

Ameliorating Effect of Dietary Sesame Oil on High Erucic Acid Rapeseed Powder–Induced Changes of Blood Serum Lipids in Rats

Md. Hafizur Rahman*, Khadija Habib, Shaikh Shahinur Rahman, Lubna Nasreen and Asad Ud-Daula

Department of Applied Nutrition and Food Technology, Islamic University, Kushtia, Bangladesh

Abstract: Vegetable oils (soybean, rapeseeds, sesame etc.) are very popular in South-Asian countries like Bangladesh, but most of these oils are rich in erucic acid which has an adverse effect on serum lipids. This study investigated the acute efficacy and protective effect of dietary supplementation of sesame oil at different concentrations on constant dose of rapeseed powder which induced elevation of serum lipids in Wister rats. In this study, rapeseeds significantly decreased body weight ($p < 0.05$) and food efficiency ratio (FER) while serum lipids like total cholesterol (TC), triglycerides (TG) and low density lipoprotein (LDL) were augmented. However, the effect of sesame oil was vice-versa. But when sesame oil was mixed with rapeseeds as dietary supplement, body weight, FER and HDL (high density lipoprotein) were increased while TC, TG and LDL were reduced significantly ($p < 0.01$). This result revealed sesame oil had ameliorated effects on rapeseed through lowering lipid levels in serum and also protected from toxicity effect of rapeseed. Therefore, regular intake of sesame oil as a dietary supplementation might improve desirable lipid profile and also maintain the proper lipid index in human.

Keywords: Rapeseeds, erucic acids, sesame oil, lipid profile

I. Introduction

In Bangladesh, most of the people meet their daily requirements of essential fatty acids from vegetable oils like rapeseed oil, soybean oil, sunflower oil, nuts oil etc. According to the USDA, rapeseed oil was the second most important edible oil in the world [1] but it contains prevalent levels of erucic acid (51.56-67.98%), which evidently causes multiple organ dysfunctions especially heart and liver [2] [3]. Although erucic acid is more readily bio-degradable and readily forms many organic compounds [4], the latent for erucic acid to produce toxic effects in the human heart, leading to increased incidence of heart disease. But there were no evidence that dietary fat consumption is a factor in any of these conditions. A number of studies of humans were available concerning the accumulation of erucic acid in the human myocardium as related to diet, the occurrence of lipodosis in humans, and the incidence of cardiomyopathy in humans and its relationship to diet [5]. Rapeseeds containing high level of erucic acid had been linked with adverse effects in asthma and hay fever sufferers [6] [7]. It was also linked with autism [8], adrenoleukodystrophy (a rare neurobiology disorder) and thrombocytopenia [9]. So, some European countries have already banned the consumption of rapeseed oil. In this context, erucic acid should be eliminated from rapeseed oils prior to its consumptions. But elimination of erucic acid from rapeseeds is a laborious and expensive process. Among the edible oils, sesame is one of the major oil seed crop in Bangladesh both in respect of acreage and production [10]. It is also an important food source in many parts of the world and is commonly used for its oil, which is a rich source of cis-unsaturated fatty acid such as linoleic acid (41% of total), oleic acid (39%), palmitic acid (8%), stearic acid (5%) and others in small amounts [11] [12]. Sesame oil is extremely defiant to oxidative deterioration due to the presence of antioxidants such as sesaminol, sesamol, pinoselinol, and P1. Sesaminol plays a significant role on protecting LDL from oxidative modification [13] [14]. Recent studies have shown that sesame oil may have significant bioactivities that are beneficial for cardiovascular disease (CVD), hypertension, hypolipidemic, hypocholesterolemic and anti-inflammatory role [12] [15]-[22]. Bhaskaran et al. also suggested that sesame oil directly inhibit atherosclerosis lesion formation, while beneficially altering the lipid profile [23] [24]. However, effects of blended rapeseed oil with sesame on plasma lipids have not yet been documented. Thus, the aim of this study was to investigate the acute efficacy and protective effect of dietary supplementation of sesame oil at different concentrations on rapeseed powder which induced elevation of serum lipids in Wister rats.

