforementioned continuous variables, paired T-test (variables distributed normally) and Wilcoxon Signed Rank test (variables not distributed normally), was used basis on the statistical distribution of the variables. P-value less than 0.05 ($p<0.05$) was considered as the threshold for establishing statistical significance.

3. Results

A total of 73 records were included in the study, of which 41 (56.16%) subjects were female. The mean age andbody mass index (BMI) of the subjects were found to be 45.67 ± 15.38 years and 26.32 ± 4.98Kg/m^2,respectively. Among all subjects,57 (78.08%) subjects were followinga non-vegetarian diet.Only 2 subjects (2.74%) did workout and exercise and 1 subject (1.37%) indulged in occasional snacking. All subjects (n=73, 100%) had intake of fruits.(Table 1)

Table 1: Dietary habits in study population (n=73)

Parameter	n (%)
Diet Pattern	
Non-vegetarian	57 (78.08%)
Vegetarian	16 (21.92%)
Occasional Snacking	1 (1.37%)
Fruits Intake	73 (100%)
Exercise	2 (2.74%)

Dyslipidemia was the most (82.19%) reported comorbid condition with a mean duration of 4.31 ± 2.9 years among all the subjects. (Figure 1)

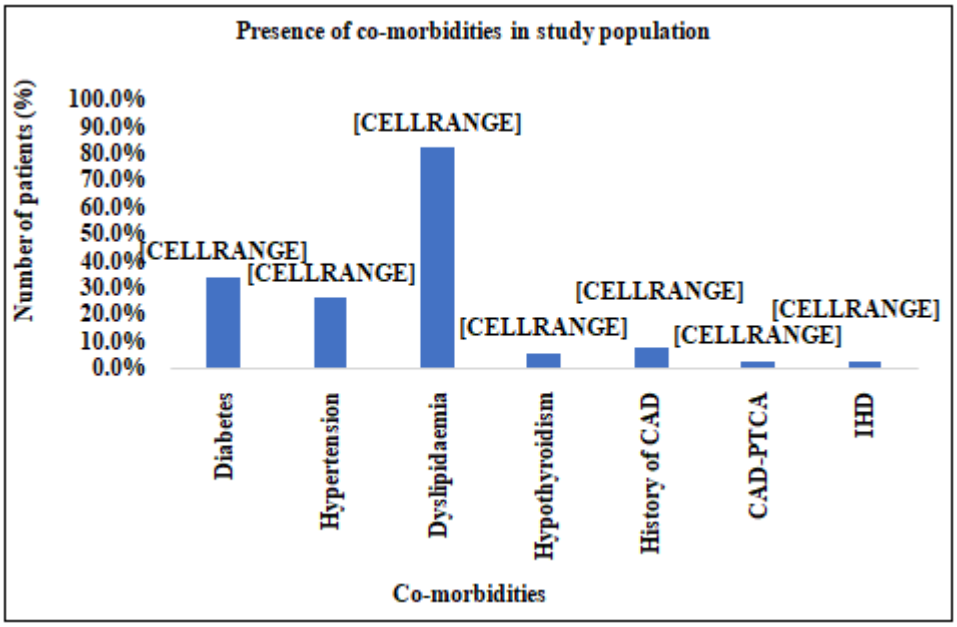

Figure 1: Co-morbidities in study population (n=73)
CAD: coronary artery disease; IHD: Ischemic heart disease, PTCA: percutaneous transluminal coronary *angioplasty*

After one month of followup, a significant reduction in total cholesterol was observed. ((TC) (p<0.001), non-high-density lipoprotein cholesterol (non-HDL) (p<0.001), TC/HDL ratio (p=0.048), LDL/HDL (p=0.041), total bilirubin (p=0.001), GGT (p=0.021), alkaline phosphatase (p=0.025), creatinine(p<0.001), calcium (p=0.020), T3 (p<0.001), T4 (p<0.001) andthyroid stimulating hormone (TSH) (p=0.051) was observed.(Table 2)

