FLAXSEEDS, OAT GRAINS, AND GINGER ARE ANTI-OBESITY NUTRACEUTICALS AND THAT CAN COMBAT THE SIDE EFFECTS ASSOCIATED WITH OBESITY

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ABSTRACT*: Obesity being a significant risk factor for many diseases has now become a major health concern. World Health Organization (WHO) estimated that ~1.12 billion people will be obese by 2030 and stressed preventive actions. The present study aimed at evaluating the beneficial effects of flaxseeds, oats grains, ginger, and their combination as anti-obesity nutraceuticals in albino rats. Sixty male albino rats Sprague Dawley Strain, weighing (160 ± 5 g.) were used in this experimental study. After the adaptation period on a basal diet, the rats were distributed into two main groups. The first main group has (6 rats) fed on a basal diet (as a control negative group). The second main group (54 rats) was split up into nine sub-groups as follows: Subgroup (1) fed on a high-fat diet (HFD) and used as a positive control group. Subgroups (2 and 3) fed on HFD" consisting of 5% and 10% flaxseeds, respectively. Subgroups (4 and 5) fed on HFD" containing 5% and 10% oat grains, respectively. Subgroups (6 and 7) fed on HFD" comprising 2.5% and 5% ginger, respectively. Subgroups (8 and 9) fed on HFD" having (5% flaxseeds, 5% oat grains and 2.5% ginger) and (10 % flaxseeds, 10 % oat grains and 5% ginger), respectively. Findings demonstrate that liver weight/body weight% of the positive control group which was nursed on HFDincreased significantly, as compared to the negative control group (3.83 ± 0.226 vs. 2.69 ± 0.093), respectively. Feeding rats that were on HFD with the two levels from (flaxseeds, oat grains, ginger, and their combination) resulted in a significant decrease (p≤ 0.05), in comparison to the positive control group. The highest decrease in the mean value of liver weight/body weight% was noted in the group fed with the combination of 10% flaxseeds, 10% oats, and 5% ginger. Additionally, the results of this study indicated that treatment of rats with the two-level of flaxseeds, oat grains, ginger, and their combination resulted in more improvement in all these parameters and side effects of obesity including a lipid profile, kidney function, liver enzymes, and leptin hormone. It is concluded that flaxseeds, oat grains, ginger, and their combinations prevent weight gain in the rat as well as handle the side effects associated with obesity.*

WOS Subject Classification: Biomedicine
Key Words: Obesity, flaxseeds, oat grain, ginger, weight gain, lipid profile, liver enzymes kidney function, glucose, leptin

1. INTRODUCTION

Obesity is becoming one of the most prevalent problems which affect the health status of people due to its inflammatory features and weakens a person's immune system [1]. There is considerable evidence that shows the relationship of obesity with various negative health outcomes including diabetes, cardiovascular diseases, failure of the endocrine and neurological system. Obesity, in fact, is becoming a global health problem due to its high prevalence across various countries and prevails among all age groups of people ranging from children to adults [2]. People with obesity have a high body mass index which is greater or equal to 30 kg of body weight / m^2 of height. It is typified by the accrual of additional fat that can lead to cardiac dysfunction, stroke, diabetes mellitus type II, ailment in the osteoarticular system, metabolic syndrome, and tumors [3].

The scientific name for oat is Avena Sativa and it is commonly called in various regions as oat, groats, Haber, hafer, straw, avena, oatmeal and family poaceae. Oat is generally derived from a weed of wheat and barley as a secondary crop leading to its ultimate domestication[4]**.** It was primarily cultivated in European countries and, later it was grown across all regions of the world. According to the United Nations Food and Agriculture Organization, oat has been cultivated for more than 2000 years in different regions globally.

Slavin [5] reported that components that are abundant in whole grains include dietary fiber, fat, starch, minerals, antioxidant nutrients, vitamins, lignans and phenolic compounds. These components have been known to reduce the risk of many chronic diseases including coronary heart disease (CHD), diabetes and cancer. Unfortunately, in the grain-refining process, most of these components are eliminated which are abundant in the raw form of germ and bran.