II. Methods

2.1. Collection Of Rapeseeds And Sesame Oil

Fresh, healthy and good quality rapeseeds and sesame seeds were collected from the local market of Kushtia, district in Bangladesh. The seeds were cleaned properly and sun dried to avoid contamination. Then the

seeds were stored at 4°C in refrigerator with sealed plastic packet to avoid the microbial contamination. During preparation of experimental diet, stored rapeseed was taken out from the refrigerator (4°C) and weighed amount of seeds were crushed and grinded by using electrical blender machine to obtain rapeseed powder (RSP). Rapeseed powder was used as a reservoir of rapeseed oil during the study.

2.2. Preparation Of Sesame Oil

The collected seeds were then cleaned and dehulled manually. Then these dehulled seeds were passed through the power driven mill. The machine squeezed the oil seed and oil from the kernel was collected in a bottle. After milling the sesame oil were strained with a cloth and then allowed to settle. Finally clean layer of oil collected and preserved for use.

2.3. Storage Of Oils

Freshly prepared sesame oil was used during this study. But as a precaution, the oils were preserved in a dark, cool and dry place. The bottle was covered with carbon papers to prevent photo oxidation. All the experiments were carried out at the Department of Applied Nutrition and Food Technology, Islamic University, Kushtia, Bangladesh.

2.4. Animal Selection And Care

Wister rats were purchased from animal house, Department of Pharmacy, Jahangirnagar University, Savar, Dhaka, with an average weight of about 90-110 gm (5 weeks of age). At the beginning of the experiment, all these rats were acclimatized to the new environmental condition for a period of one week. During the experimental period, these rats were kept in a room temperature (25°C) and a humidity range of 50-70%. All these rats were kept in plastic cases (5 rats per cage) with wide square mesh at bottom to avoid coprophagy and maintained with natural 12 hour light and dark cycle (appropriate light and dark cycle is responsible to maintain the biological rhythm that maintain hormonal cycles which in turn controls the lipid metabolism).

2.5. Composition Of Standard Diet

The diet was purchased from Animal House, Bangladesh Council of Scientific and Industrial Research (BCSIR). The composition of the BCSIR standard (Normal) diet was rice polish (20%), wheat bran (21%), wheat flour (30%), protein source/Fish-meal (10%), oilseed cake (10%), molasses (5%), soybean oil (2%), common salt (1.5%), G.S. vitamin (0.5%).

2.6. Grouping Of Experimental Rats And Feeding

Rats were divided into seven groups (n=5) named as A, B, C, D, E, F and G. In this study, 15 gm normal diet was prescribed per day/rat. Group A fed only normal diet and was considered as control group. While group B and C were fed with rapeseed powder (0.6 gm/day/rat) and sesame oil (1 gm/day/rat). The rest four groups of rat (Group D, E, F and G) were fed 0.6 gm rapeseed powder plus increasing dose of sesame oil as 0.6 gm, 0.8 gm, 1.0 gm and 1.2 gm/day/rat respectively. This experiment last for 6 weeks and all documents were recorded every day.