Table 2: Comparison of clinical parameters between baseline and one month follow-up (n=73)

Parameter	Baseline Mean ± SD/Median (IQR)	One month Follow-up Mean ± SD/ Median (IQR)	p-value
Lipid Profile			
TC (mg/dL)	175.11 ± 45.32	160.32 ± 39.68	**<0.001***
HDL (mg/dL)	43.63 ± 9.66	42.25 ± 9.9	0.167*
Non-HDL (mg/dL)	130.96 ± 45.16	117.41 ± 37.61	**<0.001***
LDL(mg/dL)	98 (41)	96 (30)	0.374
TG(mg/dL)	113 (118)	128 (103)	0.416
Apolipoprotein A (mg/dL)	116 (17)	117 (21)	0.851
Apolipoprotein B (mg/dL)	84 (28.5)	88 (28)	0.177
Apolipoprotein B/A1 Ratio	0.7 (0.3)	0.7 (0.3)	0.534
VLDL (mg/dL)	23 (23.3)	25 (21)	0.525
Lipoprotein(A) (mg/dL)	15.9 (29.45)	17.9 (29.55)	0.080
Hs-CRP	3 (7.85)	3.2 (5.3)	0.549
TC/HDL Ratio	3.9 (1.85)	3.6 (1.55)	**0.048**
LDL/HDL	2 (1.45)	2.3 (1.05)	**0.041**
Liver function test			
Total Bilirubin	0.56 (0.38)	0.5 (0.5)	**0.001**
GGT	20 (14.95)	20.4 (16.1)	**0.021**
SGOT	21 (8.5)	21 (7.85)	0.721
SGPT	17 (12)	20 (10.6)	0.445
Alkaline Phosphatase	83.31 ± 18.16	77.71 ± 18	**0.025**
Renal Function test			
EGFR	109 (25.5)	109 (22)	0.079
Urea	18 (8)	19 (7)	0.812
Creatinine	0.68 (0.21)	0.6 (0.2)	**<0.001**
Calcium	9.2 (0.45)	9.3 (0.6)	**0.020**
Uric Acid	4.6 (1.88)	4.4 (1.7)	0.651
Thyroid Function test			
T3 (ng/dL)	111.25 ± 22.2	102.81 ± 20.14	**<0.001***
T4 (µg/dL)	9.2 (2.95)	8.6 (1.8)	**<0.001**
TSH (MIU/ML)	3.04 (2.12)	2.4 (1.95)	**0.051**
Average Sugar Test			
HbA1C	5.6 (1.3)	5.7 (1.55)	0.860

Note:*Paired to test p-values and rest all are Wilcoxon-sign rank test p-values.

*EGFR:Estimated glomerular filtration rate; GGT:Gamma-glutamyl transferase; HbA1C:Glycated hemoglobin; HDL: High-density lipoprotein cholesterol; Hs-CRP: High-sensitivity C-reactive protein; LDL:Low-density lipoprotein cholesterol; SGOT:Serum glutamic-oxaloacetic transaminase; SGPT:Serum glutamic pyruvic transaminase; T3:*Triiodothyronine*; T4:Thyroxine; TC: Total cholesterol; TG: Triglycerides; TSH:*Thyroid stimulating hormone*;VLDL:Very low-density lipoprotein cholesterol.*

For diabetes patients, after one month followup, a significant reduction in total bilirubin (p=0.003), GGT(p=0.018), alkaline phosphatase (p=0.006), calcium (p=0.055),uric acid (p=0.054), T4 (p=0.025) was observed.(Table 3)

Table 3: Comparison of clinical parameters between baseline and one month follow-up for diabetes patients (n=25)

