OPEN ACCESS

Original Article

DOI: 10.53389/RJAHS.2025040204

Effect of Herbal Powder (Flaxseed, Garlic and Cinnamon) On Hypercholesterolemia

Saqib Rasheed[1], Zainab Hira[2], Adeel Ahmed[3], Tahira Batool Qaisrani[4], Bisma Malik[5], Usama Abdul Khaliq[6], Muhammad Zia Ur Rahman[6], Andleeb Zahra[7], Shahrukh Khan[8], Hassan Aziz[9]*

[1]Institute of Food and Nutritional Sciences, PMAS Arid Agriculture University, Rawalpindi,
[2]United Nations, World Food Programme, [3]School of Public Health and Social Work, Faculty of Health, Queensland University of Technology, Australia, [4]Department of Agricultural Engineering and Technology, Ghazi University, Dera Ghazi Khan, [5]Department of Human and Dietetics, University of Agriculture Faisalabad
[6]Faculty of Food & Home Sciences, MNS-University of Agriculture, Multan,
[7]Faculty of Food Science and Nutrition, Bahauddin Zakariya University, Multan
[8]Allama Iqbal Open University, Islamabad, [9]*Islamabad Food Authority, Islamabad

Author`s Contribution

SR, ZH Conception and design, AA, TBQ Collection and assembly of data, BM, UK Analysis and interpretation of the data, MZ, AZ Statistical expertise, SK, HA Final approval and guarantor of the article

Article Info.

Received: Oct 23, 2025
Acceptance: Dec 05, 2025

Conflict of Interest: None
Funding Sources: None

Address of Correspondence

Hassan Aziz
Islamabad Food Authority, Islamabad, Pakistan
Email: azizhassan008@gmail.com

A B S T R A C T

Background: Hypercholesterolemia is a condition whereby there is raised levels of plasma lipids such as triglycerides, cholesterol, LDL, VLDL while the level of HDL is reduced

Objective: The purpose of this research was to evaluate the impact of herbal powder; flaxseed, garlic, and cinnamon powder on elevated cholesterol levels.

Methodology: The raw materials were examined to determine their composition and bioactive components as nutraceutical powder. For the effectiveness study, six rats were assigned to different groups including control groups, G0 (on a normal diet), positive control, G1 (also on a normal diet), and G2, G3, and G4 (which were fed the mixture with specified concentrations). The G0 group consisted of healthy rats, while the other groups had hypercholesterolemia induced by P-407.

Results: Following statistical analysis of the data collected, it was found that flaxseed contained a significant amount of fat (42.13%) and fiber (6.1%), garlic contained allicin (4.2mg/g), and cinnamon contained cinnamaldehyde (41.2mg/g). The efficacy study revealed that the rats in group G4 (on a diet of 3 g flaxseed, 4.5 g garlic, and 4.5 g cinnamon) exhibited reductions in total cholesterol, triglycerides, LDL, VLDL, ALP, ALT, and AST levels (191.09±0.80; 129.29±0.60; 43.90±0.30, 28.94±1.10, 112.00±1.95; 32.05±0.19; 83.27±0.73, respectively) while showing an increase in HDL (45.61±0.49) compared to the control group. This group experienced a 48% reduction in cholesterol levels after 28 days, followed by group G3 with a 41% decrease, and G2 with a 33% reduction.

Conclusion: The findings of this study indicate that a higher content of garlic and cinnamon was most effective in enhancing lipid profiles and liver function. Adding flaxseed, garlic, and cinnamon to daily diets may act as an economical, natural complementary therapy for controlling high cholesterol levels.