Dietary fibers stimulate one or more of the favorable effects such as laxation and improvement of both lipids & glucose in the blood, these effects may be due to their non-digestibleness in the small intestine and fermentation in the colon. Oats are a good supplier of solvable nutritional fiber-rich in β-glucan, which is considered as a bioactive constituent in dropping postprandial glucose and insulin responses augmenting insulin sensitivity, sustaining glycemic control, and regulating blood lipids [6]. The intake of 3 g or more β-glucan from oats or barley daily is likely to decrease the risk of CHD.

Flaxseed or linseed (*Linum usitatissimum* L.) is classified as a functional food that comprises beneficial elements such as dietary fibers, alpha-linolenic acid (ALA), lignans, and a variety of antioxidants, phytoestrogens, and phytochemicals including flavonoids, phenolic acids, phytic acid & tocopherols [7], which may possess cholesterol and LDL-c lowering [8], antioxidant and anticancer activities. Also, Endoh et al., [9] suggested that flaxseed extract appears to protect liver cells against necrosis.

Previous research studies show that ginger may play a

significant role in bodyweight reduction by increasing thermogenesis, the release of catecholamines, and lipolysis in white adipose tissue [9]. The ginger extract boosted the proportion of palmitate-induced oxygen consumption, suggesting that fatty acid oxidation was increased [10]. Therefore, the purpose of this experimental research was to clarify the effects of flaxseeds, oat grains, ginger, and their combination as anti-obesity nutraceuticals in rats. Also, the experiments were designed to determine the effects of these nutraceuticals on lipid profile, kidney function, liver enzymes, and leptin hormone in these rats.

2. MATERIALS AND METHODS

Materials:

- Casein, all vitamins, minerals, cellulose, L-Cysteine and choline chloride were acquired from the company, El–Gomhoriya, Cairo, Egypt.
- Beef tallow, starch, sucrose and soybean oil were gotten from the local market, Cairo, Egypt.
- Flaxseed (*Linum usitatissimum* L), ginger (*Zingiber officinale*) and oats *(Avena sativa)* were obtained from the agricultural research center, Giza, Egypt.
- Normal male albino rats (60) of Sprague Dawley Strain taken from the Laboratory Animal Colony, Ministry of Health and Population, Helwan, Cairo, Egypt.
- Kits: These were used to measure serum cholesterol, triglycerides, HDL-c, AST, ALT, ALP, uric acid, urea nitrogen, creatinine and leptin hormone are taken from Gamma Trade co for Scientific Services & Consultation, Cairo, Egypt.

Methods:

1. Chemical analysis

Total protein, oil, fiber, ash, and β-glucan were determined in oat grains and flaxseeds and carbohydrates were calculated by difference.

2. Experiment Procedures and Biological Investigation

Male albino rats Sprague Dawley Strain (60 rats) weighing (160 ± 5 g) were housed in well-aerated cages under a hygienic condition and fed on a basal diet for a duration of one week to let them adapt to this type of diet. The basal diet consists of 14 % protein from casein (≥ 80 %), 4% soybean oil, 0. 25 % choline chloride, 1 % vitamin mixture, 3.5% salt mixture, 5 % cellulose, 0.18 % L– cysteine and the remainder is corn starch. The salt mixture and the vitamin mixture were prepared.

After the adaptation period, the rats were split into two main groups as follows :*The first main group (6 rats)* fed on a basal diet (as a control negative group). *The second main group (54 rats)* was divided into nine subgroups as follows: Subgroup (1) fed on a "high-fat diet" (HFD) containing (beef tallow 19%, soybean oil 1% to provide essential fatty acids), sucrose 10%, casein 14%, cellulose 5%, vitamin mixture 1%, salt mixture 3.5%, choline chloride 0.25% and the remainder is corn starch to induce obesity in rats and used as a positive control group. Subgroups (2 and 3) fed on the same above diet "high-fat diet" (HFD) containing 5% and 10% flaxseeds, respectively. Subgroups (4 and 5) fed on the same (HFD) containing 5% and 10% oats, respectively. Subgroups (6 and 7) fed on the same (HFD) containing 2.5% and 5% ginger, respectively. Subgroups (8 and 9) fed on the same (HFD) containing (5% flaxseeds, 5% oats and 2.5% ginger) and (10 % flaxseeds, 10 % oats and 5% ginger), respectively.

