Modulatory Effect of Whole Flour and Hydroalcoholic Extract of Finger Millet (*Elusine coracana*) on the Abnormalities Associated with Metabolic Syndrome in Hyperlipidemic Diabetic Rats

Upma Bhandari, Lata Bisht, Sweta Joshi, Priyanka Uniyal, Veerma Ram and *Mamta F Singh

School of Pharmaceutical Sciences and Technology, SBS University, Balawala, Dehradun, UK., India

***Email: mamta_fr2002@yahoo.co.in**

Doi-10.51129/ujpah-june2021-30-1(6)

Abstract- The present study was designed to evaluate the effect of whole flour and hydroalcoholic extract of finger millet (*Elusine coracana*) in high fat diet (HFD) and streptozotocin induced metabolic syndrome in rats. The HFD was fed to the rats for a period of 45 days to induce hyperlipidemia. Diabetes was induced by single intraperitoneal injection of streptozotocin (65mg/kg i.p) in 0.1M citrate buffer pH 4.5. Animals with fasting blood sugar level of 250 mg/dl were considered as hyperlipidemic diabetic rats (HDR) and were selected for the study. The HDR were divided into five groups with six animals in each group and one group of normal animals. The HDR received whole flour and hydroalcoholic extract of *Elusine coracana* at a dose of 100, 200 and 400 mg/kg for a period of 21 days. Body weight, body mass index, fasting blood sugar level, lipid profile and the level of oxidative stress was measured in animals after the treatment. All treatments significantly decreased body weight, BMI, fasting blood sugar and also improved lipid profile in HDR as compared to the toxicant control. The treatments significantly reduced the level of lipid peroxidation and improved superoxide dismutase and reduced glutathione in the pancreas of HDR. Whole flour and hydroalcoholic extract of *Elusine coracana* at a dose of 200 and 400 mg/kg caused significant alleviation of the abnormalities of metabolic syndrome in rats.

Keywords: Finger millet, High fat diet, Hyperlipidemic diabetic rats, Metabolic syndrome.

Introduction

Metabolic syndrome (MetS) is a group of metabolic disorders characterized by insulin resistance, hypertension, central obesity and atherogenic dyslipidemia. It is also known as insulin resistance syndrome or syndrome X. It is progressively being recognized as a significant cardiovascular risk factor and a vital risk factor for the expansion of type 2 diabetes mellitus worldwide(Rochlani *et al*.,2017). The diabetes consultation group of the WHO defined MetS Internationally in 1998 as the presence of insulin resistance, obesity,hyperlipidemia and hypertention in a patient (Saklayen MG, 2018). There exists a complex relationship between different factors such as lack of physical activity, stress, over intake of food, environmental and lifestyle factors and MetS. In clinical and epidemiological studies, obesity is highly connected with all cardiovascular risk factors. Adipose tissues are recognised as a source of several molecules like excess of free fatty acids, cytokines, adipokines, increase leptin, fibrinogens and AT2 that are pathogenic and contributes to the progression of MetS. It has been noticed that obese adipose tissues release excess of fatty acids and cytokines that induce insulin resistance(Grundy *et al*., 2004, Anwer *et al*., 2018). Since thousands of years medicinal plants serve as an excellent source of bioactive compounds for the treatment of various diseases including metabolic syndrome due to presence of broad range of phytochemicals with diverse metabolic effects. Now a days, attention have been focused on

