Comparison of the Effects of Canola Oil and Rice Bran Oil Consumption on Oxidative Stress and Blood Pressure in Postmenopausal Type 2 Diabetic Women: A Randomized Controlled Clinical Trial

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ABSTRACT

Background: It has been reported that vegetable oils may affect the level of oxidative stress and blood pressure. This clinical trial aimed to compare the effects of canola oil and rice bran oil consumption on serum malondialdehyde and blood pressure in postmenopausal type 2 diabetic women.

Methods: The results showed that reduction of MDA level was significantly higher in RBO (p<0.001) and CO (p<0.05) groups compared to the controls. In addition, reduction in MDA level for RBO group was more than that for CO group (p=0.012). Levels of blood pressure remained unchanged in all groups at the end of the study.

Results: Mean serum zinc was 78.3±13.7 µg/dL. Significant difference was detected between mean serum zinc among different BMI groups (ANOVA, p=0.03), while it was not significant in different education levels and age intervals (ANOVA, p=0.61 and 0.95 respectively). Participants from two western provinces of Iran (Khoozestan and Lorestan) had significantly higher zinc level. There was a positive relationship between serum iron and zinc (Pearson correlation coefficient, r=0.1, p=0.001).

Conclusion: Consuming either CO or RBO could decrease the levels of MDA and oxidative stress in diabetic patients, but RBO was more effective than CO. Neither of the oils had any significant impact on blood pressure of diabetic women.

Introduction

Increased mortality from the cardiovascular diseases (CVD) is warning in diabetic patients. Oxidative stress and hypertension are some of the most important health problems linked to CVD in diabetes [1-3]. Inflammatory conditions activate neutrophils and macrophages which produces free radicals such as hydrogen peroxide and superoxide so lead to the development of oxidative stress [4,5]. Besides, inflammation leads to insulin resistance which can cause hyperglycemia and dyslipidemia in diabetic patients [6,7]. On the other hand, hypertension is a risk factor for retinopathy, nephropathy and vascular damage. Prevalence of hypertension is about 71% among the patients with type 2 diabetes [8]. Therefore, the effort to improve the oxidative stress and hypertension to prevent

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CVD in diabetic patients is important.

Progression of CVD in diabetics may be affected by manipulation of dietary oils [9-11]. Rice bran oil (RBO) is one of the vegetable oils containing more than 4.4% antioxidant properties [12-14]. γ-oryzanol and γ-tocotrienol are two major antioxidants found in RBO which are effective against oxidative stress [15-17]. The proportion of saturated fatty acids (SFAs), mono unsaturated fatty acids (MUFAs) and poly unsaturated fatty acids (PUFAs) in RBO is approximately 25%, 38% and 37% respectively [18]. Canola oil (CO) extracted from rapeseed is a good source of mono unsaturated fatty acids (MUFAs) which is resistant to oxidative stress [19-21]. The percentage of SFAs, MUFAs and PUFAs in CO is about 7.35%, 63.2% and 28.14% respectively [22]. CO and RBO contain about 10% and 2.2% omega-3 fatty acids respectively, which cause vasodilation and blood pressure reduction as well[23, 24].

Despite the important role of edible oils in blood pressure and oxidative stress regulation, according to the best of our knowledge, there is no clinical trial which compared the effects of CO and RBO consumption in diabetic patients. So this study aimed to compare the effectiveness of these two oils on improvement of serum malondialdehyde (MDA), as an oxidative stress index, and blood pressure in women with type 2 diabetes.

Methods
Subjects
Seventy-five postmenopausal diabetic women with type 2 diabetes were participated in this randomized controlled clinical trial. Participants were out patients of Shahid Motahhari endocrinology clinic of Shiraz, Iran. Inclusion criteria included female gender, being postmenopausal, at least 6 months since diagnosed as diabetic, routine consumption of sunflower oil. Patients with thyroid disorders, kidney, liver or cardiovascular diseases, use of any medication or nutritional supplement, Insulin injection, participation in other studies during the last 6 months, smoking and alcohol consumption were excluded from participation.