The duration of the experiments was eight weeks. The researcher recorded the diets consumed by the rats and body weights twice weekly. At the end of the experiment, the animals were kept fasted over the night, then the rats were anesthetized and sacrificed, and blood samples were collected from the aorta. The blood samples were centrifuged and the serum was separated to assess some biochemical parameters, i.e. serum glucose**,** serum cholesterol, triglycerides, high-density lipoprotein HDL-c, low-density lipoprotein LDL-c and VLDL-c, Aspartate Amino transaminase (AST) and Alamino Amine Transaminase (ALT), ALP, uric acid, urea nitrogen, creatinine**,** leptin hormone determined by Leptin ELISA Kit. The liver of all rats in all groups was separated and weighted to compute organ/body weight %.

Statistical analysis

The analysis focused on determining the mean differences between groups and their significance, which were completed by applying the Analysis of Variance (ANOVA) test with a p-value significant at $p<0.05$.

3. RESULTS AND DISCUSSION

Chemical Composition of Flaxseeds, Oats Grain

In the present study flaxseeds and oat grains were analyzed for their content. In flaxseeds, the (%) of content for fat (lipid) (31.51%); protein (20%); carbohydrates (18.71%), fiber (22.03%), ash (3%) and moisture (4.75%). In oat grains, moisture (6.25%), protein (14.8%), lipid (5.9%), ash (2.11%), fiber (9.6%) and carbohydrates were (61.34%). The (%) of all nutrients except moisture and carbohydrates were higher in the flaxseeds than (%) of these nutrients in oat grains. The mean value of β-glucans was much lower in flaxseed than in the oat grains (0.7% vs. 4.05%), respectively.

Previous literature demonstrates that the mean value of total carbohydrates, dietary fiber, fat, and protein was (28.889 gm, 27.3 gm, 42.16 gm, and 18.29 gm) in each 100 gm of flaxseeds. Flaxseeds are abundant in protein, fat and dietary fiber [11]. The chemical analysis of brown Canadian flax averaged moisture (7.7%); fat (41%), dietary fiber (28%), protein (20%) and ash (3.4%) [12].

Effect of flaxseeds, oat grains, ginger and their combination on nutritional parameters and liver weight/body weight% of rats who consumed HFD

The results presented in Table-1 demonstrated non-significant changes in the initial weight were observed between all groups. On the other hand, the last measurement for weight and body weight gain% (BWG%) of the positive control group recorded a statistically significant increase ($p\leq 0.05$), as matched to the negative control group. All treated

groups recorded a statistically significant decline in the mean values of final weight and BWG%, as compared to the positive control group. The final weight and BWG% of each group treated with the high level from nutraceuticals showed a significant decrease ($p \leq 0.05$), as evaluated against the groups treated with the low levels from them. The highest decrease in final weight and BWG% was observed in the group which was fed with the blend between (flaxseeds, oats grain and ginger together), followed by the groups treated with oats grain, flaxseeds, and ginger respectively.

Table-1 Effect of flaxseeds, oat grains, ginger and their combination on nutritional parameters and liver weight/body weight% of rats fed on high-fat diet