plant foods which may be beneficial in Preventing metabolic syndrome and its associated conditions like cardiovascular diseases and diabetes. Plant derived drugs are widely used and believed to be safe, cost effective with fewer side effects. *Eleusine coracana* is an annual plant mostly grown in Asia and Africa and serves as a major meal in Southern India and Ethiopia. It is called Ragi in India and Madua in Hindi (Mall TP and Tripathi SC, 2016). *Eleusine coracana* is believed to be rich in dietary fibres (22% both soluble and insoluble), micronutrients, proteins (such as leucine, isoleucine, lysine, tryptophan etc.), carbohydrates, minerals (calcium, magnesium), fats and polyphenols. It is also said to have a high content of calcium (Erhabor *et al*., 2013). Polyphenols such as gallic acid, tannic acid, vanillic acid, ferulic acid, caffeic acid, and chlorogenic acid are present in seeds (Chethan *et al*.,2008). Various pharmacological studies have been carried out on the millet in order to validate the ethno medicinal claims and set forth detailed pharmacological activities such as antioxidant(Sreeramulu D. *et al*.,2009), anticancer (Singh *et. al*., 2009) antimicrobial, (Mathanghi SK and Sudha K, 2012), wound healing activity, (Hegde *et al*.,2002) antidiabetic (Rajasekarana *et al*., 2004) and hepatoprotective activity (Chethan *et al*., 2008). The present study was planned to determine whether chronic administration of flour of finger millet and hydroalcoholic extract of seeds of finger millet could restore the various coexisting conditions with metabolic syndrome or not. The study was aimed to evaluate and compare the effect of chronic administration of finger millet flour and whole seed extracts of finger millet in metabolic syndrome in hyperlipidemic diabetic rats.

Material and Methods

Drugs and chemicals

Streptozotocin (CDH, India), thiobarbiturtic acid, trichloroacetic acid, sodium carbonate, sodium bicarbonate, EDTA, Tris-hydrocchloride (High Media and Sigma) and DTNB (Thermfisher Scientific Company) were used in the study. Diagnostic kits used for the estimation of biochemical parameters were purchased.

Plant materials

The seeds of *Eleusine coracana* were collected from Chamoli district of Uttarakhand. The plants was identified and authenticated by Department of Botany, Forest Research Institute, Dehradun, Uttarakhand, India.

Extraction of seeds of *Eleusine coracana*

The seeds of *Eleusine coracana* were shade dried at room temperature and grounded to moderately coarse powder. 1kg of coarse powder was defatted with petroleum ether by using soxhlet apparatus. After this the plant material extracted with the mixture of water and methanol in the ratio of 60:40. The extract was collected in beaker or china dish and evaporated in water bath to get dry residue. The residue was weighed and stored in dessicators.

Preliminary phytochemical investigations

The extract of seeds of *Eleusine coracana* was subjected to qualitative phytochemical screening (carbohydrates, alkaloids, cardiac and anthraquinoneglycoside, protein, tannins, flavanoids and saponins) for identification of various phytoconstituents (Kokate CK, 1994).

Pharmacological investigations

Animals

Adult wistar albino rats of either sex (200-250gm) were used for this study. The animals were housed at 24°C ± 2°C and relative humidity 55 ± 5% with 12:12 hour light and dark cycle in standard polypropylene cages. They were provided food and water ad libitum. Before experimental studies the animals were acclimatized. The experimental protocol was approved by the Institutional Animals Ethics Committee of SBSPGI with approval number of IAEC/273CPCSEA/SBS/01/2014-2016 for conducting the experimental studies on animals.

Acute toxicity study

The toxicity studies of both of the plants was already performed by OECD guideline 423. So doses were selected on the basis of available literature on *Eleusine coracana*. Doses selected for pharmacological activity of *Eleusine coracana* was 100, 200 and 300 mg/kg (Lorke D, 1983).

Induction of hyperlipidemia and obesity

Obesity was induced in wistar rats (200 -250 gm) by commercially available edible dalda (vanaspathy) and culinary grade coconut oil obtained from local market. The high fat diet (HFD) was prepared by homogenously mixing dalda and coconut oil the ratio of 3:2w/w (Supriya K *et al*., 2012) and was given to the rats for 45 days. At the regular intervals of 7 days body weight was checked.

Induction of Diabetes

Diabetes was induced in hyperlipidemic rats (350-400 gm, body weight) by single intraperitoneal injection of streptozotocin (65mg/kg i.p) in 0.1M citrate buffer pH 4.5 (Mabhida *et al*., 2019). The control group received equivalent amount of citrate buffer. Animals showing FBS level more than 200 mg/dl were selected for the study.