III. Results And Discussion

This study indicated the changes in body weight, Food Efficiency Ratio (FER) and lipid profile (TC, TG, HDL and LDL) caused by blended rapeseed powder mixed with sesame oil. After six weeks of observation, body weight of rats were 69.18%, 43.90%, 61.16%, 47.47%, 62.96%, 59.77% and 63.32 % for Group A, B, C, D, E, F and G respectively (Table 1). This table showed that Group A (control diet) achieved the highest weight gain whereas rapeseed oil diet (Group B) was the lowest one which indicates significant decreased body weight gain in compare with control rats. This was due to the growth retarding activity caused by erucic acid [25] [23]. Sesame oil diet consuming rats (Group C) accelerate the body weight appreciably than rapeseed powder mixed diet groups (Group B). This is because the sesame oil inhibits the inflammation of tissue and protect disturbance of enzyme functions. This study also depicted that the body weight of blended groups D, E, F, and G were increased gradually except group E. When sesame oil and rapeseed powder were blended in different ratio, body weight were increased in accordance with increasing dose of sesame oil. In our study, we emphasized that erucic acid in rapeseed powder might decrease the body weight but sesame oil supposed to minimize the effect of erucic acid by lowering its level. Sesame oil also increased HDL cholesterol in blood which has anti-inflammatory properties and stop the disturbance of metabolic enzymes [15]. Table 2 showed the effect of blended rapeseed powder and sesame oils on food efficiency ratio (FER) of rats. The FER of Group A, B, C, D, E, F and G were 0.112, 0.073, 0.104, 0.087, 0.102, 0.102 and 0.104 respectively. The FER of rapeseed powder were reduced than those of control rats (Group A) which satisfied the previous result [26] [27]. This might be due to the adverse effect of erucic acid. On the other hand, sesame oil diet (Group C) showed significantly

raised FER as compared to rapeseed powder diet (Group B). Furthermore, combined diet (mixed with rapeseed and sesame oil in different ratio) exhibited improved FER than rapeseed diet (Group B) where Group E, F and G indicated significant ($P<0.05$) increased FER. So, the authors suggested that sesame oil supplemented food has ameliorating effect over the negative impact of erucic acid induced rats.

Table 3 depicted the impact of sesame oil and rapeseed powder on blood serum lipid profile. This table showed that rapeseed diet (Group B) had noteworthy elevation of total cholesterol (TC), triglyceride (TG) and low density lipoprotein (LDL) except high density lipoprotein (HDL) in compared to control diet (Group A). In case of TC, group A, B, C, D, E, F and G were 47.7, 63.14, 50.49, 58.36, 56.36, 53.19 and 52.39 mg/dl respectively. This result suggested that control diet was the lowest TC level whereas rapeseed containing diet was the highest one ($p<0.05$) which was supported by the previous research [28] [29] [26]. Additionally, when rats were fed with sesame oil and rapeseed powder in different ratios, significant ($p<0.05$) depletion of serum cholesterol level was observed in the experimental rats (Table 3) as compared with diet containing rapeseed oil (Group B). This might be the sesame lignans which had the potency to decrease serum cholesterol level [19]. Sesamin also reduce the absorption and biosynthesis of cholesterol in rats and plasma cholesterol in humans. Table 3 also illustrated that sesame oil containing rapeseed powder significantly reduced TC level in rats when evaluated with only rapeseed containing diet but when sesame oil mixed with rapeseed step by step, total cholesterol (TC) was reduced gradually, especially last two groups F and G declined significantly ($p<0.05$) than group B. This result indicated that increasing dose of sesame oil would be decreased TC level. Thus, erucic acid in rapeseed oils might elevate serum TC level while sesame oil supposed to the regulative effect on reducing cholesterol level in rats. Therefore, eating habits of consuming sesame oil regularly would be an important strategy to improve health in hyperlipidemia.

Triglyceride (TG) content of experimental rats were 111.66, 149.1, 101.93, 129.69, 116.75, 114.79 and 113.00 mg/dl for control diet (Group A), rapeseed oil diet (Group B), sesame oil diet (Group C) and blended oils diet Groups D, E, F and G respectively (Table 3). Only sesame oil diet had the lowest TG content ($p<0.01$) than control diet while other diets had greater ones. Although rapeseed powder significantly elevated triglyceride (TG), combined diet with increasing doses of sesame oil reduced TG gradually ($p<0.05$) which indicated the reduction of heart disease risk. The falloff this TG level may be due to the Linoleic acid and α -linolenic acid which were found enormously in sesame oil and were involved in the metabolic pathway of prostaglandin synthesis [23] [30]. Another important component of sesame oil was lignin sesamin which also had an effect on lipid metabolism [20]. Thus, this result indicated that rapeseed oil raised serum TG level and sesame oil is supposed to minimize the effect of erucic acid by lowering its level and by the anti-lipidemic effect of sesame oil itself.