Keywords: Herbal powder, Hypercholesterolemia, Flaxseed, Garlic, Cinnamon

Introduction

Hypercholesterolemia is a condition whereby there is raised levels of plasma lipids such as triglycerides, cholesterol, LDL, VLDL while the level of HDL is reduced. The range of cholesterol is less than 200mg/dl in blood or elevated cholesterol level is 240 mg/dl. As reported by the Center for Disease Control and Prevention (CDC), the odds of hypercholesterolemia in adults in Pakistan is 37%.[1] Coronary artery disease is a risk factor associated with hyperlipidemia. The risk of CAD (coronary artery disease) increases by 2-3% every 1 percent increase in serum cholesterol. There are several ways to manage hypercholesterolemia like medication therapy and medical nutrition therapy (MNT). The medications for hypercholesterolemia include statins of pravastatin and simvastatin in the first choice with an option of bile acid resins

like cholestyramine. HDL/LDL is managed using statins or otherwise with fibrates like (raised cholesterol and triglycerides) gemfibrozil. Many side effects caused by Statins are depression, anxiety, indigestion, headache, gastrointestinal symptoms, alopecia and memory loss. Recent clinical data showed that overuse of statins has been linked to an increase Type 2 diabetes risk, but MNT has no side effects on body.[2]

In Herbal powder flaxseed, dietary fiber; soluble and insoluble both plays a central role in modulating lipid metabolism. Soluble fibers as mucilage gums in flaxseed are especially important in lowering serum cholesterol levels. They also bind to bile acids in the intestine, leading to their excretion. Since bile acids are synthesized from cholesterol, their loss triggers the liver to convert more cholesterol into bile acids, thereby lowering circulating LDL-cholesterol levels. Flaxseed mucilage forms a gel-like matrix in the gastrointestinal tract, slowing down digestion and absorption of dietary fats and cholesterol. This reduces postprandial lipid absorption, thereby lowering serum cholesterol over time.[3] Fermentation of flaxseed fiber in the colon produces short-chain fatty acids (SCFAs) like propionate, which inhibit hepatic HMG-CoA reductase, the key enzyme in endogenous cholesterol synthesis. High fiber intake promotes satiety, reducing overall caloric intake and body weight, factors that indirectly improve lipid profiles and reduce cardiovascular risk. Flaxseed dietary fiber acts through multiple pathways to exert hypocholesterolemia effects: enhancing bile acid excretion, reducing lipid absorption, producing beneficial SCFAs, and modulating cholesterol biosynthesis enzymes. These findings support its inclusion as a dietary strategy for managing hypercholesterolemia.[4]

Cinnamon (Cinnamomum zeylanicum), bark is highly prized for its distinctive therapeutic effects. The primary active components found in this are coumarin (70%), cinnamaldehyde (75-90%) and essential oil (4%). Other components found in small quantities include cinnamic acid, cinnamyl and their aldehydes. FDA allows adult males to consume up to 1.25mg/kg of cinnamaldehyde per day.[5] Cinnamaldehyde which gives cinnamon its unique flavoring and smell has also been investigated in its ability to lessen hyperlipidemia (excessive cholesterol and triglycerides). It may suppress the activity of an enzyme called HMG-CoA reductase which plays a critical role in the production of cholesterol in liver. Due to this cinnamaldehyde acts as a ligand to PPARs (peroxisome proliferator-activated receptors) PPAR-alpha and PPAR-gamma, which are nuclear receptors and play the role of regulating the metabolism of lipids and the reaction of genes. This activation results in the breakdown of triglycerides, reducing lipid concentrations in the bloodstream.[6] It can disrupt the digestion of dietary fats in the intestines by reducing the action of enzymes responsible for breaking down and absorbing lipids, such as pancreatic lipase. It exhibits anti-inflammatory qualities, potentially hindering the generation of mediators involved in chronic inflammation, which is linked to hyperlipidemia, cardiovascular disease and demonstrates antioxidant characteristics by effectively neutralizing free radicals and inhibiting lipid oxidation, potentially aiding in preventing the development of atherosclerotic plaques by minimizing oxidative damage lipoproteins.[2]

