

Research Article	Pak-Euro Journal of Medical and Life Sciences	
DOI: 10.31580/pjmls.v6i3.3394	Copyright © All rights are reserved by Corresponding Author	
Vol. 6 No. 3, 2023: pp. 268i-268vi		
www.readersinsight.net/pjmls	Revised: August 25, 2023	Accepted: August 29, 2023
Submission: July 19, 2023	Published Online: September 04, 2023	

## EXPLORING THE HYPOLIPIDEMIC EFFECT OF DIFFERENT COMBINATIONS OF FLAX AND CHIA SEED POWDER

Muhammad Farooq<sup>1\*</sup>, Nuzhat Khalid<sup>2</sup>, Rizwan Shukat<sup>2</sup>, Syed Qamar Abbas<sup>2</sup>  
Shehzad Muzammil<sup>2</sup>, Anees Ahmed Khalil<sup>1</sup>

<sup>1</sup>University Institute of Diet and Human Nutritional Sciences, The University of Lahore, Lahore, Pakistan

<sup>2</sup>National Institute of Food Science and Technology, University of Agriculture, Faisalabad, Pakistan

\*Corresponding Author: Muhammad Farooq. Emails: [farooq.fst28@gmail.com](mailto:farooq.fst28@gmail.com)



### Abstract

The major contributing factor in the development of heart diseases is hyperlipidemia. Hyperlipidemia is one of those health issues originates from excessive consumption of unhealthy fats. The number of individuals with the problem of hyperlipidemia is increasing globally. But these numbers can be reduced with dietary modifications, lifestyle changes, and consumption of specific therapeutic foods. Different food commodities are known to have hypolipidemic potential. Flax seeds and chia seeds possess hypolipidemic properties due to the presence of large amounts of dietary fibre, unsaturated fatty acids and antioxidants. The present study was composed to examine the effect of different combinations of flax and chia seeds powder (50%+ 50%, 70%+30% and 30%+70% respectively) on serum lipid profile. An efficacy study was performed on rats, and hyperlipidemia was induced by giving a high-fat diet for a period of 15 days. The blood samples were collected after the period of induction and at the end of the study. The most observable effect was showed by the group who treated with 70% flax and 30% chia seed with normal diet. The reduction in TC 106.52±0.39→88.20±0.55 mg/dl, TGs by 164.18±0.56→140.72±0.26 mg/dl, LDL-C 59.09±0.44→51.81±0.96 mg/dl and an increase in HDL-C by 25.96±0.23→32.03±0.45 mg/dl was observed. The findings of the current study revealed that both flax and chia seeds are helpful in the maintenance of health by lowering lipid levels, which can be associated with the dietary fiber and fatty acid composition.

**Keywords:** Chia seeds, Flax seeds, Hyperlipidemia, Lipid profile

## INTRODUCTION

Worldwide, heart diseases are the main reason for a large number of deaths and it is also predicted that the situation will become worst by 2020. Moderate amount of lipids is necessary for the functioning of the vital organs. The excess amount of lipid is associated with many serious health concerns that can cause abnormalities. The condition of elevated levels of lipid includes both triglycerides and cholesterol is termed as hyperlipidaemia (1).

Hyperlipidemia is a complex medical disorder that is associated with increased blood levels of lipids or lipoproteins. It can also be termed as hypercholesterolemia and hyperlipoproteinemia (2). It causes early onset of many heart diseases like atherosclerosis, pancreatitis, and several other problems. Diabetes mellitus, diuretic, and beta blocker drugs, obesity, alcohol consumption and kidney disorders are some causes of hyperlipidaemia (3). Hyperlipidemia can be treated both pharmacologically and non-pharmacologically/by diet therapy. The basic aim of dietary therapy is to reduce the fat intake and increase the soluble fiber in daily diet along with increased consumption of omega 3 and omega 6 fatty acids which have health promoting effect (4).

Functional foods are those which provide basic nutrients as well as significantly alleviate the health status. These foods have major contribution in maintaining the health status and reducing the risk of diseases. Flaxseed is also considered as an emerging and significant functional food constituent. Flaxseed belongs to family Linaceae and its Latin name is (*Linum sitatissimum* L.) which means very useful (5).



Flaxseed is considered as a nutritional punch because it provides a variety of nutritional components. It is the best source of lignans,  $\omega$ -3 fatty acids, and dietary fiber. Flaxseed also contains a prominent amount of minerals including zinc, sodium, phosphorus, and calcium (6).