Parameter	Baseline Mean ± SD/ Median (IQR)	One month Follow-up Mean ± SD/ Median (IQR)	p-value
Lipid Profile			
TC (mg/dL)	176.52 ± 52.27	167.04 ± 44.21	0.150*
HDL (mg/dL)	46 (16)	43 (15.5)	0.532
Non-HDL (mg/dL)	131.6 ± 50.48	123.24 ± 41.16	0.177*
LDL (mg/dL)	94.12 ± 38.4	98.12 ± 34.91	0.440*
TG (mg/dL)	131 (119.5)	160 (83.5)	0.819
Apolipoprotein A (mg/dL)	119.4 ± 18.06	122.76 ± 17.08	0.159*
Apolipoprotein B (mg/dL)	88.8 ± 24.83	95.36 ± 23.97	0.106*
Apolipoprotein B/A1 Ratio	0.75 ± 0.2	0.77 ± 0.19	0.569*
VLDL (mg/dL)	26 (24)	31 (16.5)	0.972
Lipoprotein(A) (mg/dL)	17.4 (36.35)	23 (28.5)	0.076
Hs-CRP	3.3 (10.2)	2.9 (5.1)	0.079
TC/HDL Ratio	4 ± 1.24	3.91 ± 1.1	0.568*
LDL/HDL	2.03 ± 0.9	2.26 ± 0.82	0.090*
Liver function test			
Total Bilirubin	0.56 (0.34)	0.4 (0.4)	**0.003**
GGT	24 (28.55)	22 (17.9)	**0.018**
SGOT	20 (11.5)	18.6 (7.15)	0.241
SGPT	17 (11.5)	18 (10.5)	0.853
Alkaline Phosphatase	84 (26)	76 (16.5)	**0.006**
Renal Function test			
EGFR	97.88 ± 18.58	96.52 ± 23.73	0.650*
Urea	23.2 ± 7.8	22.69 ± 6.33	0.758*
Creatinine	0.66 (0.34)	0.7 (0.3)	0.248
Calcium	9.2 (0.4)	9.4 (0.55)	**0.055**
Uric Acid	4.6 (2.5)	4 (2)	**0.054**
Thyroid Function test			
T3 (ng/dL)	103.84 ± 23.03	95.88 ± 20.78	0.062*
T4 (µg/dL)	9.4 (3.3)	8.5 (1.7)	**0.025**
TSH (MIU/ML)	3.34 ± 1.81	3.65 ± 2.1	0.239*
Average Sugar Test			
HbA1C	6.9 (2.6)	7 (2.55)	0.925

Note:*Paired to test p-values and rest all are Wilcoxon-sign rank test p-values.
*EGFR:Estimated glomerular filtration rate; GGT:Gamma-glutamyl transferase; HbA1C:Glycated hemoglobin; HDL: High-density lipoprotein cholesterol; Hs-CRP: High-sensitivity C-reactive protein; LDL:Low-density lipoprotein cholesterol; SGOT:Serum glutamic-oxaloacetic transaminase; SGPT:Serum glutamic pyruvic transaminase; T3:*Triiodothyronine*; T4: Thyroxine; TC: Total cholesterol; TG: Triglycerides; TSH:T*hyroid stimulating hormone*;VLDL:Very low-density lipoprotein cholesterol.*

For dyslipidemia patients, after one month followup, a significant reduction in high-sensitivity C-reactive protein (Hs-CRP) (p=0.033), alkaline phosphatase (p=0.041) wasobserved. (Table 4)

Table 4: Comparison of clinical parameters betweenbaseline and one month follow-up fordyslipidemia patients(n=13)

Parameter	Baseline Mean ± SD/ Median (IQR)	One month Follow-up Mean ± SD/ Median (IQR)	p-value
Lipid Profile			
TC (mg/dL)	163.23 ± 44.55	152.54 ± 37.18	0.319
HDL (mg/dL)	42.77 ± 9.9	42.69 ± 10.86	0.976*
Non-HDL (mg/dL)	120.31 ± 41.77	109.31 ± 33.76	0.272*
LDL (mg/dL)	81.08 ± 29.9	85.54 ± 30.6	0.595*
TG (mg/dL)	154 (96.5)	150 (70.5)	0.346
Apolipoprotein A (mg/dL)	116.38 ± 15.82	121.77 ± 13.95	0.174*
Apolipoprotein B (mg/dL)	84.15 ± 20.96	86.38 ± 20.43	0.714*
Apolipoprotein B/A1 Ratio	0.7 (0.25)	0.7 (0.3)	0.833
VLDL (mg/dL)	30 (19.5)	29 (14)	0.507
Lipoprotein(A) (mg/dL)	16 (45.3)	20 (33.45)	0.583
Hs-CRP	3.3 (13.7)	1.7 (4.45)	**0.033**