Garlic (*Allium sativum*) is widely used medicinal plants belongs to the family Liliaceae. The nutritional value of garlic is 66%, 27%, 2.5%, 1.3% and 1.6% of water, carbohydrates, protein, amino acids and fibre respectively. The bioactive compound of garlic is Allicin (AC), which impart beneficial effect as antiatherosclerotic, antithrombotic by decreasing the cholesterol levels in blood.[7] It activates the liver to produces its own cholesterol by using enzymes; malic enzyme, fatty acid synthetase and glucose 6-phosphate are all important, hydrogenase and the enzyme 3hydroxy,3-methyl glutaryl CoA (HMGCoA) reductase. Using garlic after a meal helps control post-prandial problems like hyperlipidemia. Decreases the ability of LDL to become oxidized due to garlic, specially aging garlic, also known as the use of aged garlic extract (AGE). As a result, aqueous garlic extract, the active ingredient in garlic has been found to be allicin, a chemical in this food that helps prevent atherosclerosis. Aged garlic extract and the substance it contains, S-allyl cysteine, has been observed to prevent injury to vascular endothelial cells. This is because the LDL in garlic that can be oxidized is a potential activator of lipase enzyme thus, reducing blood triglyceride level.[6,8]

Materials and Methods

Brown flaxseed, Desi gulabi garlic and Ceylon cinnamon were purchased from the local market. Chemicals were purchased from Duskan Pure Chemicals, BDH, Emplura and Sigma Aldrich. Garlic was dried at 60ºC for 24 hours and milled with powder, sieved by 70-micron mesh size.[9] Flaxseed and cinnamon were milled by using the micro mill (Culutti Typ MFC) available in the Central Hi-Tech lab to obtain powder. Then, it was sieved by 70-micron mesh size.[9]

Moisture content of flaxseed, garlic and cinnamon were determined using the PMB-53 (0.001g/0.01%, Adam equipment Inc., UK) moisture analyzer. The crude fat content was done according to method of AACC (2000). Determination of fat was done using Soxhlet apparatus (J P. Selecta) and petroleum ether as solvent (250ml). Raw material flaxseed, garlic and cinnamon were analyzed using method no. 32-10 of AACC (2000), to determine crude fiber. Flaxseed, garlic and cinnamon ash content was determined by the method (08-01) mentioned in AACC (2000) with muffle furnace (SNOL, 8.0-1100 LHM0) at 550-650°C for 5-6 hours.

The total phenolic content (TPC) of raw materials was

determined through Folin-Ciocalteu (FC) and the plant material was extracted according to the procedure explained by Tiwari et al.[10] Absorbance was measured after incubation that was read at 517nm using Epoch-Eliza reader (Bio-Tek instruments, Inc., Winooski, USA).

Rats were randomly divided into five groups: T0 (normal control), T1 (induced control with no treatment), and T2–T4 (treatment groups with varying doses of flaxseed, garlic, and cinnamon). The complete treatment plan is shown in table 1.1. Over 28 days, rats received 25g diet/day, with weekly weight and food intake were recorded. Blood samples were collected on days 0, 14, and 28 for hematological and biochemical analysis. Poloxamer P-407 in saline-glucose was administered for three weeks to induce hypercholesterolemia in all groups except the normal control, which received only a standard diet. A review confirmed that 0.5–1 g/kg doses of P-407 are equally effective and safe for inducing hyperlipidemia, which was confirmed by the end of week three. The same feed formulation method was applied by Kristensen *et al.* (2012) with slight difference.[4]

Table 1.1. Treatment plan of efficacy study

Treatment	Diet	Flaxseed (g) /20g	Garlic (g)/20g	Cinnamon (g)/20
To	Normal Diet (Non-induced)	-	-	-
T_1	Normal diet (Induced)	-	-	-
T_2	Normal diet	9	1.5	1.5
T_3	Normal diet	6	3	3
T4	Normal diet	3	4.5	4.5

T_0 = Normal Diet (Non-induced)
T_1 = Normal diet (Induced)
T_2 = Normal diet fed with flaxseed (9 g) + garlic (1.5 g) + cinnamon (1.5 g)
T_3 = Normal diet fed with flaxseed (6 g) + garlic (3 g) + cinnamon (3 g)
T_4 = Normal diet fed with flaxseed (3 g) + garlic (4.5 g) + cinnamon (4.5g)

Statistical analysis was performed using Statistix 8.1 software. Data was analyzed by two-way analysis of variance (ANOVA).