Chia seed is the member of Labiatae family and its Latin name is (*Salvia hispanica* L.). It contains beneficial components that's why used as a source of functional food. It contains a large amount of  $\alpha$ -linolenic acid and  $\omega$ -3 fatty acids. It also exhibits the high content of antioxidants and dietary fiber which increase its use as a therapeutic diet in the management of blood glucose level, hyperlipidaemia, and hypertension (7).

Examined the effect of daily consumption of 40g of ground flaxseed in hyperlipidemic patients has been examined (8). After 56 days of trial results showed that the group consuming flaxseed, presented 31% decline in serum triglyceride levels and 16% increase in HDL-C levels in the experimental group when compared with the control group. Chia seeds and chia flour both used in this study with and without heating action and given to hyperlipidemic rats for 14 days. The results showed a beneficial impact of chia seed/flour against blood glucose levels, TG, HDL, and LDL when compared with the placebo group (9).

This study was conducted to evaluate the combined effect of flax and chia seed powder on the lipid profile and also to evaluate that which combination of flax and chia seed powder was helpful in lowering serum TC, LDL-C and TG levels.

## MATERIALS AND METHODS

### PROCUREMENT AND PREPARATION OF RAW MATERIAL

Flax and chia seeds were purchased from the local market and chemicals were purchased from the renowned company. Seeds were washed and dried from natural cooling to room temperature. Seeds were also checked to clean from other unwanted substances. After that seeds were grounded into fine powder and stored at room temperature to be used for further analysis.

### EXPERIMENTAL PLAN AND SUBJECTS

This designed study was performed for 6 weeks for investigating the lipid lowering potential of the powder of chia seeds and flax seeds in different concentrations. This efficacy trial was performed on Sprague-Dawley rats. For this study, 15 rats were used weighing 200-250 grams. Rats were purchased from the National Institute of Food Science and Technology. Experimental rat subjects were kept in a proper dark and light cycle with ambient supply of food and water during the study duration.

### INDUCTION OF HYPERLIPIDEMIA

For the induction of hyperlipidemia, an emulsion of banaspati ghee and coconut oil was given for 2 weeks. The dose of this high fat diet was 3ml/kg of body weight daily with normal rat diet. The elevated levels of hyperlipidemia were confirmed by the lipid profile tests including TC, HDL-C, LDL-C, TG, and blood glucose levels.

### DESIGN OF EFFICACY STUDY

Efficacy trial was performed on Sprague-Dawley rats. After the induction of hyperlipidemia, Treatment 1 (normal) was fed with the normal diet, Treatment 2 (Control) was fed with high fat diet only, Treatment 3 (Hyperlipidemic) with normal diet + same amount of flax (50%) and chia seed powder (50%), Treatment 4 (Hyperlipidemic) with normal diet + high amount of flax (70%) and low amount of chia seed powder (30%), Treatment 5 (Hyperlipidemic) with normal diet + low amount of flax (30%) and high amount of chia seed powder (70%). This study was performed for 6 weeks and the blood samples were collected at day 1 and 30..

### BLOOD TESTS

Blood samples were collected in sterile tubes with screw capped opening. Tubes contained EDTA solution to prevent blood clotting. The samples were examined for lipid profile and serum glucose concentration.



## STATISTICAL ANALYSIS

The significance of collected research data was interpreted through statistical analysis (10).

## RESULTS

Hypolipidemic effect of flax and chia seed was assessed by examining the different components of the serum lipid profile. For this purpose, different combinations of flax and chia seeds were provided to the hyperlipidemic rats. Table II indicates that the treatments of flax and chia seeds exhibited a significant decline in serum TC levels. Where T<sub>4</sub> showed maximum reduction that was from 106.52±0.39→89.87±0.75 mg/dl on comparison with other treatments such as T<sub>3</sub> showed a reduction from 107.38±0.59→94.48±0.55 mg/dl and T<sub>5</sub> showed a reduction from 108.17±0.47→98.02±0.62 mg/dl. After 30 days, the total cholesterol in control group (T<sub>1</sub>) was recorded from 56.85±0.73→57.45±0.56mg/dl and hyperlipidemic group (T<sub>2</sub>) 106.52±0.14→130.69±1.27mg/dl showed the highest values in serum TC levels after 30 days. The treatments of flax and chia seed showed highest reduction in TC in T<sub>4</sub> (Flax70% + Chia30%) by 15.63%, then in T<sub>3</sub> (Flax50% + Chia50%) 12.01%, and in T<sub>5</sub> (Flax30% + Chia70%) by 9.38%.