Parameter	Baseline Mean ± SD/ Median (IQR)	One month Follow-up Mean ± SD/ Median (IQR)	p-value
TC/HDL Ratio	3.9 (1.75)	3.8 (1.8)	0.220
LDL/HDL	1.8 (1.15)	2.3 (1.2)	0.291
Liver function test			
Total Bilirubin	0.71 (0.45)	0.7 (0.6)	0.152
GGT	20 (12)	22 (17.95)	0.363
SGOT	18 (9.5)	21 (9.6)	0.916
SGPT	15 (10.9)	18 (12)	0.421
Alkaline Phosphatase	92.1 ± 21.93	74.38 ± 23.99	**0.041***
Renal Function test			
EGFR	94 (20)	91 (26)	0.476
Urea	27 (13)	22 (7.5)	0.151
Creatinine	0.69 (0.26)	0.7 (0.25)	0.964
Calcium	9.2 (0.55)	9.5 (0.25)	0.077
Uric Acid	4.7 (2.97)	5.4 (2.65)	0.506
Thyroid Function test			
T3 (ng/dL)	103.77 ± 32.41	95.62 ± 23.5	0.293*
T4 (µg/dL)	9.2 (3.05)	8.1 (2.7)	0.255
TSH (MIU/ML)	4.11 (3.04)	3.2 (3.65)	0.169
Average Sugar Test			
HbA1C	6.9 (2.8)	7 (2.65)	1.000

Note:*Paired to test p-values and rest all are Wilcoxon-sign rank test p-values.
*EGFR:Estimated glomerular filtration rate; GGT:Gamma-glutamyl transferase; HbA1C:Glycated hemoglobin; HDL: High-density lipoprotein cholesterol; Hs-CRP: High-sensitivity C-reactive protein; LDL:Low-density lipoprotein cholesterol; SGOT:Serum glutamic-oxaloacetic transaminase; SGPT:Serum glutamic pyruvic transaminase; T3:*Triiodothyronine*; T4:Thyroxine; TC: Total cholesterol; TG: Triglycerides; TSH:* Thyroid stimulating hormone*; VLDL: Very low-density lipoprotein cholesterol.*

4. Discussion

The present study aimed to evaluate the effect of a blend of RBO, flaxseed oil, and sunflower oil in the general population and showed a beneficial effect on lowering the lipids, renal, hepatic, thyroid, and inflammatory markers in Indian population.

According to the Indian Dietetic Association, a BMI of 23 and above is considered as overweight and a BMI of 25 and above as obesity [24]. Previous studies have reported obesity and dyslipidemiaas the crucial factors in inducing oxidative stress and the release of proinflammatory cytokines, which are the risk factors for CVD [25]. Similar findings were observed in the current study where the mean BMI of the subjects was found to be 26.32 ± 4.98Kg/m^2, and dyslipidemia was the most (82.19%) reported comorbid condition among all the subjects.