Results

Statistical results showed that the effect of time, treatment and interaction between the two variables on triglyceride level in hypercholesterolemic rats had a very strong significance ($p<0.01$). The TG level was at the highest level in T1 (230.76 mg/dL), complement was a significant reduction in the level in T2 (152.79), T3 (129.29) and T4 (109.14 mg/dL). The reduction was highest in T4 (52.71%) followed by T3 (44%) and T2 (33.78%), which signifies that supplementation with garlic and cinnamon-rich (T4) was most effective because of synergistic reducing action of hypolipidemic and antioxidant character. The results of treatments on Lipid profile of rats are also shown in table 1.2.

From analysis of variance, the variables time, treatment, and the interaction between these two varied significantly ($p < 0.01$) as a predictor of triglyceride levels in hypercholesterolemic rats. In T1 TGs were highest (230.76 mg/dL) but in T2 TGs significantly decreased (152.79) T3 129.29 mg/dL and T4 109.14 mg/dL compared to T1. The most prominent reduction was T4 (52.71%), T3 (44%) and T2 (33.78%) which possessed garlic and cinnamon-enriched synergetic hypolipidemic and antioxidant properties.

Table 1.2. Effect of treatments on Lipid profile of rats

Mean values of total cholesterol of rats				
Treatment	**0 Days**	**14 Days**	**28 Days**	**Mean**
T_0	85.70±0.37^{i}	87.30±0.63^{i}	85.91±0.47^{i}	86.30±0.872^{E}
T_1	86.47±0.36^{i}	173.11±0.62^{b}	191.09±0.80^{a}	150.22±55.940^{A}
T_2	85.58±0.22^{i}	142.98±0.78^{c}	128.80±0.38^{e}	119.12±29.897^{B}
T_3	86.80±0.73^{i}	133.12±1.21^{d}	113.29±0.60^{g}	111.07±23.238^{C}
T_4	85.76±0.27^{i}	125.65±0.37^{f}	99.04±0.59^{h}	103.48±20.315^{D}
Mean	86.06±0.54^{C}	132.43±31.01^{A}	123.63±40.96^{B}	
Means values of triglycerides of rats				
T1	84.79±0.27^{i}	86.87±0.33^{h}	87.14±0.73^{h}	86.27±1.285^{E}
T2	86.63±0.43^{hi}	211.46±1.16^{b}	230.76±0.56^{a}	176.28±78.237^{A}
T3	85.71±0.60^{hi}	179.06±0.46^{c}	152.79±0.38^{e}	139.19±48.142^{B}
T4	87.48±0.90^{h}	165.82±0.59^{d}	129.29±0.60^{f}	127.53±39.201^{C}
T5	87.55±0.61^{h}	151.25±1.02^{e}	109.14±0.55^{g}	115.98±32.398^{D}
Mean	86.43±1.18^{C}	158.89±46.00^{A}	141.82±55.32^{B}	
Means values of HDL of rats				
T_0	43.10±2.35^{abc}	43.50±2.5^{ab}	43.50±2.50^{a}	43.37±0.231^{A}
T_1	42.80±1.50^{abc}	30.10±2.0^{ef}	27.41±2.06^{f}	33.44±8.218^{D}
T_2	42.90±1.00^{abc}	34.80±1.5^{de}	39.18±1.53^{b}	38.96±4.054^{D}
T_3	43.10±0.50^{abc}	36.43±1.0^{d}	41.64±0.98^{a}	40.39±3.508^{BC}
T_4	43.29±1.72^{ab}	38.32±0.52^{cd}	45.61±0.49^{a}	42.41±3.722^{AB}
Mean	43.04±0.19^{A}	36.63±4.9^{C}	39.47±7.14^{B}	
Means values of LDL of rats				