**Table I. Treatment plan**

Treatments	Description
T <sub>1</sub> (Normal)	Normal diet
T <sub>2</sub> (Control)	High Fat Diet
T <sub>3</sub> (Hyperlipidemic)	Normal diet+ Flax (50%) + Chia (50%)
T <sub>4</sub> (Hyperlipidemic)	Normal diet+ Flax (70%) + Chia (30%)
T <sub>5</sub> (Hyperlipidemic)	Normal diet+ Flax (30%) + Chia (70%)

**Table II. Effect of different treatments (T1-T5) on a measured variable**

Day	Treatments					Mean
	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	T <sub>5</sub>	
1	56.85±0.73 <sup>f</sup>	106.52±0.14 <sup>b</sup>	107.38±0.59 <sup>b</sup>	106.52±0.39 <sup>b</sup>	108.17±0.47 <sup>b</sup>	97.08 <sup>a</sup>
30	57.45±0.56 <sup>f</sup>	130.69±1.27 <sup>a</sup>	94.48±0.55 <sup>d</sup>	89.87±0.75 <sup>e</sup>	98.02±0.62 <sup>c</sup>	94.10 <sup>b</sup>
Mean	57.15 <sup>e</sup>	118.60 <sup>a</sup>	100.93 <sup>c</sup>	98.20 <sup>d</sup>	103.10 <sup>b</sup>	

**Table III. Effect of Different Treatments (T1-T5) on a Measured Variable over Time**

Day	Treatments					Mean
	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	T <sub>5</sub>	
1	44.70±0.59 <sup>f</sup>	59.61±0.24 <sup>b</sup>	60.15±0.63 <sup>b</sup>	59.09±0.44 <sup>b</sup>	59.91±0.33 <sup>b</sup>	56.69 <sup>ba</sup>
30	45.43±0.51 <sup>f</sup>	79.0±1.14 <sup>a</sup>	54.14±0.24 <sup>d</sup>	51.81±0.11 <sup>e</sup>	57.43±0.40 <sup>c</sup>	57.63 <sup>a</sup>
Mean	45.06 <sup>e</sup>	69.30 <sup>a</sup>	57.32 <sup>c</sup>	55.45 <sup>d</sup>	58.67 <sup>b</sup>	

Table III clearly reflects that most reduction in LDL levels can be seen in T<sub>4</sub> which was 59.09±0.44→51.81±0.11 mg/dl after the supplementation of flax and chia seed powder for the period of 30 days. While the reduction in T<sub>3</sub> was 60.15±0.63→54.14±0.24mg/dl and in T<sub>5</sub> was 59.91±0.33→57.43±0.40mg/dl after the period of 30 days. However, T<sub>1</sub> (normal control) showed inconsiderable changes in low-density lipoprotein levels and T<sub>2</sub> (hyperlipidemic control) showed an elevation in the levels of LDL-C from 59.61±0.24→79.0±1.14 mg/dl after 30 days. The treatments of flax and chia seed powder showed highest reduction in LDL levels in T<sub>4</sub> (Flax 70% + Chia 30%) by 12.2%, then in T<sub>3</sub> (Flax 50% + Chia 50%) 8.82%, and in T<sub>5</sub> (Flax 30% + Chia 70%) by 4.3%.

Table IV showed that maximum reduction in the levels of TG occurred in T<sub>4</sub> which was 164.18±0.56→140.72±0.26 mg/dl after the period of 30 days. Other groups also showed a significant reduction in TG levels such as in T<sub>3</sub>; TG reduced from 165.09±0.58→145.74±0.91mg/dl and in T<sub>5</sub> from 165.94±0.35→148.55±2.32mg/dl. After the time of 30 days, the triglyceride in control group (T<sub>1</sub>) and hyperlipidemic group (T<sub>2</sub>) was recorded from 84.02±0.64→84.44±0.68mg/dl and 165.25±0.63→188.95±0.92 mg/dl respectively which indicated that TGs in T<sub>1</sub> reduced slightly while in T<sub>2</sub> serum TG levels raised. The

treatments of flax and chia seed powder showed highest reduction in TG in T<sub>4</sub> (Flax 70% + Chia 30%) by 14.28%, then in T<sub>3</sub> (Flax 50% + Chia 50%) 11.7%, and in T<sub>5</sub> (Flax 30% + Chia 70%) by 10.47%.