Treatment Protocol

The Hyperlipidemic diabetic rats were divided into 5 groups and one group of normal rats with each group having 5 animals. The animals received the seed extract as a suspension in 1% CMC using distilled water as a vehicle for a period of 21 days. One group of animals received the pellets of flour of seeds of *Eleusine coracana* along with the High Fat Diet (HFD) for 21 days.

Group 1(Normal control):- Normal animals received 1% CMC in distilled water (1 ml/kg,p.o.).

Group 2 (Toxicant control):- Hyperlipidemic diabetic animals received 1% CMC in distilled water (1 ml/kg, p.o.).

Group 3:- Hyperlipidemic diabetic animals + Pellets of flour of seeds of *Eleusine coracana*

Group 4:- Hyperlipidemic diabetic animals + hydroalcoholic extract of *Eleusine coracana* (100 mg/kg, p.o).

Group 5:- Hyperlipidemic diabetic animals + hydroalcholic extract of *Eleusine coracana* (200 mg/kg,p.o.).

Group 6:- Hyperlipidemic diabetic animals + hydroalcoholic extract of *Eleusine coracana* (400 mg/kg,p.o.).

Before induction and after the treatment period of 21 days body weight was checked and BMI was calculated. Average feed intake was estimated for all the treated animals and physical, biochemical parameters and oxidative stress was estimated. Blood was collected from the retro orbital puncture under mild anaesthesia from the animals and it was then centrifuged at 2500rpm with the help of cooling centrifuge and serum was separated to evaluate various biochemical parameters by using autoanalyser.

Estimation of body weight

After HFD and treatment of plant extracts body weight of all animals in each group were checked and the weight difference was calculated.

Body mass index (BMI)

Obesity is defined by body mass index and further evaluated by both percentage body fat and total body length (Paras Gupta *et.al*.,2011).

BMI= mass(kg)/(height(m)) 2 Or

BMI=mass (lb)/ (height (in)) 2 X 703

Where m and h are the subject's weight and height respectively

Estimation of blood glucose

The blood samples were collected from retro orbital puncture on days 0, 7, and 14 following overnight fasting and blood glucose levels were measured by using GOD-POD kit by Erba, India in an auto-analyser. The method uses a modified Trindercolor reaction (Trinder, 1969).

Estimation of Serum Lipid Profiles

At the end of treatment period, animals were fasted overnight, blood sample was collected by retro orbital puncture under ether anaesthesia and it was then centrifuged at 2500rpm with the help of cooling centrifuge and serum was separated to determine the level of total cholesterol, triglycerides and high density lipoprotein were evaluated by Enzymatic Colorimetric Method (Mirlohi *et al*., 2012) and phosphotungstic Acid Method (Miller *et al*., 1977) respectively, using Bayer Diagnostic Kit, India in an auto-analyser.

Estimation of Lipid peroxidation and superoxide and reduced glutathione

Estimation of lipid peroxidation and superoxide and reduced glutathione was done by from the tissue supernatant by the method Slater and Sawyer, 1971, Mishra *et al*., 1972 and Moron *et al*.,1979 respectively.

Statistical Analysis

The results were expressed as mean ± SEM from six animals. Statistical difference in mean was analyzed using one way ANOVA (Analysis of Variance) followed by Dunnett's 't' test .P values less than 0.05 will be considered as indicative of significance.

Results and Discussion

Preliminary phytochemical identification test of hydroalcoholic extract of seeds of *Eleusine coracana*

Phytochemical studies revealed the presence of alkaloids, carbohydrate (non-reducing sugar), protein, amino acid and tannins in the seed extract of *Eleusine coracana* (Table-1).