Experimental design
After a 4 week- run in period, using balanced block randomization method the participants were allocated to 3 groups including: 1) control group (taking 30g/day sunflower oil), 2) CO group (taking 30g/day CO) and 3) RBO group (taking 30g/day RBO). Based on the estimated energy requirement (EER) formula, a balanced diet (55% carbohydrate, 18% protein and 27% fat) was designed for each participant. Every diet contained a 30 gr vegetable oil (canola, rice bran or sunflower oils). All participants were provided with the oils and asked to add 30gr/day on their salad or baked foods using a measuring spoon. Complete description of the methodology is explained in the previous article of this study[25]. The research protocol was registered in IRCT with the ID of IRCT2014050417568N1.

Anthropometric measurements and dietary intake assessment
Anthropometric indices including weight and height were measured at baseline. Body weight was measured using a scale (Seca, Germany), without shoes and in light clothing to the nearest 100g. Height was measured barefoot by mounted tape to the nearest 0.1cm. Then BMI was calculated as weight (kg)/height^2 (m). Weight was measured again after 8 weeks. At baseline, week 4 and week 8 dietary intakes were assessed using 24-hour food record method (2 week day? and 1 weekend). Dietary intake analyses were done by Nutritionist 4 software (First Databank Inc., Hearst Corp., and San Bruno, CA).

Blood pressure and biochemical assays
At baseline and after 8 weeks a 5cc venous blood sample was obtained from each participant between 7:00 to 9:00 AM after an overnight fast. Then serums were separated by centrifuging and kept in −70° C until further analysis. The serum MDA level was estimated using a reaction with thiobarbituric acid (TBA)[26]. Blood pressure was measured from the same arm, with subjects in a sitting position, after 10 min of rest. Measurements were repeated 3 times at 2-min intervals and the means of the 3 measurements were recorded.

Ethical consideration
The study aims and methods were described to the participants then written consent was taken. The study was approved by the ethics committee of Shiraz University of Medical Sciences.

Statistical analysis
Data was analyzed using SPSS software (version 19; SPSS Inc., Chicago, IL). Normal distribution of variables was tested by Kolmogorov- Smirnov test. Baseline

Table 1. General characteristics, anthropometric status and dietary intake of participants at Baseline

Variables	Canola oil (n=24)	Rice bran oil (n=25)	Control group (n=23)	P value
Age (y)	52.18± 2.43	50.19±7.08	51.97±6.42	0.345
Duration of diabetes (y)	6.22± 4.31	8.54±3.86	5.62±6.21	0.368
Height (cm)	162.21± 6.90	160.48± 6.47	161.70± 6.09	0.634
Weight (kg)	78.39±7.26	75.24±5.34	79.66±6.55	0.545
BMI (kg/m^2)	29.81±2.81	29.37±2.44	30.54±2.68	0.303
Energy (kcal/day)	1970.08±124.99	1940.44±169.23	1996.79±203.04	0.921
Carbohydrate (% of energy)	61.51 ±1.70	59.52±1.30	61.14±101.00	0.881
Protein (% of energy)	15.32±0.91	15.93±2.10	15.36±1.00	0.651
Fat (% of energy)	24.74±1.10	26.31±1.72	25.36±2.11	0.454
ΣSFA (% o total fat)	12.14± 0.91	12.82± 1.11	12.9± 1.32	0.552
ΣMUFA (% of total fat)	6.9± 0.62	7.63± 0.21	6.5± 0.71	0.374
ΣPUFA (% of total fat)	3.6± 0.40	4.94± 0.13	5.1± 0.30	0.429
ΣOmega-3fatty acids (% of total fat)	0.9±0.11	1.1±0.20	1.2±0.22	0.223
Fiber(g/day)	19.09±2.63	19.82±2.35	19.35±2.40	0.332

BMI: body mass index, SFAs: saturated fatty acids, MUFAs: monounsaturated fatty acids, PUFAs: polyunsaturated fatty acids. All values are mean ± Standard deviation. * One-way ANOVA.

