Therapeutic evaluation of grain based functional food formulation in a geriatric animal model

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Abstract This study investigates the effect of wholesome grain based functional food formulation, on clinical and biochemical parameters in 24–30 months old Wistar albino geriatric rats, corresponding to human age 60–75 years. Animals were randomly divided into five, groups. Experimental diets were compared to the basal rat diet (Group I). Four food, formulation were—wheat based (Group II), finger millet based (Group III), wheat based, diet + fenugreek seed powder (Group IV), finger millet based diet + fenugreek powder, (Group V). These five types of diets were fed to the experimental rats for 6 weeks. Hematological and biochemical parameters were evaluated. The results showed that, feed intake was influenced by the type of feed. Diets supplemented with, fenugreek (Group IV) caused a significant increase in serum hemoglobin. The total serum protein values were significantly highest in Group III. Total serum albumin was found to be lower in Group I and highest in Group II. The concentration of BUN was highest in Group I and the lowest in control diet. Serum cholesterol and glucose were significantly reduced in Group IV. Several hematological and serum mineral values were influenced by the type of diet. The type of diet did not influence the organs weight. A moderate hypoglycemic and hypercholesterolemic effect

was observed in composite mix fed rats. This study clearly justifies the recommendation to use wholesome grain based functional foods for geriatric population.

Keywords Geriatric population · Functional foods · Composite mix · Hypoglycemic food · Antihypercholesterolemic food

Introduction

The factor of aging involves gradual degeneration of the structure and functioning of organism and it is associated with higher prevalence of chronic degenerative diseases. It is also identified that the nutrition is the major factor of ageing. Moreover it is defined as the ability to maintain three key behaviors: low risk of disease and disease related disability, high mental and physical function, and active engagement of life (Kronold et al. 2008). There are several functional products which have been designed to reduce the risk of chronic diseases (Sanders 1998; Ziemer and Gibson 1998). The disease protection is offered by all grains in prospective epidemiological studies far exceeds the protection from isolated nutrients and phytochemicals in all grains (Slavin 2004) hence the concept of functional foods includes; foods or food ingredients that exert a beneficial effect on host health and/or reduce the risk of chronic disease beyond basic nutritional functions (Huggett and Schlitter 1996). Although these are physiological, psychosocial and architectural changes and presence of non communicable diseases contribute to the special dietary needs in geriatric population that may be augmented by an easy to use and wholesome functional food.

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All grains and millets are the ideal base for a wholesome diet. This is because all variants of grains and millets are low cost, nutritious and locally available food stuff. Moreover, all grains have impact on glucose and insulin responses, on other it has slower rate of digestion (Hallfrisch and Behall 2000), due to more of dietary fiber, resistant starch, and oligosaccharides in it. All grains are rich in antioxidants, phenolic compounds, phytate, phytoestrogens such as lignan, plant stanols and sterols, vitamins and minerals. Epidemiological studies found that all grains intake is protective against cancer, cardio vascular diseases, diabetes, and obesity. All grain feeding studies in human subjects also report improvements in biomarkers such as weight loss, blood-lipid improvement and antioxidant protection (Slavin et al. 1999; Flynn et al. 2003; Slavin 2004).

As a researcher of the present case study in regard to the all grain for the experimental purpose and to highlight the importance of the dietary fiber contained in soybeans reduces the rate of emptying of the digestive tract, increases the rate of peristalsis of the bowel thus it is effective in controlling blood glucose (Penha et al. 2007) and these legumes contains complex carbohydrates, vegetable protein, dietary fibre, oligosaccharides, phytochemical and minerals. Further, the flaxseed or linseed (*Linum usitatissimum* L.) has been the focus of growing interest for the nutritionists and medical researchers due to its potential health benefits associated with its biologically active components such as α -Linolenic Acid (ALA), omega-3 fatty acids, lignan-Secoisolariciresinol diglucoside (SDG) and proteins are being taken into consideration in prevention as well as to alleviate the life style of diabetes, hypercholesterolemia and atherosclerosis. Although these foods also contain tocopherols, carotenoids, phenolics and flavanoids are excellent source of natural antioxidants (Namiki 1990; Gunger and Sengul 2008; Asharani et al. 2010) and have beneficial effects on health (Stanner et al. 2004). There are studied in regard to composite flours containing wheat and legumes have considered their role in therapeutic, medicinal and also help full for the preparation of fiber rich products. Composite flour prepared by blending wheat and legumes in proper proportions may increase the fiber content of the diet resulting in easiest bowel movement, reduction in cholesterol level in serum and liver (FAO 1998). Fenugreek (*Trigonella foenum-graecum*) is a common herbal medicine use from ancient times as well as considered as fiber rich food and 20–50% of total fiber and mucilaginous fibre in it. Green leafy vegetables are store house of vitamins such as beta-carotene, ascorbic acid, folic acid and riboflavin as well as minerals such as iron calcium and phosphorus. They also contain immense variety of bioactive non-nutritive but health promoting factors as antioxidants, phytochemical,