Table-1 Phytochemical investigation of hydroalcholic extract of *Eleusine coracana*

S.N	Phytochemical test	Petroleum ether extract of *Eleusine coracana*	Hydroalcoholic extract of *Eleusine coracana*
1	Alkaloid	(+)	(+)
2	Flavanoids	(-)	(-)
3	Carbohydrate	(-)	(-)
4	Test for non -reducing polysaccharides	(-)	(+)
5	Protein	(-)	(+)
6	Tannins	(+)	(+)
7	Amino acids	(-)	(+)
8	Saponins	(-)	(-)
9	Triterpenoids	(-)	(+)
10	Steroids	(+)	(-)

Effect of whole flour and hydroalcoholic extract of seeds of *Eleusine coracana* on the body weight and body mass index in hyperlipidemic diabetic rats

Effect of the treatments on body weight and BMI of animals was recorded on various time intervals as shown in Table-3.2. In normal animals no significant weight change (210± 0.5 g) was observed during various time intervals. In the HFD treated animals (toxicant control) the weight gain and BMI was significant ($p<0.001$) on 21st day when compared to the first day of the treatment. Significant decrease ($p<0.01$) in body weight was observed in groups treated with the flour and hydroalcoholic extract of *Eleusine coracana* at a dose of 200 mg/kg and 400 mg/kg given for a period of 30 days as compared to the toxicant control group. The hydroalcoholic extract at a dose of 400 mg/kg exhibited maximum reduction in body weight among all the treatment groups on day 21st as compared to the body weight of hyperlipidemic diabetic animals on the 1st day of the treatment. In the study, the whole flour and hydroalcoholic extracts of *Eleusine coracana* at a dose of 200 mg/kg and 400 mg/kg caused significant decrease in BMI. However hydroalcoholic extract at a dose of 400 mg/kg caused most significant reduction ($p<0.001$) in BMI in hyperlipidemic diabetic rats as compared to the day 1 of the treatment.

Results suggest that the flour of *Eleusine coracana* protected the animals from the effect of high fat diet and prevented further induction of obesity as indicated by decrease in BMI as comapred to other.

Table-2 Effect of whole flour and hydro alcoholic extracts of seed of *Eleusine coracana* on body weight and body mass index in hyperlipidemic diabetic rats

Treatment	Body weight(gm)	Body mass index(gm/kg/day)
Normal (1ml/kg normal saline, p.o.)	149±3.50	7.89±0.06
HFD+STZ (60 mg/kg, ip. in citrate buffer pH 4.5)	380.6±2.31	15.21±0.8
HFD+STZ+ flour of seeds of *Eleusine coracana* (as food palate)	190.56±5.58	12.66±3.8*
HFD+STZ+ hydroalcoholic extract of seed of *Eleusine coracana* (100 mg/kg, p.o.)	186.78±3.9	15.9±0.4
HFD+STZ+ hydroalcoholic extract seeds of *Eleusine coracana* (200 mg/k5mg/kg, p.o.)	297±4.88	8.59±2.6***
HFD+STZ+ hydroalcoholic extract of seeds of *Eleusine coracana* (400 mg/kg, p.o.)	301.1±6.78	8.07±6.98***

The statistical significance of difference between means was calculated by ANNOVA followed by t-test for unpaired comparison. N=6.Values are expressed as Mean ±SEM. *P< 0.05, **P< 0.01, ***P< 0.001. The results of test groups were compared with the HFD + STZ treated group (positive control).

Index: STZ = Streptozotocin, HFD= high fat diet p.o= per oral, i.p.=intraperitoneally.

Effect of whole flour and hydroalcoholic extract of *Eleusine coracana* on fasting blood sugar level in hyperlipdemic diabetic rats

Feeding flour of seeds of *Eleusine coracana* to the hyperlipidemic diabetic animals showed no improvement in the FSG level at 0 day after induction of diabetes (Table-3). The animals treated with the flour of seeds of *Eleusine coracana* showed decrease in blood glucose level on 7th and 14th day and at 21st day, on 21st day the treatment caused significant decrease in fasting serum glucose (FBG) level in diabetic rat. Results in Table-3 indicate administration of the hydroalcholic extract of seeds of *Eleusine coracana at* dose of 200 mg/kg caused significant ($P<0.001$) decrease in fasting blood sugar on 7th and 14th day after 21 days in hyperlipidemic rats as compaired to day 1 of treatment. Hydroalcoholic extract of seed of *Eleusine coracana* at the lower dose level (100mg/kg)caused mild decrese in FBG on 21st day in hyperlipidemic rats. Results suggest that feeding the whole flour and hydroalcoholic extract of seeds of *Eleusine coracana* for a long period of time prevented induction of diabetes and also lowered the FSG level to normal in diabetic animals.