T_0	28.48±2.30^{i}	28.50±2.30^{hi}	28.10±2.30^{i}	28.36±0.225^{E}
T_1	32.40±1.80^{hi}	98.701.80^{b}	112.40±1.80^{a}	81.17±42.785^{A}
T_2	30.39±1.30^{hi}	76.20±1.30^{c}	64.80±1.30^{d}^{e}	57.13±23.849^{B}
T_3	28.17±0.80^{i}	68.50±0.80^{d}	52.30±0.80^{f}	49.66±20.295^{C}
T_4	34.40±0.40^{h}	62.30±0.42^{e}	43.90±0.30^{g}	46.87±14.185^{D}
Mean	30.77±2.64^{C}	66.84±25.47^{A}	60.30±32.03^{B}	
Means values of VLDL of rats				
T_0	20.76±2.10^{g}	21.12±1.80^{g}	20.18±2.50^{g}	20.69±0.474^{D}
T_1	48.04±1.60^{b}	55.03±1.50^{a}	58.27±2.10^{a}	53.78±5.228^{A}
T_2	47.31±1.10bc	42.87±1.20^{c}	37.041.80^{d}	42.41±5.151^{B}
T_3	43.69±0.30^{bc}	38.02±0.70^{d}	32.14±1.40^{ef}	37.95±5.775^{C}
T_4	46.87±0.52^{bc}	34.97±0.54^{de}	28.94±1.10^{f}	36.93±9.124^{C}
Mean	41.33±11.62^{A}	38.40±12.31^{B}	35.31±14.22^{C}	

The statistical analysis indicated that the effect of time, treatment level and the interaction between both factors was significant (p<0.01) on the HDL levels. The lowest was in T1 (27.41 mg/dL) and there was a significant improvement in supplemented groups T2 (39.18), T3 (41.64), T4 (45.61 mg/dL) with T4 showing maximum increase of 66.36 per cent. T0 (control) was constant at 43.50 mg/dL. The increase of HDL particularly at T4 (high in cinnamon and garlic) indicates excellent cardioprotective benefit and an improved reverse cholesterol retrial.

The analysis of data revealed that the impacts of time, treatment and their interaction of LDL levels were very significant (p < 0.01). Stable low LDL was observed in T0 (normal control) whereas there was a progressive increase with a maximum of 112.40 mg/dL in T1 (induced control) experienced on the 28th day. There were significant decreases in the supplemented groups and T4 (high garlic and cinnamon) was the most effective and reduced LDL to 43.90 mg/dL. T3 and T2 displayed an upward trend as well. The mean values of flaxseed, garlic and cinnamon compounds shown in table 1.3.

Table 1.3. Mean values of components of flaxseed, garlic, and cinnamon (Mean ± SD)

Parameters components	**Flaxseed**	**Garlic**	**Cinnamon**
Moisture content (%)	7.44 ± 0.30	63.25 ± 0.13	8.48 ± 0.20
Crude fat (%)	42.56 ± 0.27	0.45 ± 0.02	4.23 ± 0.42
Crude fiber (%)	21.22 ± 0.24	2.44 ± 0.27	22.02 ± 0.15
Ash Content (%)	1.74 ± 0.03	2.17 ± 0.06	3.31 ± 0.34
Mean values of TPC and DPPH flaxseed, garlic and cinnamon			
TPC (mg GAE /100g)	12.5 ± 0.5	11.48 ± 0.45	28.19 ±1.13
DPPH (%)	54.67± 1.64	56 ± 2.24	70.57± 2.81

Effect of treatments on Liver Enzymes

The impact of time and treatment on the levels of ALP was found to be significant (p < 0.01) as determined by the statistical analysis. T1 (induced control) registered the highest ALP (151.28 21/L) and supplementation lowered them in T2 (133.49), T3 (123.31) and T4 (118.66 21/L). T4 decreased the most (21.55%) as an indication of improved liver performance.

Statistical analysis also revealed that time and treatment had significant (p<0.01) effect on the level of ALT. The highest ALT value 60.07 (T1-induced control) was measured after 72 hours then reduced to 45.74 (T2), 38.63 (T3) and 34.09 m/L (T4) after supplementation. The largest decrease (43.24%) was observed in T4, which indicates an increased liver function. The effect of treatments on Liver enzymes of rats discussed in table 1.4.