Table 2. Dietary intake of participants during the study

Variables	Canola oil (n=24)	Rice bran oil (n=25)	Control (n=23)	P value
Energy (kcal/day)	2013±224.04	2027±221.42	1993±243.39	0.967
Carbohydrate (% of energy)	56.61 ±0.71	57.32±0.7	56.41±1.02	0.645
Protein (%of energy)	15.61±1.2	15.97±1.3	15.87±1.5	0.924
Fat (%of energy)	26.26±2.1	26.42±0.7	27.64±1.2	0.507
ΣSFAs (%of total fat)	6.51± 0.7	7.01± 0.2	7.19±1.42	0.156
ΣMUFAs (%of total fat)	12.21±0.8	11.54± 0.42	6.93±0.81	<0.001
ΣPUFAs (% of total fat)	5.97± 0.5	5.62±0.34	12.38±0.6	0.014
Omega-3 fatty acids (% of total fat)	1.83±0.2	1.4±0.1	0.79±0.31	0.027
Fiber (g/day)	18.74±2.21	19.50±2.22	18.91±1.69	0.551

SFAs: saturated fatty acids, MUFAs: monounsaturated fatty acids, PUFAs: polyunsaturated fatty acids
All values are mean ± Standard deviation. * One-way ANOVA.

measurements and dietary intakes of subjects were compared among three groups using one way ANOVA. Also one way ANOVA was used to identify any significant differences in serum MDA and blood pressure changes among the three groups. MDA level and blood pressure changes in each group were assessed by paired samples *t*-test. P value less than 0.05 was considered significant.

Results

Of the 75 participants, 72 people completed the study. One person in CO group and 2 people in the control group dropped out due to need for insulin injection, lipid-lowering medication demand and unwillingness to continue the cooperation. Participants did not report any adverse effects with the consumption of the oils during the study.

Table 1 show that there were no significant differences in the age, weight, BMI, energy intake, macronutrients distribution and dietary fatty acids pattern of participants among the three groups at baseline.

According to Table 2, mean intake of energy,

macronutrients and saturated fatty acids (SFAs) during the intervention were not significantly different among the three groups, but intake of MUFAs and omega 3 fatty acids were significantly higher in CO and RBO groups compared to the controls.

Comparison of the mean changes of serum MDA and blood pressure among the three groups after 8 weeks intervention is shown in Table 3. Paired samples t-test showed that MDA levels decreased significantly in the CO group (p<0.001) and RBO group (p<0.001) compared to the baseline values.

After adjusting for baseline values, duration of diabetes and changes of body weight during the study with analyses of covariance, changes in serum MDA levels were significantly different among the three groups (p=0.024). Bonferroni Post hoc test showed that reduction of MDA levels were significantly higher in RBO (p=0.008) and CO (p=0.037) groups compared to the control group. Reduction of MDA level in RBO group was more than that of CO group (p=0.012) as well.

Table 3. Comparison of serum MDA and blood pressure changes among the three groups

Variables	Canola oil (n=24)				Rice bran oil (n=25)				Control (n=23)				
	Before	After	Changes	P	Before	After	Changes	P*	Before	After	Changes	P*	P
MDA (nmol/dL)	4.19±1.94	2.76±1.53	-1.43±1.08[bc]	<0.001	4.29±1.72	2.17±1.20	-2.02±1.22[ca]	<0.001	2.95±1.66	3.40±1.72	0.45±1.48	0.098	0.024**
SBP (mmHg)	118.22±2.94	116.35±1.67	1.87±1.24	0.421	116.10±1.85	115.00±2.09	2.12±1.24	0.092	114.30±2.03	113.71±1.98	1.01±0.86	0.211	0.762***
DBP (mmHg)	81.11±10.51	79.16±9.40	1.95±1.41	0.67	75.61±8.10	73.90±1.97	1.71±1.82	0.08	75.33±8.61	74.21±8.51	1.29±0.06	0.140	0.697***

MDA; Malondialdehyde, SBP; systolic blood pressure, DBP; diastolic blood pressure. All values are mean±standard deviation. *paired sample t-test. **Analysis of covariance ***One-way ANOVA. The same letters show significant differences: (a: p=0.008, b: p=0.037, c: p=0.012, Bonferroni post hoc test).

Results of statistical analysis indicated that level of blood pressure changes were not significantly different within and between groups at the end of the study.

Discussion

The present study compares, for the first time, the effectiveness of canola oil and rice bran oil on the level of serum malondialdehyde (MDA), as a marker of oxidative stress, and blood pressure in postmenopausal type 2 diabetic women.