Groups		Feed intake (g)	Initial weight (g)	Final weight (g)	BWG%	Liver weight/ body weight%
Control (-ve) fed on BD		17.72 ^{a} ± 0.837	164.00 ^{a} ± 4.049	182.83 ^{f} ± 4.215	11.49 ^{e} ± 1.242	2.69 ^{h} ± 0.093
Control (+ve) fed on HFD		16.70 ^{abc} ± 0.558	161.33 ^{a} ± 2.943	265.50 ^{a} ± 3.016	64.61 ^{a} ± 3.400	3.83 ^{a} ± 0.226
Rats fed on HFD containing	5 % Flaxseeds	16.15 ^{c} ± 0.703	161.00 ^{a} ± 2.366	211.67 ^{b} ± 4.926	31.48 ^{b} ± 3.165	3.52 $^{b\,c}$ ± 0.131
	10 % Flaxseeds	14.72 ^{d} ± 1.375	161.20 ^{a} ± 2.683	192.80 ^{d} ± 2.774	19.62 ^{d} ± 2.246	3.28 $^{d\,e}$ ± 0.084
	5 % Oats	16.642 ^{abc} ± 1.827	161.71 ^{a} ± 2.288	202.71 ^{c} ± 6.799	25.36 ^{c} ± 3.925	3.39 $^{c\,d}$ ± 0.142
	10 % Oats	16.216 ^{bc} ± 1.085	159.67 ^{a} ± 3.265	180.50 ^{f} ± 3.937	13.05 ^{e} ± 0.994	3.15 $^{e\,f}$ ± 0.099
	2.5 % Ginger	17.466 ^{ab} ± 0.454	160.67 ^{a} ± 2.066	214.50 ^{b} ± 3.937	33.51 ^{b} ± 2.139	3.57 ^{b} ± 0.095
	5 % Ginger	16.12 ^{c} ± 0.523	160.83 ^{a} ± 1.834	202.00 ^{b} ± 2.449	25.61 ^{c} ± 1.940	3.34 ^{d} ± 0.104
	5% Flaxseeds, 5% Oats and 2.5% Ginger	15.85 $^{c\,d}$ ± 0.861	160.67 ^{a} ± 1.966	188.00 ^{e} ± 2.450	17.03 ^{d} ± 2.081	3.12 ^{f} ± 0.117
	10% Flaxseeds, 10% Oats and 5% Ginger	15.38 $^{c\,d}$ ± 0.913	162.00 ^{a} ± 3.162	183.00 ^{f} ± 2.441	12.985 ^{e} ± 1.942	2.92 ^{g} ± 0.139

Values are given as mean ± SD. LSD: Least significant differences ($p<0.05$).

Mean values in each column with same letters are not significantly different.

The liver weight/body weight% of the positive control group which was nursed on HFD increased significantly, as compared to the negative control group (3.83 ± 0.226 vs. 2.69 ± 0.093), respectively. Feeding rats that were on HFD with the two levels from (flaxseeds, oat grains, ginger, and their combination) resulted in a significant decrease in weight measurements, in comparison to the positive control group ($p \leq 0.05$). The highest decrease in the mean value of liver weight/body weight% was noted in the group fed with the combination of 10% flaxseeds, 10% oats, and 5% ginger (Table 2). Previous literature demonstrates that fat content is one of the major factors affecting the energy concentration of diets and a rise in energy density was found to contribute to the excess intake of calories; passive extra intake in humans which consequently promotes the increase of obesity [12].

Motlagh et al., [13] reported that flaxseed intake may improve markers of adiposity, for instance, adiponectin level. Thus, intake of flaxseed could be an adjunctive therapy to mitigate central obesity. The change in body weight and Body Mass Index (BMI) during the treatment period was considerably different between the control group and flaxseed groups in patients with Type II diabetes [14]. Oat β-glucan is mixed-binding, soluble water with, high molecular weight of sugars. It forms a viscous solution even at low concentrations. Viscosity depends on molecular weight, solubility, and β-glucan concentration. The viscosity capacity of β-glucan oatmeal was suggested to be decisive for its effect on satiation. Some studies reported that β-glucan showed a substantial decrease in weight and BMI during the follow-up of three to four weeks of type 2 diabetic patients [15].

Murad et al.,[16] concluded that in 3-months of therapy with active constituents of ginger resulted in a significant dropping of plasma lipids and body weight. These outcomes of therapy eventually prevent coronary artery disease (CAD) in primary and secondary hyperlipidemic patients. One study showed ginger contributes to decreasing body weight, waist-to-hip ratio, fasting glucose levels and insulin resistance index, and improved HDL-cholesterol [17]. Ginger is useful to lessen obesity through different possible mechanisms, including improving thermogenesis, lipolysis and suppression of lipogenesis, regulating intestinal absorption, and appetite control. Consequently, the utilization of ginger can be a beneficial adjunct therapy to prevent obesity progression and associated complications.