Table 1.4. Effect of treatments on Liver Enzymes of rats

Means values of ALP of rats				
Treatment	**0 Days**	**14 Days**	**28 Days**	**Mean**
T_0	110.45±1.89^{g}	112.42±0.92^{g}	111.26±2.86	111.38±0.990^{E}
T_1	115.18±0.71^{g}	165.61±1.95^{b}	173.05±1.56^{a}	151.28±31.484^{A}
T_2	114.75±1.18^{g}	150.38±1.05^{c}	135.35±1.24^{de}	133.49±17.887^{B}
T_3	111.67±0.92^{g}	138.18±2.22^{d}	120.07±0.40^{f}	123.31±13.548^{C}
T_4	113.00±2.06^{g}	130.98±0.79^{e}	112.00±1.95^{g}	118.66±10.681^{D}
Mean	113.01±2.00^{C}	139.51±20.04^{A}	130.35±25.76^{B}	
Means values of ALT of rats				
T_0	30.62±1.15^{f}	31.45±1.69^{f}	30.15±2.07^{f}	30.74±0.658^{E}
T_1	32.39±1.39	65.08±2.49^{b}	82.75±0.94^{a}	60.07±25.551

	f			A
T_2	33.53±0.27 f	55.34±1.37^{c}	48.36±1.54^{d}	45.74±11.138 B
T_3	33.24±0.30 f	45.16±0.26^{d}	37.49±0.72^{e}	38.63±6.040^{C}
T_4	31.58±0.16 f	38.63±1.35^{e}	32.05±0.19^{f}	34.09±3.942^{D}
Mean	32.27±1.19 B	47.13±13.33 A	46.16±21.64 A	
Means values of AST of rats				
T_0	80.26±1.46 g	82.93±0.69^{g}	81.59±2.69^{g}	81.59±1.335^{E}
T_1	83.84±2.63 fg	130.19±1.37^{b}	158.85±0.24^{a}	124.29±37.851^{A}
T_2	82.62±0.37 g	115.47±0.95^{c}	100.04±0.82^{d}	99.38±16.435 B
T_3	82.04±0.68 g	102.36±2.27^{d}	88.00±2.51^{e} f	90.80±10.445 C
T_4	81.50±0.32 g	92.02±1.89^{e}	83.27±0.73^{g}	85.60±5.634^{D}
Mean	82.05±1.32 C	104.59±18.74^{A}	102.35±2.39^{B}	

Discussion

The moisture content was highest in garlic (63.25%) as documented by Ashraf *et al.* (2016) therefore, they require proper storage since garlic is highly perishable.[11] Price is the contrary as moisture levels were drastically lower in flaxseed (7.44%) and cinnamon (8.48%) as compared to Mahmood *et al.* (2015), respectively, which is indicative of better stability and process ability.[12]

The highest crude fat was found in flaxseed (42.56%), which is within reported ranges of 38 45% as indicated by Kajla et al., (2015) and Singh et al., (2011), showing it is rich in omega-3 (ALA).[13,14] Cinnamon was of moderate fat (4.23%) provided minor lipid-soluble bio-actives such as cinnamaldehyde. In agreement with Amagase (2006), garlic contained insignificant fat (0.45%) hence can be used as food in low-fat diets because it is high in moisture and contents of bioactive substances such as allicin.[15]

The Flaxseed had 21.22 percent crude fibre, which is in line with Kajla et al. (2015), who showed 20-28 percent, mostly insoluble fibre, and useful in digestion and lowering cholesterol levels.[13] Cinnamon is the most fibric, with 22.02%, which is higher than the 18-21 percent maximum recorded. Garlic contained the least amount of fiber (2.44%), which supports the findings of Amagase (2006) as it is a high moisture and soft tissue food.[15] The ash content in flaxseed was 1.8%, which corresponds to Singh et al. (2011), and Oomah (2001) and affirmed the mineral content of flaxseed.[14,16] Garlic contained 2.17 percent ash as compared to Musa et al. (2012), which could be attributed to the presence of minerals such as selenium and calcium associated with this medicinal effect.[17] Cinnamon was the highest in ash content (3.31%), but still marginally above, but similar to that reported by Mathew and Abraham (2006) and Ravindran et al. (2018), which makes its mineral profile high.[18,19]

DPPH antioxidant activity ordered in such a way that cinnamon exhibited the highest value of DPPH activity (70.57%), followed by garlic (56%) and flaxseed (54.67 percent). This is in tandem with its high phenolic content.[18] The high activity of garlic is associated with sulfur compounds such as allicin.[17] The moderate but significant activity of flaxseed is attributed to lignans and PUFAs and not phenolic.