The main finding of this study is that MDA levels showed statistical significant decreases in both test groups compared to the values at the beginning of the study. This finding is in agreement with other studies that indicated the role of CO and RBO in reducing oxidative stress [27-32]. However, regarding to the MDA levels as an indicator of lipid peroxidation, some investigations revealed increased [21, 33] or insignificant changes [30,34] in lipid peroxidation by canola oil ingestion. It should be noted that exact mechanism of antioxidant property of CO is still unclear but it can be attributed to increased intake of MUFAs and their less sensitivity to oxidation than PUFAs [35-37].

In accordance with our findings, some studies reported the antioxidant effects of RBO [32, 38-40]. Furthermore, it has been revealed that the concentration of thiobarbituric acid reactive substances (TBARS) , as an indicator of oxidative stress and lipid peroxidation process, also MDA can be decreased by γ-oryzanol treatment [17,32,39,41,42] which is a major antioxidant found in RBO [15,16]. Proposed mechanism for antioxidant property of RBO is inhibition of lipid peroxidation as well as increasing gene expression of superoxide dismutase, catalase and glutathione peroxidase; consequently improving antioxidant defense system and decreasing oxidative stress [41, 43].

Our results showed that reduction of MDA level in RBO group was more than that in CO group. Although the proportion of PUFAs is more in RBO, it seems that its antioxidant components act stronger and reduce the oxidative stress compared to CO. Tocotrienols in RBO [15,16] are considered to be more potent antioxidant than tocopherols which are found abundantly in CO [44-46]. In addition, oryzanol is a powerful antioxidant only found in RBO [17]; therefore it has more potent antioxidant property than other vegetable oils [47] and it could be a proper explanation for our results which showed more decrease in oxidative stress in RBO group. However, in other studies it has been revealed that RBO and CO have similar effects on oxidative stress [45].

Our results indicated that levels of blood pressure remained unchanged in all groups at the end of the study. This finding is in accordance with Lai and colleagues' study [48]. However, other investigations revealed that CO and RBO cause reduction in blood pressure, especially in hypertensive individuals and improve cardiovascular disease risk [49-51]. We assume that finding no effects on blood pressure in this study could be the result of recruiting normotensive participants, thus more comprehensive studies are recommended either in normotensive or hypertensive individuals to establish the exact effect of these vegetable oils on blood pressure as an important risk factor for cardiovascular diseases [52-54].

Conducting any survey in various scientific fields has its own limits; also there are limitations in our study. First, it should be considered that approving the effectiveness of the mentioned effects of Co and RBO may require a longer period of intervention. Second, measurement of fatty acids in erythrocytes, as an assessment for the participants' compliance, was not done due to financial constraints. Also, physical activity level, fitness and health status of each participant should be assessed in future investigations due to their potential impacts on the effectiveness of these vegetable oils in decreasing risk factors for cardiovascular diseases especially in diabetic women.

Conclusion

It can be concluded that CO and RBO are useful for attenuating oxidative stress in diabetic patients so improve their health condition. Cost effectiveness, availability and causing less health complications are the proposed benefits of consuming these vegetable oils compared to other treatments. In addition, the findings of this study provide valuable data for practitioners who have responsibility for advising diabetic patients on their diet as well as health authorities in order to have precise control and scientific-based monitoring on health status of this type of patients.

Conflict of interest

The authors declare that they have no competing interests.