Effect of flaxseeds, oat grains, ginger and their combination on lipid profile of rats fed on HFDs

The effect of flaxseeds, oats grain, ginger, and their groupings on lipid profile containing (triglycerides, cholesterol, high-density lipoprotein- cholesterol HDL-c, low-density lipoprotein- cholesterol LDL-c, and very-low-density lipoprotein- cholesterol VLDL-c) (mg/dl) of rats fed on HFD. The mean values of lipid fractions, except HDL-c, were significant for rats fed on HFD $p \leq 0.05$ (control positive group), as matched with the negative control group fed on a basal (low fat) diet.

Feeding rats groups on HFD containing (5 and 10% flaxseeds, 5 and 10% oat, 2.5 and 5% ginger and their combinations) led to a statistically significant decrease ($p \leq 0.05$) in serum cholesterol, triglycerides, VLDL-c and LDL-c, while the rise in HDL-c, as compared to the positive control group. A gradual decrease was noted in the mean values of the serum cholesterol, triglycerides, LDL-c, and VLDL-c with higher levels of flaxseeds, oat grains, and ginger. Additionally, the same trend was witnessed in the levels of HDL-c. The highest positive outcomes in lipid profile were noted for the group fed on HFD containing the blend of 10% flaxseeds, 10% oat, and 5% ginger, consequent to the group fed on HFD having 5% flaxseeds, 5% oats, and 2.5% ginger, respectively.

Findings match with literature that reported that HFD leads to unbalanced fat in the body and consequently to adipose mass accumulation. HFD does not seem to activate the rate of fat oxidation in a similar manner in obese and slim subjects [18]. The previous study demonstrated 30 days' intake of flaxseed may significantly lower the total cholesterol and raise the levels of high-density lipoprotein cholesterol in the blood [19]. Omega-3 fatty acids, alpha-linolenic acid ALA, and lignans which are present in flaxseeds have a favorable outcome on lipids and decrease the risk for heart disorders. Flaxseed is among the few richest reserves of the plant-based ω-3 fatty acid, lignans, and alpha-linolenic acid (ALA). These reserves have fought against the development of cardiovascular diseases. Flaxseed rich in alpha-linolenic acid (ALA) and omega-3 fatty acid, bring 11% decreases in tachycardia [19].

Flaxseed consumption led to a decrease in LDL cholesterol and total cholesterol level, while flaxseed oil does not contribute to this [20]. Thus, the fiber component of flaxseeds is likely to be an agent of this cardioprotective effect. Andersson, [21] detected that soluble fibers and beta-glucans in oats may support the cholesterol-lowering phenomenon. Oats also contain antioxidants and anti-inflammatory components, which also decrease the risk for the formation of atheroma.

Ginger stimulates the enzyme which boosts the use of cholesterol by the body ultimately lowering its level in the blood. An experimental study shows that ginger can lower high cholesterol in animals which were generated experimentally in their bodies, but we need more validated evidence to determine the beneficial effects of ginger on high cholesterol in humans before it can be marketed as a therapy [22]. Empirical evidence showed that daily intake of 1500 mg of ginger for 12 weeks substantially reduces serum levels of total cholesterol, fasting blood sugar, LDL-C, and ALT [23]. Fakhri et al., [24] reported that ginger supplementation significantly reduces LDL, TG, and TC, but not HDL. This property empowers ginger to control the lipid profile. However, we need strong research evidence in form of randomized controlled trials RCTs to verify the beneficial outcomes of ginger supplementations on HDL levels.

Effect of flaxseeds, oat grains, ginger and their combination on serum glucose and leptin hormone of rats fed on HFD

The effect of flaxseeds, oat grains, ginger, and their blend on serum glucose (mg/dl) and leptin hormone (ng/ml) of rats fed on a high-fat diet is shown in Table-2. Feeding rats on HFD (the positive control group) led to a rise in serum glucose and leptin hormone, as compared to the negative control group with statistical significance at $p<0.05$. HFD caused an increase of serum glucose and leptin hormone in the positive control group by about 97.72% and 328.21% in comparison to the negative control group.