The effects of blended rapeseed with sesame oil in different ratios on serum HDL of rats were shown in Table 3 where HDL levels were found 38.35, 37.77, 48.34, 43.17, 43.27, 48.12 and 51.09 mg/dl for Group A, B, C, D, E, F and G respectively. The results found that there was no significant changes between rapeseed oil diet (Group B) and control diet (Group A). But when rats were fed a diet in combination with sesame oil showed highly significant ($P<0.01$) elevation of HDL compared with both control diet and rapeseed diet (Table 3). According to Ajayi et.al, 5% sesame oil fed to rats increased HDL-C in blood serum [31]. Yamashita K et. al also studied about the influence of dietary sesame seed and its ingredients on human health [32]. In this study, we additionally mixed sesame oil and rapeseed oil with the normal diet and found that serum HDL level were increased gradually with high amount of sesame oil doses where group F showed significant ($p<0.05$) elevation of HDL. These findings indicated that sesame oil supposed to minimize the effect of erucic acid by lowering its level and also by hypocholesterolemic effect of sesame oil itself.

Table 3 also explained the effect of experimental diets on blood serum LDL level in the experimental rats. This table showed that rapeseed increased LDL moderately ($p<0.05$) while high erucic acid rapeseed oil might be causative factor for increasing LDL [26]. Olubunmi BA et al found that sesame oil fed to rats decreased LDL in blood serum [31]. In our study, it was proved that sesame oil was highly significant ($p<0.01$) for both control and rapeseed induced diet. On the other hand, when sesame oil mixed with rapeseed containing diet with increasing doses, LDL levels were decreased considerably where group F and G were proximately the same as the sesame oil containing diet (group C) i.e. highly significant for both group A and B ($p<0.01$). This study showed that erucic acid in rapeseed oils might elevate serum LDL level and sesame oil supposed to minimize the effect of erucic acid by lowering its level and also by the hypocholesterolemic effect of sesame oil itself. However, it was evident from the table that sesame oil reduced LDL as certain amount of daily intake and had ameliorating effects over rapeseed oil.

IV. Conclusion

This study was designed to evaluate the effect of sesame oil on the alteration of TC, TG, HDL and LDL induced by rapeseed in rats. The experiment showed that sesame oil reduced erucic acid content of rapeseed which had an augment propensity towards blood serum lipids in rats. Thus, the authors suggested that

regular intake of sesame oil as a dietary supplementation might improve desirable lipid profile and also maintain the proper ratio of lipid index in human.

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Table 1. Consequence of experimental diet (rapeseed with sesame oil to a varying ratio) on rat's body weight gain

Name of groups	Diet provided	Effect of oils on body weight			
		Initial body Wt. (gm) ± SD	Final body Wt. (gm) ± SD	Body wt. gain (gm)± SD	% of change
Group A	Balanced diet	100.22 ± 11.63	170.15 ± 26.80	69.93 ± 15.78	69.18
Group B	Balanced diet 14.4 g + RSP 0.6 g	110.00 ± 5.77	158.30 ± 14.81	48.3 ± 9.99	43.90*a
Group C	Balanced diet 14.0 g+ SO 1 g	106.83 ± 5.67	172.16 ± 19.52	65.33 ± 15.19	61.16*b
Group D	Balanced diet 13.8 g+ RSP 0.6 g + SO 0.6 g	110.00 ± 14.45	162.22 ± 18.04	52.22 ± 10.85	47.47
Group E	Balanced diet 13.6 g+ RSP 0.6 g + SO 0.8 g	101.53 ± 5.97	165.66 ± 18.04	64.13 ± 10.62	62.96*b
Group F	Balanced diet 13.4 g+ RSP 0.6 g + SO 1.0 g	105.6 ± 14.43	168.20 ± 13.98	62.60 ± 6.98	59.77*b
Group G	Balanced diet 13.2 g + RSP 0.6 g + SO 1.2 g	100.20 ± 17.60	162.73 ± 13.17	62.53 ± 12.16	63.32*b