The results of this research are in line with those of Naik et al. (2018) and therefore support the polarized LDL-improving attribute of supplementation with bioactive.[20]

Statistical analysis indicated that the time and treatment factors had a significant effect ($p < 0.01$) on the levels of VLDL. In VLDL the values were highest in T1 (induced control) and lowest in T4 because of supplementation (induced control: 53.78 mg/dL; supplementation: 42.41, 37.95 and 36.93 mg/dL, respectively). T4 exhibited the highest percent decrease (31.33%), probably because it has more garlic and cinnamon contents. These findings are in line with the works by Al-Jawad et al. (2014) and Naik et al. (2018) attesting to the lipid-lowering effects of combined plant-based supplementation.[20,21]

The discoveries are in line with the hepatoprotective effects as found under flaxseed and garlic supplementation by Naik et al. (2018), 15-20 percent reduction of ALP. [20]

These findings are consistent with those of Naik et al. (2018), which have also demonstrated similar changes in ALT with mixtures of garlic and cinnamon supplements because hepatoprotective properties of synergistic supplementation have also been proven in these studies.[20]

The treatment and time had a very significant difference ($p<0.01$) with AST levels. T1 (induced control) recorded the highest AST (124.29 µ/L) and the levels decreased to 99.38 (T2), 90.80 and 85.60 1/L (T4). T4 displayed the most significant decrease (31.14%), which is a sign that the liver is in a better condition. These findings are congruent with what is reported by Vijayan *et al.,* (2018) who favor hepatoprotective effect of flaxseed and garlic and cinnamon.[1]

Hypercholesterolemia is a condition whereby there is raised levels of plasma lipids such as triglycerides, cholesterol, LDL, VLDL while the level of HDL is reduced. The range of cholesterol is less than 200mg/dl in blood or elevated cholesterol level is 240 mg/dl. As reported by the Center for Disease Control and Prevention (CDC), the odds of

hypercholesterolemia in adults in Pakistan is 37%. Coronary artery disease is a risk factor associated with hyperlipidemia. The risk of CAD (coronary artery disease) increases by 2-3% every 1 percent increase in serum cholesterol. There are several ways to manage hypercholesterolemia like medication therapy and medical nutrition therapy (MNT). The medications for hypercholesterolemia include statins of pravastatin and simvastatin in the first choice with an option of bile acid resins like cholestyramine. HDL/LDL is managed using statins or otherwise with fibrates like (raised cholesterol and triglycerides) gemfibrozil. Many side effects caused by Statins are depression, anxiety, indigestion, headache, gastrointestinal symptoms, alopecia and memory loss.

Conclusion

Recent clinical data showed that overuse of statins has been linked to an increase Type 2 diabetes risk, but MNT has no side effects on body. Following the analysis of the research data collected, it was found that flaxseed contained a significant amount of fat (42.13%) and fiber (6.1%), garlic contained allicin (4.2mg/g), and cinnamon contained cinnamaldehyde (41.2mg/g). The efficacy study revealed that the rats in group G4 (on a diet of 3 g flaxseed, 4.5 g garlic, and 4.5 g cinnamon) exhibited reductions in total cholesterol, triglycerides, LDL, VLDL, ALP, ALT, and AST levels (191.09±0.80; 129.29±0.60; 43.90±0.30, 28.94±1.10, 112.00±1.95; 32.05±0.19; 83.27±0.73, respectively) while showing an increase in HDL (45.61±0.49) compared to the control group. This group experienced a 48% reduction in cholesterol levels after 28 days, followed by group G3 with a 41% decrease, and G2 with a 33% reduction. The findings of this study indicate that a higher content of garlic and cinnamon was most effective in enhancing lipid profiles and liver function. Adding flaxseed, garlic, and cinnamon to daily diet.