Feeding rats on an HFD containing the two levels from (flaxseeds, oats, ginger, and their mixture) brought a decrease in serum glucose and leptin hormone, in contrast to the group which was fed on HFD (positive controls) with p-value significance ($p<0.05$). Whereas the decrease of serum glucose and leptin hormone cause a gradual decreased increase in the levels of tested nutraceuticals in the diets.

Results in this study revealed that the combination between (flaxseeds, oats, and ginger) recorded more effective in decreasing the mean value of serum glucose, followed by oats grain, ginger, and flaxseeds, respectively. The data in this Table-2 showed that the mixture of (flaxseeds, oats, and ginger) recorded more effectiveness in decreasing the mean value of leptin hormone, followed by other tested nutraceuticals. From these results, it could be observed that the best outcomes in improving serum glucose and leptin hormone noted for the group which was fed on HFD containing the high levels from (flaxseeds, oats, and ginger together), this intervention moderated the mean value of serum glucose and leptin hormone by about 36.34% and 64.987%, respectively.

Draganescu et al.,[24] reported that the utilization of flaxseeds led to lower blood glucose levels and hyperlipidemia, along with a recovery of the impaired function of some organs in diabetic rats. The regular consumption of lignans compounds and polyphenols has therapeutic capacity in the management of patients with diabetes mellitus.

Table-2. Effect of flaxseeds, oat grains, ginger and their combination on leptin hormone and glucose of rats fed on HFD.

Groups		Glucose mg/dl	Leptin ng/ml
Control (-ve) fed on BD		84.953 ^{g} ± 2.694	4.623 ^{e} ± 0.276
Control (+ve) fed on HFD		167.965 ^{a} ± 5.787	19.796 ^{a} ± 1.451
Rats fed on HFD containing	5 % Flaxseeds	153.871 ^{b} ± 7.118	15.105 ^{b} ± 1.219
	10 % Flaxseeds	132.166 ^{d} ± 4.877	9.998 ^{c} ± 1.295
	5 % Oats	146.890 ^{c} ± 5.781	16.075 ^{b} ± 2.687
	10 % Oats	129.456 ^{de} ± 4.718	11.683 ^{c} ± 1.453
	2.5 % Ginger	150.680 ^{bc} ± 6.895	15.803 ^{b} ± 1.483
	5 % Ginger	131.765 ^{de} ± 5.004	11.153 ^{c} ± 1.165
	5% Flaxseeds, 5% Oats and 2.5% Ginger	125.275 ^{e} ± 6.334	10.405 ^{c} ± 0.729
	10% Flaxseeds, 10% Oats and 5% Ginger	106.923 ^{f} ± 3.276	6.931 ^{d} ± 0.794

Values are given as mean ± SD for 6 rats in each group.
Mean values in each column with same letters are not significantly different.
LSD: Least significant differences (P<0.05).

Cereal fiber has been effective in lowering appetite and decreasing weight gain thus inhibiting various obesity-associated diseases and disorders [25]. Study trials with animal and human populations have verified that fiber can decrease plasma leptin, as well as intake of fiber, is negatively associated with plasma leptin concentrations in samples [26]. Oat β -glucan, considered the important soluble dietary fiber found in oats, oats are a good source of β- glucan "soluble dietary fiber", β- glucan reduced postprandial glucose and insulin responses, improving insulin sensitivity, maintaining glycemic control and regulating blood lipids [26].

Rats treated with gingerol and fed an HFD had decreased glucose level, body weight, leptin, insulin, amylase, lipase plasma and tissue lipids when compared to normal control ($p < 0.05$) as shown in (Table-2). Rats treated with gingerol and fed an HFD showed decreased glucose level, body weight, leptin, insulin, amylase, lipase plasma and tissue lipids when compared to normal control ($p < 0.05$).

Saravanan et al.,[27] reported that obese rats were fed on HFD and treated orally with the active component of ginger (25, 50, and 75 mg "gingerol" /kg) once daily for 30 days. The measurements on body weight, glucose concentration, leptin, lipid profile, insulin levels, insulin resistance, amylase, and lipase were improved in HFD rats with statistical significance ($p < 0.05$). Rats fed an HFD and but also given gingerol had lowered levels of glucose, low tissue lipids, leptin, insulin, amylase, and lipase plasma and decrease body weight in comparison to normal control with a p-value <0.05.