Several studies have revealed that specific oil blends can improve blood lipid profiles and other cardiometabolic parameters, when using blended vegetable oils that are widely consumed in Asia [26]-[27]. In the current study, after one month of follow up, a significant reduction in TC (p<0.001), non--HDLC (p<0.001), TC/HDL ratio (p=0.048), and LDL/HDL (p=0.041), was observed. In concordance with the present study findings, Sumanto et al., reported the blend of refined RBO, flaxseed, and sesame oils, significantlyreduced TC (p<0.0001), LDLC (p<0.0001), TG (p<0.0001), apoB (p<0.0001), and HDLC (p<0.0001) [26]. A single blind crossover Indian study by Kennedyet al., demonstrated RBO and sunflower oil blend significantly reduced TC and LDL in hyperlipidemic (8% and 7%) and normolipidemic (4% and 5%)patients respectively [8]. The possible mechanism of action by which gamma oryzanol reduces cholesterol may be by inhibition of β-Hydroxy β-methylglutaryl-CoA (HMG-CoA) reductase, a key enzyme involved in cholesterol synthesis in the liver. Moreover, sterols in the gamma-oryzanol molecule may also decrease cholesterol absorption [8], [28], [29].

After one month of follow up, the current study showed a significant reduction in total bilirubin (p=0.001), GGT (p=0.021), alkaline phosphatase (p=0.025), creatinine (p<0.001), and calcium (p=0.020). In concordance, Stuglinet al., reported that use of flaxseed oil for 4 weeks significantly decreased serum levels of creatinine [30]. Rana et al., in albino rats, reported a decrease in plasma alkaline phosphatase activity inRBO fed group (490.00±57.12) as compared to the groundnut oil group (583.30±33.00) [31]. Few studies have reported modulation of risk factors by RBO in renal disease[32], [33].Probably, the blends of these edible oils reducethe calcium absorption, which help in reducing formation of renal calculi and aid in prevention of renal disease[34], [35].

RBO, sunflower oil and flaxseed oilhave shown a beneficial effect in diabetes patients. Data from different studies recommend the consumption of a blend of edible oils in diabetes patients [22]. In the present study, for diabetes patients after one month follow up, a significant reduction in total bilirubin (p=0.003), GGT(p=0.018), alkaline phosphatase (p=0.006), calcium (p=0.055), uric acid (p=0.054), T4 (p=0.025) was observed.

Dyslipidemia is a consequence of the interplay between genetic faults and environmental factors (such as nutrition, exercise, and pharmacological effect), with the type of fatty acids in the diet having an influence on the blood lipid profile [36].The current study reported a significant reduction in Hs-CRP (p=0.033), alkaline phosphatase (p=0.041) after one month follow up in patients with dyslipidemia. Moreover, RBO has been shown to protect against oxidative stress and inflammation [37]. Many

epidemiological reports have revealed the anti-inflammatory characteristics of gamma oryzanol, cycloartenylferulate and ferulic acid in RBO[38], [39]. Rao et al. showed that RBO can reduce serum concentrations of CRP, an indicator of acute inflammation, and interleukins [40]. Marjaan et al., reported a decrease in the pro-inflammatory and pro-oxidative mediators (for example, CRP, interleukin (IL)-1b) with consumption ofRBO and/or its main components [23].

After one month of follow up, the present study showed a significant reduction in T3 (p<0.001), T4 (p<0.001) and TSH (p=0.051). Yohnosuke et al., reported that gamma oryzanol extracted from RBO produced a significant reduction in the elevated serum TSH levels in hypothyroid patients [41]. Further, Saeed et al., reported that flaxseed oil has a beneficial effect on thyroid function by enhancing oxidative status in male rats [42]. The lack of change in serum thyroid hormone levels after gamma oryzanol consumption suggests that the blend of these edible oils inhibit TSH secretion by a direct action on the hypothalamus or pituitary gland [43].

Different edible oils have been recognized to regulate blood lipid levels for almost a century. According to several studies, a blend of edible oils reduces the lipid parameters, glycemic levels, and inflammatory markers [21]-[23].RBO, flaxseed oil and sunflower oil blend, has been recognized as ahealthy blend of oils for cardiovascular health because of its lipid lowering properties. The major phytochemical found in RBO is gamma-oryzanol, and phytosterols in flaxseed oil and sunflower oil has been shown to improve levels of blood lipids and reduce oxidative stress, thereby possibly reducing CVD risk [29], [44].