Table-3 Effect whole flour and hydro alcoholic extracts of seed of *Eleusine coracana* on the level of fasting blood sugar level in hyperlipidemic diabetic rats

Treatment + Groups	0 hour	72 hours	14th day	21st day
Normal (1ml/kg normal saline, p.o.)	112.7±1.56	109.69±0.58	110.23± 0.79	112.21± 1.05
HFD+STZ (60 mg/kg, ip. in citrate buffer pH 4.5)	116.3±1.46	256.38±1.68	240.66± 4.18	225.72± 3.57
HFD+STZ+ flour of seeds of *Eleusine coracana*	113.3±2.32	170.74±1.4	137.48± 0.81**	130.46± 0.77**
HFD+STZ+ hydroalcoholic extract of seed of *Eleusine coracana* (100mg/kg, p.o.)	111.1±1.66	264.68±1.24	182.54± 0.93*	146.94± 0.67**
HFD+STZ+ hydroalcoholic extract of seeds of *Eleusine coracana* (200 mg/kg, p.o.)	112.4±2.05	251.64±1.16	210.92± 1.19	204.98± 1.05
HFD+STZ+ hydroalcoholic extract of seeds of *Eleusine coracana* (400 mg/kg, p.o.)	111.7±2.72	254.51±1.05	157± 1.4**	122.32± 0.97***

The statistical significance of difference between means was calculated by ANNOVA followed by t test for unpaired comparison. N=6. Values are expressed as Mean ±SEM. *P< 0.05, **P< 0.01, ***P< 0.001. Results on 21st day were compared with the results after 72 hours of HFD+STZ administration.

Index: STZ = Streptozotocin, HFD= high fat diet p.o= per oral, i.p.=intraperitoneally.

Effect of whole flour and hydroalcoholic extract of *Eleusine coracana* on lipid profile in hyperlipidemuc diabetic rats

Results in Table-4 showed administration of high fat diet for a period of 45 days caused significant increase in the cholesterol (226.3±8.11 mg/dl) and triglyceride (242.2± 7.07 mg/dl) level and decrease in the blood HDL (18.4±1.06 mg/dl) level as compared to normal animals.

Results indicate that the whole flour and hydroalcoholic extract of seeds of *Eleusine coracana* on lipid profile in hyperlipidemic diabetic rats. Chronic administration of flour of seeds of *Eleusine coracana* for 21 days caused significant reduction ($p<0.01$, $p<0.001$) in thelevel of cholesterol and triglyceride in Hyperlipidemic diabetic rats suggesting flour of seeds of *Eleusine coracana* possess antihyperlipidemic effect. Administration of flour of seeds of *Eleusine coracana* caused significant increase ($p<0.01$) in the level of HDL-cholesterol in hyperlipidemic diabetic animals.

Treatment with the hydroalcoholic extracts of seeds of *Eleusine coracana* at the intermediate and high dose level for 21 days caused significant ($P<0.001$) decrease in the cholesterol and triglyceride level whereas increased the HDL level in hyperlipidemic diabetic rats. Results suggest that treatment of hyperlipidemic diabetic rats with hydroalcoholic extracts of seed of *Eleusine coracana* showed anti hyperlipidemic activity.

Table-4 Effect of whole flour and hydro alcoholic extracts of seed of *Eleusine coracana* on lipid profile in hyperlipidemic diabetic rats

Treatment	HDL(mg/dl)	TG(mg/dl)	Cholesterol (mg/dl)
Normal (1ml/kg normal saline, p.o.)	48.2±2.64	105.7±1.4	68.1±2.51
HFD+STZ (60 mg/kg, ip. in citrate buffer pH 4.5)	18.4±1.06	242.2±7.07	226.3±8.11
HFD+STZ+ flour of seeds of Eleusine coracana(as food palate)	43.3±2.17***	154.7±5.71**	104.4±5.14**
HFD+STZ+ hydroalcoholic extract of seed of *Eleusine coracana* (100mg/kg, p.o.)	35.1±1.57*	195.51±4.22*	168.6±2.66*
HFD+STZ+ hydroalcoholic extract of seeds of *Eleusine coracana* (200 mg/kg, p.o.)	23.2±1.48	180.44±5.61*	203.1±2.5
HFD+STZ+ hydroalcoholic extract of seeds of *Eleusine coracana* (400 mg/kg, p.o.)	44.7±1.05**	138.21±5.55***	119.2±2**