References

1. Goldberg RB. Cardiovascular disease in diabetic patients. Med Clin North Am. 2000;84(1):81-93.
2. Laing SP, Swerdlow AJ, Slater SD, Burden AC, Morris A, Waugh NR, et al. Mortality from heart disease in a cohort of 23,000 patients with insulin-treated diabetes. Diabetologia. 2003;46(6):760-5.
3. Ray A, Huisman MV, Tamsma JT, van Asten J, Bingen BO, Broeders EA, et al. The role of inflammation on atherosclerosis, intermediate and clinical cardiovascular endpoints in type 2 diabetes mellitus. Eur J Intern Med. 2009;20(3):253-60.
4. Didangelos T, Doupis J, Veves A. Oxidative Stress in Diabetes Mellitus and Possible Interventions. In: Obrosova I, Stevens MJ, Yorek MA, editors. Studies in Diabetes. Oxidative Stress in Applied Basic Research and Clinical Practice: Springer New York; 2014. p. 237-61.
5. Yang H, Jin X, Kei Lam CW, Yan SK. Oxidative stress and diabetes mellitus. Clin Chem Lab Med. 2011;49(11):1773-82.
6. Kawahito S, Kitahata H, Oshita S. Problems associated with glucose toxicity: Role of hyperglycemia-induced oxidative stress. World J Gastroenterol. 2009;15(33):4137-42.
7. Vikram A, Tripathi DN, Kumar A, Singh S. Oxidative stress and inflammation in diabetic complications. Int J Endocrinol. 2014;679754.
8. Esteghamati A, Gouya MM, Abbasi M, Delavari A, Alikhani S, Alaedini F, et al. Prevalence of diabetes and impaired fasting glucose in the adult population of Iran: National Survey of Risk Factors for Non-Communicable Diseases of Iran. Diabetes Care. 2008;31(1):96-8.
9. Fattore E, Bosetti C, Brighenti F, Agostoni C, Fattore G. Palm oil and blood lipid–related markers of cardiovascular disease: a systematic review and meta-analysis of dietary intervention trials. Am J Clin Nutr. 2014 Jun;99(6):1331-50.10.   Lin L, Allemekinders H, Dansby A, Campbell L, Durance-Tod S, Berger A, et al. Evidence of health benefits of canola oil. Nutr Rev. 2013;71(6):370-85.
11. Ng C-Y, Leong X-F, Masbah N, Adam SK, Kamisah Y, Jaarin K. Heated vegetable oils and cardiovascular disease risk factors. Vascul Pharmacol. 2014;61(1):1-9.
12. Cicero AF, Gaddi A. Rice bran oil and gamma-oryzanol in the treatment of hyperlipoproteinaemias and other conditions. Phytother Res. 2001;15(4):277-89.
13. Thanonkaew A, Wongyai S, Decker E, McClements D. Formation, antioxidant property and oxidative stability of cold pressed rice bran oil emulsion. J Food Sci Technol. 2015:1-9.
14. Wanyo P, Meeso N, Siriamornpun S. Effects of different treatments on the antioxidant properties and phenolic compounds of rice bran and rice husk. Food Chem. 2014;157(0):457-63.
15. Goufo P, Pereira J, Figueiredo N, Oliveira MBPP, Carranca C, Rosa EAS, et al. Effect of elevated carbon dioxide (CO2) on phenolic acids, flavonoids, tocopherols, tocotrienols, γ-oryzanol and antioxidant capacities of rice (Oryza sativa L.). J Cereal Sci. 2014;59(1):15-24.
16. Goufo P, Trindade H. Rice antioxidants: phenolic acids, flavonoids, anthocyanins, proanthocyanidins, tocopherols, tocotrienols, γ-oryzanol, and phytic acid. Food Sci Nutr. 2014;2(2):75-104.
17. Jin Son M, C WR, Hyun Nam S, Young Kang M. Influence of oryzanol and ferulic Acid on the lipid metabolism and antioxidative status in high fat-fed mice. J Clin Biochem Nutr. 2010;46(2):150-6.
18. Orthoefer FT. Bailey's Industrial Oil and Fat Products. 6 ed: John Wiley & Sons; 2005. p. 465.
19. Claus T, Maruyama SA, Palombini SV, Montanher PF, Bonafé EG, de Oliveira Santos Junior O, et al. Chemical characterization and use of artichoke parts for protection from oxidative stress in canola oil. LWT - Food Science and Technology. 2015;61(2):346-51.
20. Kuwahara H, Kanazawa A, Wakamatu D, Morimura S, Kida K, Akaike T, et al. Antioxidative and antimutagenic activities of 4-vinyl-2,6-dimethoxyphenol (canolol) isolated from canola oil. J Agric Food Chem. 2004;52(14):4380-7.
21. Papazzo A, Conlan X, Lexis L, Lewandowski P. The effect of short-term canola oil ingestion on

oxidative stress in the vasculature of stroke-prone spontaneously hypertensive rats. Lipids Health Dis. 2011;10:180.

22. Comparisons of Dietary Fats Chart: Canola Council of Canada; 2008-09-03.

23. Asadi F, Shahriari A, Chahardah-Cheric M. Effect of long-term optional ingestion of canola oil, grape seed oil, corn oil and yogurt butter on serum, muscle and liver cholesterol status in rats. Food Chem Toxicol. 2010;48(8-9):2454-7.