Values are mean ±SD; n=5, RSP = Rapeseed powder, SO= Sesame oil

*significant values p<0.05 a values significant differ from control

**High significant values p<0.01 b values significant differ from rapeseed

Table 2. Consequence of experimental diet (rapeseed with sesame oil to a varying ratio) on Food Efficiency Ratio (FER) of rats

Name of groups	Diet provided	Effect of oils on body weight		
		Body wt. gain (gm) ± SD	Food intake (gm) ± SD	FER
Group A	Balanced diet	69.93 ± 15.78	620.43 ± 2.08	0.112 ± 0.0260
Group B	Balanced diet 14.4 g + RSP 0.6 g	48.3 ± 9.99	657.08 ± 1.97	0.073 ± 0.014
Group C	Balanced diet 14.0 g+ SO 1.0 g	65.33 ± 15.19	625.05 ± 2.44	0.104**b ± 0.01
Group D	Balanced diet 13.8 g+ RSP 0.6 g + SO 0.6 g	52.22 ± 10.85	600.39 ± 1.28	0.087 ± 0.003
Group E	Balanced diet 13.6 g+ RSP 0.6 g + SO 0.8 g	64.13 ± 10.62	625.85 ± 1.90	0.102*b ± 0.021
Group F	Balanced diet 13.4 g+ RSP 0.6 g + SO 1.0 g	62.6 ± 6.98	609.99 ± 3.52	0.102**b ± 0.01
Group G	Balanced diet (13.2 g + RSP 0.6 g + SO 1.2 g)	62.53 ± 6.16	598.08 ± 1.47	0.104**b ± 0.02

Values are mean ±SD; n=5; RSP=Rapeseed Powder, SO=Sesame Oil

* significant values p<0.05 a values significant differ from control

**High significant values p<0.01 b values significant differ from rapeseed

Table 3. Consequence of experimental diet (rapeseed with sesame oil to a varying ratio) on serum TC, TG, HDL, LDL of rat

Name of groups	Diet provided	Blood Serum lipids (mg/dl)			
		TC ± SD	TG ± SD	HDL ± SD	LDL ± SD
Group A	Balanced diet	47.70 ± 2.57	111.66 ± 10.86	38.35 ± 2.85	11.67 ± 1.22
Group B	Balanced diet 14.4 g + RSP 0.6 g	63.14*a ± 1.03	149.1*a ± 7.84	37.77 ± 5.04	13.30*a ± 0.95
Group C	Balanced diet 14 g+ SO 1g	50.49*b ± 3.03	101.93**b ± 8.21	48.34*a**b ± 2.91	8.65*a**b ± 1.11
Group D	Balanced diet 13.8 g+ RSP 0.6 g + SO 0.6 g	58.36 ± 6.09	129.69 ± 6.27	43.17 ± 3.50	11.05 ± 2.19
Group E	Balanced diet 13.6 g+ RSP 0.6 g + SO 0.8 g	56.36 ± 7.54	116.75**b ± 8.88	43.27 ± 5.87	10.2*b ± 0.59
Group F	Balanced diet 13.4 g+ RSP 0.6 g + SO 1.0 g	53.19*b ± 4.02	114.79*b ± 9.94	48.12*b ± 2.50	9.2*a**b ± 0.39
Group G	Balanced diet 13.2 g + RSP 0.6 g + SO 1.2 g	52.39 ± 5.26	113.00*b ± 10.12	51.09 ± 4.41	9.1*a**b ± 0.71

TC=Total Cholesterol; TG= Triglyceride; HDL=High density lipoprotein; LDL=Low density lipoprotein; RSP=Rapeseed Powder; SO=Sesame Oil

Values are mean ±SD; n=5

*significant values p<0.05 a values significant differ from control

**High significant values p<0.01 b values significant differ from rapeseed