essential fatty acids and dietary fibre (Kaur and Kapoor 2004). *Aswagnandha* (*Withania somnifera*) and *amruthballi* (*Tinospora cordifolia*) stem powder are widely used ayurvedic medicinal herbs used as ingredient in many formulations prescribed for a variety of musculoskeletal conditions and as a general tonic to improve overall health, prevent disease in adult, elderly and pregnant women. These herbs are promoted because of its benefits including antioxidants, mind-boosting, anti-inflammatory, anti-tumour, anti-stress, immune-enhancing and anti-ageing properties (Reddy 2007). Keeping these claims in mind this study was undertaken to develop and evaluate grain based wholesome functional food products in the form of composite mix flours for geriatric population. It is assumed that such a mix will also be convenient, as the elderly are known to have difficulty in assembling the various dietary components due to ambulatory limitation and also lowered motivation.

Materials and methods

Wheat (*Triticum aestivum*), finger millet (*Eleusine coracana*), grain amaranth (*Amaranthus hypochondriacus*), soybean (*Glycine max*), flaxseed (*Linum usitatissimum*), shepu (*Anethum graveolens* Linn. Syn. *Pecedanum graveoles* Linn.), carrot (*Daucus carota*), drumstick leaves (*Moring oleifera* Linn), *Amruthballi* (*Tinospora cordifolia*) and *Aswagnadha* (*Withania somnifera*) were cleaned, dried, milled and mixed to produce composite flour. There were two variations, one was finger millet based and other was wheat based. Further fenugreek seeds powder was added to both these mixes. The amount of wheat, finger millet and fenugreek powder used to make composite mix blend diet was 70, 70 and 15 g each respectively. Thus altogether there were four composite mixes tested in this experiment. Raw flour was used to make pellet form of diet for the feeding trial. 24–30 months old Wistar albino geriatric rats (260–280 g) of either sex corresponding to human age 60–75 years were taken and were acclimatized for 10 days under standard housing conditions (26 ± 2 °C, 45–55% RH, with a 12 h (light) –12 h (dark) cycle). Necessary approval obtained before conducting the experiment at Institutional Animal Ethics Committee (IAEC), Indian Institute of Science, Bengaluru, India. These are habituation of animals to laboratory condition that is 48 h prior to the experiment as well as to lessen out stress related. Further the animals maintained under the condition of standard which is approved by the Committee for the purpose of control and supervision of experiments on animals (CPCSEA).

The formulated diets were weighed on a triple beam balance to maintain uniformity in feeding. These diets were prepared twice in a week and stored in air tight container

under refrigerated condition. Test animals were selected and divided into 5 diet groups [(n = 10 per group, 5 (♂) + 5 (♀)]. Control and experimental rats were fed on 100% commercial basal rat diet and freshly prepared diets (20 g/day/kg body weight, respectively) and water on daily basis up to 6 weeks and are as follows: Group I—Basal rat diet (control, 100% commercial) served as control. Group II—Composite mix A diet (Wheat based composite flour). Group III—Composite mix B diet (Finger millet based composite flour). Group IV—Composite mix A diet + Fenugreek powder. Group V—Composite mix B diet + Fenugreek powder. The diets were pelleted before feeding the experimental animals.

All animals were observed daily for mortality and morbidity and physical examinations were given weekly. The clinical observations recorded include assessing the general appearance of the animal and determining if behavior is affected. The individual body weight of each animal was recorded on day one prior to group allocation and end of the study. The fractions of weights were adjusted to the nearest decimal unit. At scheduled sacrifice, the following organs like, heart, liver, kidneys, lungs, and spleen were weighed after careful dissection and trimming of fat and other contiguous tissue.

The animals abstain from food since overnight until blood collection for hematology and biochemical studies. Blood samples were obtained from the orbital sinus following anesthesia with CO₂ at the scheduled necropsy. Blood sample collected into tubes containing anticoagulant ethylenediamine tetra acetic acid (EDTA) for analysis of plasma for various parameters viz. total red blood cells (RBC), hemoglobin, packed cell volume (PCV), mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), mean corpuscular hemoglobin concentration (MCHC), total platelet count, total white blood cells (WBC), Neutrophils and lymphocytes using automated hematology analyzer (Sysmex KX-21, Japan).