24. Sugano M, Koba K, Tsuji E. Health benefits of rice bran oil. Anticancer Res. 1999;19(5A):3651-7.

25. Salar A, Faghih S, Pishdad GR. Rice bran oil and canola oil improve blood lipids compared to sunflower oil in women with type 2 diabetes: A randomized, single-blind, controlled trial. J Clin Lipidol. 2016 Mar-Apr;10(2):299-305 26. Buege JA, Aust SD. Microsomal lipid peroxidation. Methods Enzymol. 1978;52:302-10.27. Azizi-Soleiman F, Jazayeri S, Eghtesadi S, Rajab A, Heidari I, Vafa MR, et al. Effects of pure eicosapentaenoic and docosahexaenoic acids on oxidative stress, inflammation and body fat mass in patients with type 2 diabetes. Int J Prev Med. 2013;4(8):922-8.

28. Fang J, Seki T, Tsukamoto T, Qin H, Yin H, Liao L, et al. Protection from inflammatory bowel disease and colitis-associated carcinogenesis with 4-vinyl-2,6-dimethoxyphenol (canolol) involves suppression of oxidative stress and inflammatory cytokines. Carcinogenesis. 2013;34(12):2833-41.

29. Haghighat N, Vafa M, Eghtesadi S, Heidari I, Hosseini A, Rostami A. The Effects of Tocotrienols Added to Canola Oil on Microalbuminuria, Inflammation, and Nitrosative Stress in Patients with Type 2 Diabetes: A Randomized, Double-blind, Placebo-controlled Trial. Int J Prev Med. 2014;5(5):617-23.

30. Papazzo A, Conlan XA, Lexis L, Lewandowski PA. Differential effects of dietary canola and soybean oil intake on oxidative stress in stroke-prone spontaneously hypertensive rats. Lipids Health Dis. 2011;10:98.

31. Posuwan J, Prangthip P, Leardkamolkarn V, Yamborisut U, Surasiang R, Charoensiri R, et al. Long-term supplementation of high pigmented rice bran oil (Oryza sativa L.) on amelioration of oxidative stress and histological changes in streptozotocin-induced diabetic rats fed a high fat diet; Riceberry bran oil. Food Chem. 2013;138(1):501-8.

32. Sengupta A, Ghosh M, Bhattacharyya DK. Antioxidative effect of rice bran oil and medium chain fatty acid rich rice bran oil in arsenite induced oxidative stress in rats. J Oleo Sci. 2014;63(11):1117-24.

33. Ohara N, Naito Y, Kasama K, Shindo T, Yoshida H, Nagata T, et al. Similar changes in clinical and pathological parameters in Wistar Kyoto rats after a 13-week dietary intake of canola oil or a fatty acid composition-based interesterified canola oil mimic. Food Chem Toxicol. 2009;47(1):157-62.

34. Ohara N, Kasama K, Naito Y, Nagata T, Saito Y, Kuwagata M, et al. Different effects of 26-week dietary intake of rapeseed oil and soybean oil on plasma lipid levels, glucose-6-phosphate dehydrogenase activity and cyclooxygenase-2 expression in spontaneously hypertensive rats. Food Chem Toxicol. 2008;46(7):2573-9.

35. Gillingham LG, Harris-Janz S, Jones PJ. Dietary monounsaturated fatty acids are protective against metabolic syndrome and cardiovascular disease risk factors. Lipids. 2011;46(3):209-28.

36. Mahan, L. Kathleen., Escott-Stump, Sylvia., Raymond, Janice L.Krause, Marie V. (13th ed) (2012) Krause's food & the nutrition care process /St. Louis, Mo. : Elsevier/Saunders, c2012.

37. Schwingshackl L, Hoffmann G. Monounsaturated fatty acids and risk of cardiovascular disease: synopsis of the evidence available from systematic reviews and meta-analyses. Nutrients. 2012;4(12):1989-2007.

38. Hsieh RH, Lien LM, Lin SH, Chen CW, Cheng HJ, Cheng HH. Alleviation of oxidative damage in multiple tissues in rats with streptozotocin-induced diabetes by rice bran oil supplementation. Ann N Y Acad Sci. 2005;1042:365-71.