5. Conclusion

The blend of rice bran oil, flaxseed oil, and sunflower oilsignificantly lowered total cholesterol, non-high-density lipoprotein cholesterol, TC/HDL ratio, LDL/HDL, total bilirubin, gamma-glutamyl transferase, alkaline phosphatase, creatinine, calcium, uric acid, T3, T4, thyroid stimulating hormone, high-sensitivity C-reactive protein, and alkaline phosphatase. Hence, the blend of these edible oils could be considered beneficial for lowering the lipids, renal, hepatic, thyroid, and inflammatory markers in the Indian population.

References

[1] Prabhakaran D, Jeemon P, Roy A. Cardiovascular Diseases in India: Current Epidemiology and Future Directions. Circulation. 2016;133(16):1605-20.
[2] Krepel Volsky S, Shalitin S, Fridman E, Yackobovitch-Gavan M, Lazar L, Bello R, et al. Dyslipidemia and cardiovascular disease risk factors in patients with type 1 diabetes: A single-center experience. World J Diabetes. 2021;12(1):56-68.
[3] Yusuf S, Hawken S, Ounpuu S, Dans T, Avezum A, Lanas F, et al. Effect of potentially modifiable risk factors associated with myocardial infarction in 52 countries (the INTERHEART study): case-control study. Lancet. 2004;364(9438):937-52.
[4] Feingold KR. The Effect of Diet on Cardiovascular Disease and Lipid and Lipoprotein Levels. In: Feingold KR, Anawalt B, Blackman MR, Boyce A, Chrousos G, Corpas E, et al., editors. Endotext. South Dartmouth (MA): MDText.com, Inc.
[5] Copyright © 2000-2023, MDText.com, Inc.; 2000.
[6] Gotto A, Bierman E, Connor W, Ford C, Frantz I, Glueck C, et al. Recommendations for treatment of hyperlipidemia in adults. A joint statement of the nutritism committee and the Council on arteriosclerosis. Circulation. 1984;69(5).
[7] Harris CP, Von Berg A, Berdel D, Bauer C-P, Schikowski T, Koletzko S, et al. Association of dietary fatty acids with blood lipids is modified by physical activity in adolescents: results from the GINIplus and LISA Birth Cohort Studies. Nutrients. 2018;10(10):1372.
[8] Wilson TA, Nicolosi RJ, Woolfrey B, Kritchevsky D. Rice bran oil and oryzanol reduce plasma lipid and lipoprotein cholesterol concentrations and aortic cholesterol ester accumulation to a greater extent than ferulic acid in hypercholesterolemic hamsters. The Journal of nutritional biochemistry. 2007;18(2):105-12.
[9] Kennedy A, Menon SD, Suneetha E. Study on Effect of Rice bran & SunÀower oil blend on Human Lipid profile. Indian J Applied & Pure Bio Vol. 2010;25(2):375-84.
[10] Pal YP, Pratap AP. Rice Bran Oil: A Versatile Source for Edible and Industrial Applications. J Oleo Sci. 2017;66(6):551-6.
[11] Sohail M, Rakha A, Butt MS, Iqbal MJ, Rashid S. Rice bran nutraceutics: A comprehensive review. Crit Rev Food Sci Nutr. 2017;57(17):3771-80.
[12] Rukmini C, Raghuram TC. Nutritional and biochemical aspects of the hypolipidemic action of rice bran oil: a review. J Am Coll Nutr. 1991;10(6):593-601.
[13] Mahdavi-Roshan M, Salari A, Ghorbani Z, Nikpey Z, Haghighatkhah M, Fakhr Mousavi A, et al. The effects of rice bran oil on left ventricular systolic function, cardiometabolic risk factors and inflammatory mediators in men with coronary artery disease: a randomized clinical trial. Food Funct. 2021;12(10):4446-57.
[14] Punia S, Kumar M, Siroha AK, Purewal SS. Rice bran oil: Emerging trends in extraction, health benefit, and its industrial application. Rice science. 2021;28(3):217-32.
[15] Ren G-Y, Chen C-Y, Chen G-C, Chen W-G, Pan A, Pan C-W, et al. Effect of flaxseed intervention on inflammatory marker C-reactive protein: a systematic review and meta-analysis of randomized controlled trials. Nutrients. 2016;8(3):136.
[16] Parikh M, Netticadan T, Pierce GN. Flaxseed: its bioactive components and their cardiovascular benefits. Am J Physiol Heart Circ Physiol. 2018;314(2):H146-h59.
[17] Sun X, Wang Y, Li H, Zhou J, Han J, Wei C. Changes in the volatile profile, fatty acid composition and oxidative stability of flaxseed oil during heating at different temperatures. Lwt. 2021;151:112137.
[18] Zivkovic AM, Telis N, German JB, Hammock BD. Dietary omega-3 fatty acids aid in the modulation of