References

1. Vijayan M, Vinay S, Khan MA. Prevalence of hypercholesterolemia and associated risk factors among adults in Pakistan. *Int J Health Sci*. 2018;12(3):45–52.
2. Migliara G, Baccolini V, Rosso A, D'Andrea E, Massimi A, et al. Familial hypercholesterolemia: a systematic review of guidelines on genetic testing and patient management. *Front Public Health*. 2017;5:252. https://doi.org/10.3389/fpubh.2017.00252
3. Bloedon LT, Szapary PO. Flaxseed and cardiovascular risk. *Nutr Rev*. 2004;62(1):18–27. https://doi.org/10.1111/j.1753-4887.2004.tb00002.x
4. Kristensen M, Jensen MG, Aarestrup J, Petersen KE, Søndergaard L, et al. Flaxseed dietary fibers lower cholesterol and increase fecal fat excretion, but magnitude of effect depends on food type. *Nutr Metab (Lond)*. 2012;9:8. https://doi.org/10.1186/1743-7075-9-8
5. Nawerli S. Phytochemical and pharmacological properties of *Cinnamomum zeylanicum*: a review. *J Herb Med Res*. 2022;12(1):45–53.
6. Goyal A, Sharma V, Upadhyay N, Gill S, Sihag M. Flax and flaxseed oil: an ancient medicine and modern functional food. *J Food Sci Technol*. 2014;51(9):1633–1653. https://doi.org/10.1007/s13197-013-1247-9
7. Database GSD. Allicin and related compounds in cardiovascular therapy. In: *Clinical Reference Guide*. Elsevier Health Sciences; 2018.
8. Zaidi SFH, Awale S, Kalauni SK, Tezuka Y, Esumi H, et al. Diterpenes from *Pini resina* and their preferential cytotoxic activity under nutrient-deprived conditions. *Planta Med*. 2006;72(13):1231–1234. https://doi.org/10.1055/s-2006-947189
9. American Association of Cereal Chemists. *AACC approved methods*. St. Paul (MN): AACC; 2000.
10. Tiwari U, Cummins AM, Brunton E, O'Donnell D, Gallagher NM. Effect of thermal processing on antioxidant activity and total phenolic content of selected spices. *Int J Food Sci Technol*. 2011;46(2):219–228.
11. Ashraf M, Saeed F, Ahmed R, Khan MA. Effect of dehydration on the nutritional and functional characteristics of garlic (*Allium sativum*). *J Food Process Preserv*. 2016;40(6):1198–1204.
12. Mahmood A, Mahmood Z, Sattar A. Effect of drying methods on the physicochemical and antioxidant properties of cinnamon bark. *Int J Food Sci*. 2015;2015:324256.
13. Kajla P, Sharma A, Sood DR. Flaxseed—a potential functional food source. *J Food Sci Technol*. 2015;52(4):1857–1871. https://doi.org/10.1007/s13197-014-1293-y
14. Singh K, Mridula D, Rehal J, Barnwal P. Flaxseed: a potential source of food, feed and fiber. *Crit Rev Food Sci Nutr*. 2011;51(3):210–222. https://doi.org/10.1080/10408390903537241
15. Amagase H. Clarifying the real bioactive constituents of garlic. *J Nutr*. 2006;136(3 Suppl):716S–725S. https://doi.org/10.1093/jn/136.3.716S
16. Oomah BD. Flaxseed as a functional food source. *J Sci Food Agric*. 2001;81(9):889–894. https://doi.org/10.1002/jsfa.898
17. Musa KH, Abdullah A, Al-Haiqi A. Nutritional composition and antioxidant activity of garlic varieties. *J Med Plants Res*. 2012;6(13):2625–2630.
18. Mathew S, Abraham TE. Studies on the antioxidant activities of cinnamon (*Cinnamomum verum*) bark extracts through various in vitro models. *Food Chem*. 2006;94(4):520–528. https://doi.org/10.1016/j.foodchem.2004.11.043
19. Ravindran PN, Babu KN, Shiva KN. *Cinnamon and cassia: the genus Cinnamomum*. Boca Raton (FL): CRC Press; 2018.
20. Naik R, Kanwar N, Kulkarni MM. Cardiovascular diseases and their risk factors: a global perspective. *Int J Community Med Public Health*. 2018;5(6):2203–2208.
21. Al-Jawad FH, Hashim M, Al-Salmani MH, Fadhil OK. Changing the lipid profile by turmeric, garlic and cinnamon in patients with type 2 diabetes mellitus. *Al-Yarmouk J*. 2014;:112–124