39. Wang O, Liu J, Cheng Q, Guo X, Wang Y, Zhao L, et al. Effects of Ferulic Acid and γ-Oryzanol on High-Fat and High-Fructose Diet-Induced Metabolic Syndrome in Rats. PLoS ONE. 2015;10(2):e0118135.

40. Xu Z, Godber JS. Antioxidant activities of major components of γ-oryzanol from rice bran using a linoleic acid model. J Amer Oil Chem Soc. 2001;78(6):645-9.

41. Ismail M, Al-Naqeeb G, Mamat WA, Ahmad Z. Gamma-oryzanol rich fraction regulates the expression of antioxidant and oxidative stress related genes in stressed rat's liver. Nutr Metab (Lond). 2010;24(7):23.

42. Ternero CP, Claro C, Rodriguez-Rodriguez R, Alvarez de Sotomayor M, Herrera MD. Rice bran enzymatic extract reduces oxidative stress and restores mesenteric endothelium dependant dilatation in apo e (-/-) mice. Atherosclerosis.2014; 235(2):e250.

43. Xu J, Zhou X, Gao H, Chen C, Deng Q, Huang Q, et al. Micronutrients-fortified rapeseed oil improves hepatic lipid accumulation and oxidative stress in rats fed a high-fat diet. Lipids Health Dis. 2013;6(12):28.

44. Herting DC, Drury EJ. Vitamin E content of vegetable oils and fats. J Nutr. 1963;81(4):335-42.

45. Ranjbar-Zahedani M, Alinejad N, Abdollah Zadeh SM, Mazloom Z. Comparison of the Effects of Edible Oils: Rice Bran, Grape Seed, and Canola on Serum Lipid Profile and Paraoxonase Activity in Hyperlipidemic Rats. Int Cardiovasc Res J.

2015;9(1):28-33.

46. Sen CK, Khanna S, Roy S. Tocotrienols: Vitamin E beyond tocopherols. Life Sci. 2006;78(18):2088-98.

47. Dhavamani S, Poorna Chandra Rao Y, Lokesh BR. Total antioxidant activity of selected vegetable oils and their influence on total antioxidant values in vivo: A photochemiluminescence based analysis. Food chem. 2014;164(0):551-5.

48. Lai M-H, Chen Y-T, Chen Y-Y, Chang J-H, Cheng H-H. Effects of rice bran oil on the blood lipids profiles and insulin resistance in type 2 diabetes patients. J Clin Biochem Nutr. 2012;51(1):15-8.

49. Ardiansyah, Shirakawa H, Koseki T, Ohinata K, Hashizume K, Komai M. Rice bran fractions improve blood pressure, lipid profile, and glucose metabolism in stroke-prone spontaneously hypertensive rats. J Agric Food Chem. 2006;54(5):1914-20.

50. Jenkins DJ, Kendall CW, Vuksan V, Faulkner D, Augustin LS, Mitchell S, et al. Effect of lowering the glycemic load with canola oil on glycemic control and cardiovascular risk factors: a randomized controlled trial. Diabetes Care. 2014;37(7):1806-14.

51. Jones PJ, Senanayake VK, Pu S, Jenkins DJ, Connelly PW, Lamarche B, et al. DHA-enriched high-oleic acid canola oil improves lipid profile and lowers predicted cardiovascular disease risk in the canola oil multicenter randomized controlled trial. Am J Clin Nutr. 2014;100(1):88-97.

52. Emdin CA, Rahimi K, Neal B, Callender T, Perkovic V, Patel A. Blood pressure lowering in type 2 diabetes: A systematic review and meta-analysis. JAMA. 2015;313(6):603-15.

53. Hove KD, Brøns C, Færch K, Lund SS, Rossing P, Vaag A. Effects of 12 weeks of treatment with fermented milk on blood pressure, glucose metabolism and markers of cardiovascular risk in patients with type 2 diabetes: a randomised double-blind placebo-controlled study. Eur J Endocrinol. 2015;172(1):11-20.

54. Maahs DM, Daniels SR, de Ferranti SD, Dichek HL, Flynn J, Goldstein BI, et al. Cardiovascular Disease Risk Factors in Youth With Diabetes Mellitus: A Scientific Statement From the American Heart Association. Circulation. 2014;130(17):1532-58.