inflammation and metabolic health. Calif Agric (Berkeley). 2011;65(3):106-11.
[19] Shahidi S, Mahmoodi MS, Komaki A, Sadeghian R. The comparison of omega-3 and flaxseed oil on serum lipids and lipoproteins in hyperlipidemic male rats. Heliyon. 2022;8(6):e09662.
[20] Akkaya MR. Prediction of fatty acid composition of sunflower seeds by near-infrared reflectance spectroscopy. J Food Sci Technol. 2018;55(6):2318-25.
[21] Saedi S, Noroozi M, Khosrotabar N, Mazandarani S, Ghadrdoost B. How canola and sunflower oils affect lipid profile and anthropometric parameters of participants with dyslipidemia. Med J Islam Repub Iran. 2017;31:5.
[22] Kuriyan R, Gopinath N, Vaz M, Kurpad AV. Use of rice bran oil in patients with hyperlipidaemia. National Medical Journal of India. 2005;18(6):292.
[23] Rehman A, Saeed A, Kanwal R, Ahmad S, Changazi SH. Therapeutic Effect of Sunflower Seeds and Flax Seeds on Diabetes. Cureus. 2021;13(8):e17256.
[24] Mahdavi-Roshan M, Salari A, Vakilpour A, Savar Rakhsh A, Ghorbani Z. Rice bran oil could favorably ameliorate atherogenicity and insulin resistance indices among men with coronary artery disease: post hoc analysis of a randomized controlled trial. Lipids in Health and Disease. 2021;20(1):153.
[25] Indian Dieteic Association [Internet]. Available from: https://idaindia.com/ida-documents/
[26] Teng KT, Chang CY, Chang LF, Nesaretnam K. Modulation of obesity-induced inflammation by dietary fats: mechanisms and clinical evidence. Nutr J. 2014;13:12.
[27] Haldar S, Wong LH, Tay SL, Jacoby JJ, He P, Osman F, et al. Two Blends of Refined Rice Bran, Flaxseed, and Sesame Seed Oils Affect the Blood Lipid Profile of Chinese Adults with Borderline Hypercholesterolemia to a Similar Extent as Refined Olive Oil. J Nutr. 2020;150(12):3141-51.
[28] Manchanda SC, Passi SJ. Selecting healthy edible oil in the Indian context. Indian Heart J. 2016;68(4):447-9.
[29] Zavoshy R, Noroozi M, Jahanihashemi H. Effect of low calorie diet with rice bran oil on cardiovascular risk factors in hyperlipidemic patients. J Res Med Sci. 2012;17(7):626-31.
[30] Bumrungpert A, Chongsuwat R, Phosat C, Butacnum A. Rice Bran Oil Containing Gamma-Oryzanol Improves Lipid Profiles and Antioxidant Status in Hyperlipidemic Subjects: A Randomized Double-Blind Controlled Trial. J Altern Complement Med. 2019;25(3):353-8.
[31] Stuglin C, Prasad K. Effect of flaxseed consumption on blood pressure, serum lipids, hemopoietic system and liver and kidney enzymes in healthy humans. Journal of cardiovascular pharmacology and therapeutics. 2005;10(1):23-7.
[32] Rana P, Vadhera S, Soni G. In vivo antioxidant potential of rice bran oil (RBO) in albino rats. Indian J Physiol Pharmacol. 2004;48(4):428-36.
[33] Siqueira JS, Francisqueti-Ferron FV, Garcia JL, Silva C, Costa MR, Nakandakare-Maia ET, et al. Rice bran modulates renal disease risk factors in animals submitted to high sugar-fat diet. J Bras Nefrol. 2021;43(2):156-64.