The statistical significance of difference between means was calculated by ANNOVA followed by t-test for unpaired comparison. N=6.Values are expressed as Mean ±SEM. *P< 0.05, **P< 0.01, ***P< 0.001. The results of test groups were compared with the HFD + STZ treated group (positive control).
Index: STZ = Streptozotocin, HFD= high fat diet p.o= per oral, i.p.=intraperitoneally.

Effect of whole flour and hydroalcoholic extract of *Eleusine coracana* on oxidative stress in hyperlipidemic diabetic rats

Table-5 indicates that malondialdehyde level was significantly increased in the hyperlipidemic diabetic rats. Treatment with whole flour and intermediate dose of *Eleusine coracana* showed significant decrease (P<0.01) in the malondialdehyde level in hyperlidemic diabetic rats. Moreover, malondehyde level was more significantly decreased (P < 0.001) in the diabetic rats treated with high dose of *Eleusine coracana*. As indicated in Table -5, the level of superoxide dismutase (SOD) and glutathione (GSH) level was highly decrease in the hyperlipidemic diabetic rats. Treatment with the whole flour and intermediate and high doses of hydroalcoholic extract of *Eleusine coracana* significantly (P<0.001) increased the level of SOD and GSH in hyperlipidemic diabetic rats suggesting antioxidant activity of seeds of *Eleusine coracana*.

Table-5 Effect of whole flour and hydro alcoholic extracts of seed of *Eleusine coracana* on the level of oxidative stress in hyperlipidemic diabetic rats

Treatment	Lipid peroxidation (nmol/l)	Superoxide Dismutase (EU/dl)	Reduced Glutathione (µg of tissue/ml)
Normal (1ml/kg normal saline, p.o.)	44.9 ± 1.7	24.7±1.41	41.4±1.26
HFD+STZ (60 mg/kg, ip. in citrate buffer pH 4.5)	78.8±1.26	11.3±1.11	13.7±1.35
HFD+STZ+ flour of seeds of *Eleusine coracana*(as food palate)	55.7±1.05*	18.3±0.849**	34.2±1.82**
HFD+STZ+ hydroalcoholic extract of seed of *Eleusine coracana* (100mg/kg,p.o.)	57.7±2.07*	16.7±0.561*	20.9±1.56*
HFD+STZ+ hydroalcoholic extract of seeds of *Eleusine coracana* (200 mg/kg, p.o.)	62±1.38	13.1±1.06	16.6±2.55
HFD+STZ+ hydroalcoholic extract of seeds of *Eleusine coracana* (400 mg/kg, p.o.)	50.6±1.77**	19.7±0.671**	27.4±3.21**

The statistical significance of difference between means was calculated by ANNOVA followed by t-test for unpaired comparison. N=6.Values are expressed as Mean ±SEM. *P< 0.05, **P<0.01, ***P< 0.001. The results of test groups were compared with the HFD + STZ treated group (positive control).

Index: STZ = Streptozotocin, HFD= high fat diet p.o= per oral, i.p. =Intraperitoneally.