**Table IV.** Effect of treatments (T1-T5) on a measured variable on day 1 and day 30

Day	Treatments					Mean
	T1	T2	T3	T4	T5	
1	84.02±0.64 <sup>f</sup>	165.25±0.63 <sup>b</sup>	165.09±0.58 <sup>b</sup>	164.18±0.56 <sup>ba</sup>	165.94±0.35 <sup>b</sup>	148.90 <sup>a</sup>
30	84.44±0.68 <sup>f</sup>	188.95±0.92 <sup>a</sup>	145.74±0.91 <sup>d</sup>	140.72±0.26 <sup>e</sup>	148.55±2.32 <sup>c</sup>	141.68 <sup>b</sup>
Mean	84.23 <sup>e</sup>	177.10 <sup>a</sup>	155.42 <sup>c</sup>	152.45 <sup>d</sup>	157.25 <sup>b</sup>	

**Table V.** Effect of treatments (T1-T5) on a measured variable on days 1 and 30

Day	Treatments					Mean
	T1	T2	T3	T4	T5	
1	35.63±0.56 <sup>a</sup>	26.30±0.2 <sup>de</sup>	25.96±0.23 <sup>e</sup>	26.06±0.35 <sup>de</sup>	26.36±0.37 <sup>de</sup>	28.06 <sup>b</sup>
30	36.07±0.39 <sup>a</sup>	18.70±0.53 <sup>f</sup>	29.33±0.28 <sup>c</sup>	32.03±0.45 <sup>b</sup>	27.33±0.73 <sup>d</sup>	28.69 <sup>a</sup>
Mean	35.85 <sup>a</sup>	22.50 <sup>e</sup>	27.65	29.05 <sup>b</sup>	26.85 <sup>d</sup>	

## DISCUSSION

In current study different combinations of flax and chia seeds were provided to the hyperlipidemic rats for the period of 30 days which showed significant reduction in lipid profile. The highest reduction was observed in T<sub>4</sub> (Flax 70% + Chia 30%) which was followed by T<sub>3</sub> (Flax 50% + Chia 50%) and T<sub>5</sub> (Flax 30% + Chia 70%).

The findings of total cholesterol obtained from the current study are closely related to (11) who demonstrated the impact of flaxseed on total cholesterol by giving a dose of 30g of flaxseed powder per day for the duration of 40 days which showed a significant reduction in the serum TC from 226.05→214.53 mg/dl. The results supported by another study which showed that the consumption of 35g of chia seeds on daily basis for 12 weeks reported a significant decline in total cholesterol by 13.8% (12). (13) Reported the effect of flaxseed by the administration of 10g of raw flaxseed in a normal diet to hypertensive rats for the duration of 8 weeks and observed a considerable reduction in the serum triglyceride levels which indicate the hypolipidemic effect of flaxseed. (14) Also studied the effect of flaxseed oil on TG levels. Hypercholesterolemia rats fed with normal diet and flaxseed oil 270 mg/kg body weight for the period of 6 weeks and observed a significant reduction in triglyceride levels from 87.59→62.55 mg/dl. (15) Also confirmed the significant decrease (p<0.05) in TG levels with the administration of chia seeds, nopal, oat, and soy protein. Results of the current study also supported by the verdicts of Kothari and Jeyaraj (2016) who reported 20.7% reduction in serum triglyceride levels with the supplementation of 12.5g chia seeds to hypercholesterolemic women. Chia seeds are a rich source of omega-3 fatty acids, PUFA, and dietary fiber which helps in the lowering of serum TG levels. Many studies proved that the administration of long chain PUFA helps in the prevention of diseases like heart diseases, inflammatory diseases, and hypertension. Findings of the current study supported by (16)) who demonstrated the outcome of flaxseed on low-density lipoproteins. For this purpose, hyperlipidemic subjects were selected with the levels of 124-200 mg/dl. Two groups were made; one considering as a control group having a normal diet while others received 15g powder of cooked flaxseed added in chappatis for the extent of 30 days. The results indicated that serum LDL levels reduced by 9–18% when compared to the control group. Flaxseed is a natural source of plant-based lignans and dietary fiber; both components aid in lowering plasma lipid levels. Therefore, (17) conducted 8 weeks placebo-control randomized clinical trial on 55 patients that were suffering from hypercholesterolemia. Participants divided into two groups' placebo and 300/600 mg per day extract of flaxseed-based SDG to examine the levels of LDL. The end results disclosed, the group consuming 600mg/day extract of SDG showed a reduction in low-density lipoproteins by 22.1%. While the group consumed 300mg/day extract of SDG from flaxseed showed a reduction in plasma LDL levels by 17.03%.