[34] Maurya NK, Arya P, Sengar N. Hypolipidemic effect of rice bran oil on chronic renal failure (undergoing hemodialysis) patients. Plant Archives. 2020;20:3285-9.
[35] Benefits of Oil [Internet]. Available from: https://www.ediblegroup.in/benefits-of-oil/.
[36] Shkembi B, Huppertz T. Calcium Absorption from Food Products: Food Matrix Effects. Nutrients. 2022;14(1):180.
[37] Wang Q, Zhang H, Jin Q, Wang X. Effects of Dietary Linoleic Acid on Blood Lipid Profiles: A Systematic Review and Meta-Analysis of 40 Randomized Controlled Trials. Foods. 2023;12(11).
[38] Sakai S, Murata T, Tsubosaka Y, Ushio H, Hori M, Ozaki H. γ-Oryzanol reduces adhesion molecule expression in vascular endothelial cells via suppression of nuclear factor-κB activation. J Agric Food Chem. 2012;60(13):3367-72.
[39] Islam M, Murata T, Fujisawa M, Nagasaka R, Ushio H, Bari A, et al. Anti-inflammatory effects of phytosteryl ferulates in colitis induced by dextran sulphate sodium in mice. British journal of pharmacology. 2008;154(4):812-24.
[40] Rigo LA, Pohlmann AR, Guterres SS, Beck RCR. Rice bran oil: benefits to health and applications in pharmaceutical formulations. Wheat and Rice in Disease Prevention and Health: Elsevier; 2014. p. 311-22.
[41] Rao YP, Kumar PP, Lokesh BR. Molecular Mechanisms for the Modulation of Selected Inflammatory Markers by Dietary Rice Bran Oil in Rats Fed Partially Hydrogenated Vegetable Fat. Lipids. 2016;51(4):451-67.
[42] Shimomura Y, Kobayashi I, Maruto S, Ohshima K, Mori M, Kamio N, et al. Effect of gamma-oryzanol on serum TSH concentrations in primary hypothyroidism. Endocrinol Jpn. 1980;27(1):83-6.
[43] Al-Saeed FAA. Comparative Study on the Influence of Argan Oil and Flaxseed Oil on Rats Exposed to Diazinon: KING ABDULAZIZ UNIVERSITY JEDDAH; 2021.
[44] Lemus C, Angelis A, Halabalaki M, Skaltsounis AL. γ-Oryzanol: An attractive bioactive component from rice bran. Wheat and rice in disease prevention and health: Elsevier; 2014. p. 409-30.
[45] Bai G, Ma C, Chen X. Phytosterols in edible oil: Distribution, analysis and variation during processing. Grain & Oil Science and Technology. 2021;4(1):33-44.

Author Profile

Dr. Rajagopal Jambunathan is a Consultant Cardiologist at Cauvery Heart & Multispecialty Hospital with 15 years of experience in healthcare and has participated in more than 15 clinical trials.

Dr. Arjun Adnaik is a Consultant Cardiologist at Swastik Hospital with 15 years of experience in healthcare.

Dr. Vanita S Bhat is a Clinical Cardiologist at Cauvery Heart & Multispecialty Hospital with 14 years of experience in healthcare.

Divya Kumari Nityanandan is the Clinical Research Coordinator at Cauvery Heart & Multispecialty Hospital with 10 years of experience in healthcare.