Influence of flaxseeds, oat grains, ginger and their combination on liver enzymes of rats fed on HFD

The impact of an HFD comprising two levels from (flaxseeds, oats, ginger, and their mixture) on serum liver enzymes including, (ALT), (AST), and (ALP) in rats presented in Table-3. The mean values of ALT, AST, and ALP enzymes were significantly higher in (the positive control group) ($p \leq 0.05$). Rats in the positive control group were fed on HFD and compared with rats fed on a basal diet (the negative control group).

All groups which were fed on various diets which contain flaxseeds, oats, ginger, and the mixture from them showed a significant reduction with p-value (≤ 0.05) in ALT, AST and ALP, as matched to the positive control group. Data show best results in serum liver enzymes for the group fed on HFD which contained high levels from the blend of flaxseeds, oats, and ginger, followed by the group which fed on the identical diet with low quantities from flaxseeds, oats, and ginger.

Schindhelm et al., [28] study indicated that ALT was considerably decreased in the oat-treated group than the control group. These findings support the health benefits of oat through counteracting the growth of fatty liver. The pathogenesis of metabolic syndrome, type II diabetes mellitus, and cardiovascular disease is attributable to high levels of ALT.

The reuptake of ginger caused a drop in the elevated serum level of ALT, AST and ALP. Finally, the ginger intervention prior to acetaminophen demonstrated a noteworthy hepatoprotective outcome because of the decline in the concentration of bilirubin in plasma and levels of hepatic marker enzymes [29].

Based on the current findings, it can be proposed that the 6-gingerol antioxidant nature and anti-inflammatory action mediates the hepatoprotective action and contributes to treating liver diseases.

Table-3 Effect of flaxseeds, oats grain, ginger and their combination on liver enzymes of rats fed on HFD

		AST	ALT	ALP
			U/l	
Control (-ve) fed on BD		55.258 ^{g} ± 3.106	17.791 ^{g} ± 1.884	75.248 ^{g} ± 4.094
Control (+ve) fed on HFD		101.053 ^{a} ± 6.125	60.515 ^{a} ± 3.788	155.765 ^{a} ± 4.408
Rats fed on HFD containing	5 % Flaxseeds	89.418 ^{b} ± 2.620	45.660 $^{c\,d}$ ± 4.215	126.240 ^{c} ± 5.998
	10 % Flaxseeds	71.448 ^{e} ± 3.048	35.896 ^{e}± 2.101	109.298 ^{e}± 4.424
	5 % Oats	87.804 $^{b\,c}$± 7.196	47.391 $^{b\,c}$± 7.078	135.110 ^{b} ± 14.444
	10 % Oats	78.880 ^{d} ± 2.347	41.596 ^{d} ± 2.628	113.033 $^{d\,e}$ ± 2.428
	2.5 % Ginger	99.705 ^{a} ± 3.151	51.255 ^{b} ± 2.838	139.163 ^{b} ± 4.262
	5 % Ginger	83.288 $^{c\,d}$ ± 2.869	43.766 $^{c\,d}$ ± 2.417	118.833 $^{c\,d}$ ± 3.941
	5% Flaxseeds, 5% Oats and 2.5% Ginger	71.038 ^{e} ± 3.622	35.326 ^{e} ± 3.742	110.273 ^{e} ± 6.624
	10% Flaxseeds, 10% Oats and 5% Ginger	60.686 ^{f} ± 3.408	27.368 ^{f} ± 2.892	92.388 ^{f} ± 5.810

Values are given as mean ± SD for 6 rats in each group.
Mean values in each column with same letters are not significantly different.
LSD: Least significant differences (p<0.05).

Effect of flaxseeds, oats grain, ginger and their combination on kidney functions of rats fed on HFD

Table-4 illustrates the effect of flaxseeds, oats grain, ginger and their arrangement at two levels on kidney functions (urea nitrogen, uric acid, and creatinine "mg/dl") of rats fed on HFD. The analysis of mean values demonstrates that levels of serum uric acid, urea nitrogen, and creatinine in the positive control group increased significantly ($p \leq 0.05$), then the negative control group.