There were also increased plasma concentration of enterolactone, enterodiol (ED), and secoisolariciresinol (SECO) in the group consuming higher SDG extract.

Chia seeds are also known for their therapeutic effect against the LDL levels. Administration of 12.5g of chia seed twice a day to hyperlipidemic subjects. After the period of 2 months, the low-density lipoproteins decreased by 3.2% (18). Chia seed is a natural source of plant-based omega fatty acids which include considerable amount of alpha-linolenic acid. Ayerza and Coates reported the outcome of alpha linolenic acid on the LDL plasma levels and showed a decrease about 4.17% when treated with 16% of chia seed powder for the period of 4 weeks.

Current results are supported by the former study of (19) who conducted an unblended randomized control study. The patients were advised to consume 40g ground flaxseed daily for a period of 8 weeks. The outcomes of the study showed that the HDL-C increased by 16% in the experimental group when compared with the control group. Therefore, flaxseed intervention was helpful in the reduction of lipid levels and systemic inflammation. Another study also demonstrated the effect of roasted flaxseed supplementation on HDL. For this purpose, 40 hyperlipidemic patients were selected and advised to consume 15g of roasted flaxseed for 30 days. The result showed that HDL-C levels increase from 41.5→45.54mg/dl in flaxseed supplemented group (19) also supported the result of current study who demonstrated an increase in HDL-C by 11.7% and 12.4% in groups consuming golden and brown flaxseed. The improvement in HDL-C can be associated with high fiber content and omega-3 fatty acids of the flaxseed (20).

The results of the current study also supported by the study of who performed a trial to check the impact of chia seed supplementation on lipid profile. Consumption of 16% of milled chia seed increase HDL-C from 25.35→36.42 mg/dl. (21) Stated that the inclusion of chia seed increase HDL-C from 28.00 ± 4.38→35.50 ± 3.23 mg/dl and consumption of chia flour increase the levels of HDL from 33.83 ± 3.50→37.50 ± 4.36 mg/dl. The results were also supported by Kothari who reported that the consumption of 12.5g of chia seed increase HDL levels by 4.7%.

## CONCLUSION

This study concluded that the addition of flax and chia seed powder in normal diet plays important role in lowering lipid levels and other related factors. Which confirms the functional and nutrition characteristics of both because flax and chia seed contain abundant amount of dietary fiber, proteins and PUFA. The effect is based on the concentration of the flax and chia seed powder. This study reveals that the inclusion of flax and chia seed powder in normal diet helps in lowering serum lipid profile (TC, TGs, LDL-C) and increase HDL-C levels. Briefly, the consumption of flax and chia seed powder is effective against blood lipid profile.

### Acknowledgments:

The authors highly appreciate of the, Pakistan for providing experimental materials and facilities needed for the research.

### Ethical statement:

No ethical issues were raised during the course of study.

### Authors` Contribution:

Concept: MF, NK, RS, SQA Writing, review and editing: MF, NK, and RS All authors have reviewed and consented to the final version of the manuscript for publication.

### Conflicts of interest:

The authors declare that they have no conflicts of interest.

### References:

1. Fatima T. Cardiovascular diseases are considered to be the leading cause of deaths all over the world and it is anticipated that the number of deaths due to CVDs may augment by the year 2020. *Int J Pharm Res.* 2017; 8:110-124.