Discussion

The present study was aimed to evaluate the effect of whole flour and hydroalcoholic extract of seeds of *Eleusine coracana* on metabolic syndrome in hyperlipidemic diabetic rats. Metabolic syndrome is a vital and increasing public-health and clinical challenge worldwide in the wake of urbanization, unsuitable nutrition, surplus energy intake, increasing obesity and sedentary life habits. It is a severe metabolic disorder, characterized with increased in energy intake and decrease in energy output concerning body weight and glucose metabolism. Metabolic syndrome is associated with insulin resistance and type II diabetes mellitus. As metabolic syndrome is associated with alteration of lipid metabolism and increased oxidative stress, so the study was further designed to evaluate the anti hyperlipidemic and antioxidant effect of the isolated compounds on streptozotocin diabetic rats. Phytochemical studies revealed the presence of alkaloids, carbohydrate (non-reducing sugar), proteins and amino acid and tannins in the seed extract of *Eleusine coracana*. The hydroalcoholic extract of seed of *Eleusine coracana* caused significant decrease in the body weight and BMI in hyperlipidemic diabetic rats. However the whole flour of *Eleusine coracana* does not cause any decrease in body weight and BMI in hyperlipidemic diabetic rats. The whole flour and hydroalcoholic extract (intermediate and higher dose) of *Eleusine coracana* significantly reduced fasting serum glucose level and restored lipid profile to normal in hyperlipidemic diabetic rats. The treatment at different dose levels also decreased the level of lipid peroxidation and improved the level of antioxidant enzymes (reduced glutathione, superoxide dismutase and catalase) in hyperlipidemic diabetic rats at different dose level. Presence of various antioxidants vitamins and total phonolic components, may attribute to the antioxidant effect of seeds of *Eleusine coracana* .

Conclusion

From the results presented above it can be concluded that treatment with whole flour and intermediate and higher doses of hydroalcoholic extract of *Eleusine coracana* exert significant antiobesity, hypoglycaemic, hypolipidemic and antioxidant activity. Moreover, the hydroalcohlic extract of seeds of *Eleusine coracana* at high dose showed best responses. Further detailed studies to find out the exact mechanism of these plants and to identify the active phytoconstituents involved in showing positive effect in metabolic syndrome are required.

Acknowledgment

The authors are immensely thankful to the management SBS University, Balawala, Dehradun, India for providing all the facilities.

Conflict of interest

The authors of the manuscript have no conflict of interest.

Funding Status

NIL

References

1. Anwer, A.; Kaleem, M.; Abbas, H. and Hanif, A. Metabolic syndrome; Frequency in patients presented with Ischemic Heart Disease. *Professional Medical Journal,* 2018, 25:2.1.

2. Chethan, S.; Daharmesh, S.M.; Nagappa, G. and Malleshi, G. Inhibition of aldose redutase from cataracted eye lenses by finger millet (Eleusinecoracana) polyphenols. Bioorganic and *Medicinal Chemistry Journal,* 2008, 16:10085-10090.

3. Erhabor, J.O.; Idu, M. and Udo, F.O. Ethnomedicinal survey of medicinal plants used in the treatment of male infertilty among the IFA Nkari People of Ini Local Government Area of AkwaIbom State, *Nigerian Research Journal of Science.,* 2013, 2:5-11.

4. Grundy, S.M.; Hansen, B.; Smith, Jr.S.C.; Cleeman, J.I. And Kahn, R.A. Conference Participants, Clinical management of metabolic syndrome: report of the American Heart Association/National Heart, Lung, and Blood Institute/American Diabetes Association conference on scientific issues related to management. *Circulation*, 2004, 109(4) : 551-556.

5. Gupta, P.; Tyagi, S.; Mukhija, M.; Saini, A.S.; Goyal, R. and Sharma, P.L. Obesity: An introduction and evaluation. *Journal of Advanced Pharmacy Education & Research,* 2011, 2:125-37.