Table-4 Effect of flaxseeds, oats grain, ginger and their combination on kidney functions of rats fed on HFD

		Uric acid	Urea nitrogen	Creatinine
			mg/dl	
Control (-ve) fed on BD		1.493 ^{f} ± 0.061	19.533 ^{f} ± 1.469	0.508 ^{h} ± 0.044
Control (+ve) fed on HFD		2.363 ^{a} ± 0.119	62.121 ^{a} ± 2.669	1.626 ^{a} ± 0.084
Rats fed on HFD containing	5 % Flaxseeds	1.865 $^{c\,d}$ ± 0.096	48.510 ^{b} ± 2.261	1.076 ^{c} ± 0.039
	10 % Flaxseeds	1.566 $^{e\,f}$ ± 0.073	37.814 ^{d} ± 1.907	0.728 $^{f\,g}$ ± 0.082
	5 % oats	1.956 ^{c} ± 0.165	48.152 ^{b} ± 6.359	1.211 ^{b} ± 0.179
	10 % oats	1.563 $^{e\,f}$ ± 0.099	41.686 $^{c\,d}$ ± 2.149	0.916 $^{d\,e}$ ± 0.118
	2.5 % Ginger	2.155 ^{b} ± 0.086	51.410 ^{b} ± 2.900	1.325 ^{b} ± 0.077
	5 % Ginger	1.780 ^{d} ± 0.107	42.383 ^{c} ± 2.841	0.988 $^{c\,d}$ ± 0.132
	5% Flaxseeds, 5% oats and 2.5% Ginger	1.641 ^{e} ± 0.108	39.230 $^{c\,d}$ ± 3.819	0.843 $^{e\,f}$ ± 0.059
	10% Flaxseeds, 10% oats and 5% Ginger	1.490 ^{f} ± 0.090	32.233 ^{e} ± 1.114	0.618 $^{g\,h}$ ± 0.049

Values are given as mean ± SD for 6 rats in each group.
Mean values in each column with same letters are not significantly different.
LSD: Least significant differences (P<0.05).

Findings revealed that the highest effect in improving kidney functions in rats fed on HFD was noted for the group fed with flaxseeds, followed by oats grain, and ginger, respectively. From these results, it could be observed that the best outcomes in improving urea nitrogen, creatinine and serum uric acid were recorded for the group which was fed on HFD containing the high levels from (flaxseeds, oats, and ginger together), followed by the group fed on HFD containing 10% flaxseeds and the group which was given the mixture of the (flaxseeds, oats, and ginger together) with low levels, respectively.

Feeding mice on HFD in the long-term initiates tissue lipid accumulation thus causing kidney injury. Additionally, it increased oxidative stress, and dysfunction of mitochondrial, which stimulate cell death in excess. Draganescu *et al.,* [24] reported the administration of flaxseed extract caused a significant decrease in serum urea, uric acid, creatinine, and blood urea nitrogen levels in patients with diabetes mellitus. Hill et al., (2020) [31] reported that a diet augmented with b-glucan is good and possibly effective in lowering serum level intensities of trimethylamine N-oxideTMAO in patients with chronic kidney disease CKD.

4. CONCLUSION

Findings demonstrate several beneficial outcomes of the therapeutic value of ginger as tested by several experimental conditions and measurement of outcomes. The final weight and body weight gain percent of rat groups treated with the high level from nutraceuticals showed a significant decrease, as evaluated against the groups treated with the low levels' nutraceuticals from them. The highest positive outcomes in lipid profile were noted for the rat group fed on HFD containing the blend of 10% flaxseeds, 10% oat, and 5% ginger, consequent to the group fed on HFD having 5% flaxseeds, 5% oats, and 2.5% ginger, respectively. The findings demonstrate that the 6-gingerol antioxidant nature and anti-inflammatory action mediates the hepatoprotective action and contributes to treating liver diseases. Finally, the best outcomes in improving urea nitrogen, creatinine and serum uric acid were recorded for the group which was fed on HFD containing the high levels from flaxseeds, oats, and ginger together. The numerical solution is obtained for MHD flow over a stretching / shrinking surface with suction and heat transfer. The main findings of this study are summarized as follows:

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