2. Martinez-Hervas S, Ascaso JF. Hypercholesterolemia. *Span Biomed Res Centre Diabetes Assoc Metab Disord.* 2018; 44:1274-1283.
3. Nirosha K, Divya M, Vamsi S, Sadiq M. A review on hyperlipidemia. *Int J Novel Trends Pharm Sci.* 2014; 4:81-92.
4. Dhaliya SA, Surya AS, Dawn VT, Betty C, Arun K, Sunil C. A review of hyperlipidemia and medicinal plants. *Int J Adv Pharm Sci.* 2013; 2:219-237.
5. Kaur P, Waghmare R, Kumar V, Rasane P, Kaur S, Gat Y. Recent advances in utilization of flaxseed as potential source for value addition. *OCL.* 2018; 25:115-132.
6. Ullah R, Nadeem M, Khalique A, Imran M, Mehmood S, Javid A, Hussain J. Nutritional and therapeutic perspectives of Chia (*Salvia hispanica* L.): a review. *J Food Sci Technol.* 2016; 53:1750-1758.
7. Soltani KS, Jamal Uddin R, Tabibi H, Mohd Yusof BN, Atabak S, Loh SP, Rahmani L. Effects of flaxseed consumption on systemic inflammation and serum lipid profile in hemodialysis patients with lipid abnormalities. *Hemodial Int.* 2013;17:275-281.
8. Da Silva BP, Dias DM, de Castro Moreira ME, Toledo RCL, da Matta SLP, Della Lucia CM, Martino HSD, Pinheiro-Sant'Ana HM. Chia seed shows good protein quality, hypoglycemic effect and improves the lipid profile and liver and intestinal morphology of Wistar rats. *Plant Foods Hum Nutr.* 2016; 71:225-230.
9. Dodin S, Lemay A, Jacques H, Legare F, Forest JC, Masse B. The effects of flaxseed dietary supplement on lipid profile, bone mineral density, and symptoms in menopausal women: a randomized, double-blind, wheat germ placebo-controlled clinical trial. *J Clin Endocrinol Metab.* 2005; 90:1390-1397.
10. Montgomery DC. *Design and analysis of experiments.* 7th ed. Hoboken: John Wiley & Sons; 2008. p. 1-656.
11. Torkan M, Hassan Entezari M, Siavash M. Effect of flaxseed on blood lipid level in hyperlipidemic patients. *Rev Recent Clin Trials.* 2015; 10:61-67.
12. Toscano LT, Toscano LT, Tavares RL, da Silva CSO, Silva AS. Chia induces clinically discrete weight loss and improves lipid profile only in altered previous values. *Nutr Hosp.* 2015; 31:1176-1182.
13. Al-Bishri WM. Favorable effects of flaxseed supplemented diet on liver and kidney functions in hypertensive Wistar rats. *J Oleo Sci.* 2013; 62:709-715.
14. Hussein SA, El-Senosi YA, Ragab MR, Hammad MM. Beneficial effect of flaxseed oil on lipid metabolism in high cholesterol diet fed rats. *Ban̄ha Vet Med J.* 2014; 27:290-301.
15. Guevara-Cruz M, Tovar AR, Aguilar-Salinas CA, Medina-Vera I, Gil-Zenteno L, Hernández-Viveros I, López-Romero P, Ordaz-Nava G, Canizales-Quinteros S, Guillen Pineda LE, Torres N. A dietary pattern including nopal, chia seed, soy protein, and oat reduces serum triglycerides and glucose intolerance in patients with metabolic syndrome. *J Nutr.* 2011; 142:64-69.
16. Parameshwari S, Nazni P. Fatty acid composition and hypolipidemic effect of roasted flaxseed powder. *Int J Pharma Med Biol Sci.* 2012; 1:150-158.
17. Zhang W, Wang X, Liu Y, Tian H, Flickinger B, Empie MW, Sun SZ. Dietary flaxseed lignan extract lowers plasma cholesterol and glucose concentrations in hypercholesterolemic subjects. *Br J Nutr.* 2008;99:1301-1309.
18. Kothari M, Jeyaraj S. Effect of chia seed supplementation on the anthropometric measurements and serum lipid profile in women with hypercholesterolemia. *World J Pharm Res.* 2016; 6:929-936.
19. Ayerza R, Coates W. Effect of dietary  $\alpha$ -linolenic fatty acid derived from chia when fed as ground seed, whole seed and oil on lipid content and fatty acid composition of rat plasma. *Ann Nutr Metab.* 2007; 51:27-34.
20. Bernacchia R, Preti R, Vinci G. Chemical composition and health benefits of flaxseed. *Austin J Nutr Food Sci.* 2014; 2:1045-1050.
21. Da Silva CS, Kanaguchi G, de Arruda Monteiro CR, Feder D, Azzalis LA, Perazzo FAF, Maifrino LBM, Ornelas E, Rosa PCEP, Fonseca FLA. Biochemical parameters and Histomorphometric cardiac evaluation among Wistar rats treated with chia seed (*Salvia hispanica* L.): experimental model. *Afr J Pharm Pharmacol.* 2016; 10:95-100.