6. Hegde, P.S.; Chandrakasan, G. and Chandraa, T.S. Inhibition of collagen glycation and crosslinking in vitro by methanolic extracts of Finger millet (Eleusinecoracana) and Kodo millet (Paspalumscrobiculatum). *Journal of Nutritional Biochemistry,* 2002, 13:517-521.
7. Kokate, C.K. Practical Pharmacognosy. 4 [sup] th ed. New Delhi: Vallabh Prakashan. 1994:107.
8. Lorke, D. A new approach to practical acute toxicity testing. Archives of toxicology, Dec 1, 1983, 54(4):275-87.
9. Mabhida, S.E.; Johnson, R.; Ndlovu, M.; Louw, J.; Opoku, A. and Mosa, R.A. Molecular basis of the anti-hyperglycemic activity of RA-3 in hyperlipidemic and streptozotocin-induced type 2 diabetes in rats. Diabetology & Metabolic Syndrome. Dec., 2019, 11(1):1-5.
10. Mall, T.P. and Tripathi, S.C. Millets-the nutrimental potent ethno-medicinal grasses: a review. World Journal of Pharmaceutical Research, 2016, 5(2):495-520.
11. Mathanghi, S.K. and Sudha, K. Functional and phytochemical properties of finger millet (Eleusinecoracana L.) for health. *International Journal of Pharmaceutical, Chemical and Biological Sciences,* 2012, 2(4): 31-438.
12. Miller, N.E.; Thelle, D.S.; Førde, O.H. and Mjøs, O.D. The Thermoheart Study: High-Density Lipoprotein and Coronary Heart-Disease: A Prospective Case-Control Study. *The Lancet.,* May,7, 1977, 309(8019):965-8.
13. Mirlohi, M.; Madany, G.; Hassanzadeh and Yadav, M.J. On the Colorimetric Method for Cholesterol Determination in the Laboratory Media. *International Journal of Biological Chemistry*, 2012, 6: 37-41.
14. Misra, H.P. and Fridovich, I. The role of superoxide anion in the autoxidation of epinephrine and a simple assay for superoxide dismutase. *Journal of Biological chemistry,* 1972, 247:3170-3175.
15. Moron, M.S.; Depierre, J.W. and Mannervik, B. Levels of glutathione, glutathione reductase and glutathione S-transferase activities in rat lung and liver. Biochimicaetbiophysicaacta (BBA)-general subjects., Jan 4,1979, 582(1):67-78.
16. Rajasekarana, N.S.; Nithyac, M.; Rosec, C. and Chandraa, T.S. The effect of finger millet feeding on the early responses during the process of wound healing in diabetic rats. *Biochim Biophys Acta.,* 2004, 1689(3):190-201.
17. Rochlani, Y.; Pothineni, N.V.; Kovelamudi, S. and Mehta, J.L. Metabolic syndrome: pathophysiology, management, and modulation by natural compounds. Therapeutic Advances in Cardiovascular Disease, Aug, 2017, 11(8):215-25.
18. Saklayen, M.G. The global epidemic of the metabolic syndrome. Current hypertension reports, 2018, 20(2): 12.
19. Shobana, S.; Sreerama, YN. and Malleshi, NG. Composition and enzyme inhibitory properties of finger millet (*Eleusine coracana* L.) seed coat phenolics: Mode of inhibition of α-glucosidase and pancreatic amylase. *Journal of Food Chemistry.,* 2009,115(4):126-873.
20. Singh, N.; Meenu, G.; Sekhar, A. and Abraham, J. Evaluation of antimicrobial and anticancer properties of finger millet (Eleusinecoracana) and pearl millet extracts. *Journal of Pharmaceutical Innovations,* 2015, 3(11):82-86.
21. Slater, T.F. and Sawyer, B.C. The stimulatory effects of carbon tetrachloride and other halogenoalkanes on peroxidative reactions in rat liver fractions in vitro. General features of the systems used. *Biochemical Journal*, Aug., 1971, 123(5):805-14.
22. Sreeramulu, D.; Redddy, C.V.K. and Raghunath, M. Antioxidant activity of commonly consumed cereals, millets, pulses and legumes in India. *Indian Journal of Biochemistry and Biophysics*, 2009, 46:112-115.
23. Supriya, K.; Kotagiri, S.; Swamy, V.; B.; Swamy, A.; P. and Vishwanath, K.M. Anti-Obesity activity of Shorearobusta G. leaves extract on monosodium glutamate induced obesity in albino rats. *Research Journal of Pharmaceutical, Biological and Chemical Sciences*, 2012, 3(3):555-65.
24. Trinder, P. Enzymatic methods for glucose determination. *Annals of Clinical Biochemistry,* 1969, 6:24-6.