And also the following other parameters like, total protein content, albumin content, blood urea nitrogen (BUN) content, alkaline phosphatase (ALP), aspartate amino transferase (AST), alanine amino transferase (ALT), gamma glutamyltransferase (GGT), amylase, cholesterol, glucose, triglycerides, creatinine, urea, globulin, calcium (Ca), inorganic phosphorus, sodium (Na), potassium (K) and chloride (Cl), were measured using Erba Chem-7 clinical autoanalyzer (Germany).

Statistical analysis

Data were expressed as mean + SEM. Statistical analysis was done for the animal assay for evaluating the hypoglycemic and hypocholesterolemic effect were analyzed using one way analysis of variance (ANOVA) followed by Dunnet's-'t' test using the Graph Pad Prism software version 5. A $P \leq 0.01$ was considered as statistically significant.

Results and discussion

The human life expectancy in world is about 70 years with certain amount differences in few nations. Although life expectancy is correlated with economic developed of the nations. On average humans live approximately 80 years in developed societies. Thus rats aged 24 weeks which corresponded to human age 60 years were selected as the animal model to test the hypoglycemic and hypercholesterolemic effect of the mixes. The effect of these experimental diets on various parameters is presented here.

Feed and water intake

Mean feed and water intake of different diet groups is presented in Table 1. Study period significantly affected the feed intake. Group IV diet had the highest feed intake

Table 1 Effect of wholesome grain based functional foods on mean daily food and water intake in Wistar strain albino rats (age 24–30 months)

Treatments	Food intake (g/day)		Water intake (ml/day)	
	Initial	Final	Initial	Final
Commercial rat diet (GI)	17.56 ^a	18.08 ^a	43.25 ^a	43.33 ^a
Wheat based composite mix (GII)	17.58 ^b	18.29 ^b	43.56 ^b	44.33 ^b
Finger millet based composite mix (GIII)	17.83 ^c	18.51 ^c	42.4 ^c	44.27 ^b
Fenugreek powder + Wheat based composite mix (GIV)	18.29 ^d	19.30 ^d	42.9 ^d	44.33 ^b
Fenugreek powder + Finger millet based composite mix (GV)	18.07 ^e	19.53 ^c	40.71 ^e	44.83 ^b
F-value	**	**	**	**
SEM±	0.0023	0.004	0.2104	0.8464
CD	0.0094	0.0162	0.1853	0.7455

** Significant at 0.01% level

a, b, c, d, e means bearing the same superscript within the same column do not differ significantly ($p < 0.01$)

($P \leq 0.01$) followed by Group III, Group II, Group I and lowest was in control diet. It is apparent from the results that the highest feed intake was observed on 6th week in Group I ($P \leq 0.01$) followed by Group III, Group II, Group I and lowest was in control diet per rat per day. It is apparent from the results that the rats on Group IV diet had the highest feed intake ($P \leq 0.01$) followed by Group III, Group II, Group I and lowest was in control diet. Teradal (2013) evaluated the sensory acceptability of composite mixes containing similar ingredients among human subjects. These combinations were found highly acceptable. This may have resulted in a better feed intake. Similarity in discriminative taste behavior in humans and rats has been documented. Taste is an important factor governing ingestion. Taste buds are preserved well in healthy rats but in debilitated condition altered taste perceptions make the rats anorexic and compromise nutrition (Food and Agriculture Organization of the United Nations 1998). The feed intakes seen in this experiment validate the acceptability of the developed products.

Body and organ weight

The body weight is a parameter considered as a predictor of side effects in various organs (Seralini et al. 2011). Table 2 demonstrates the weights of rats fed on commercial basal diet (Control), Composite mix A diet (Wheat based composite flour), Composite mix B diet (Finger millet based composite flour) and Composite mix A or B with Fenugreek powder diet groups. The data show that there were non-significant differences between different diet groups in the beginning; however at the end of the experiment, slight differences in weight gain were observed in all the diet groups compared to control. However, the mean weights of all groups at all times were within a narrow healthy range. Organ weight can be the most sensitive indicator to know an effect of an experimental task and is judged by any significant differences in organ weight between treated and untreated animals (Bailey et al. 2004). Liver and kidney function test along with serum contents have been used by other evaluate safety of novel foods (Farag et al. 2006). Means for organ weight of different groups of rats express that diets prepared from selected compositions of composite flours have marginal effect on liver, spleen, heart, lung and kidney remained unaffected by using various diets (Table 2). Non-significant differences were seen for all the organ weights. At the end of study body weight of rats in diet Group IV was highest followed by Group III, control, Group II and Group I. Marginal but progressive increase in body weights and organ weights of rats during the study period may indicate the improvement in the nutritional state of the animals.

Table 2 Effect of wholesome grain based functional foods on body weight and organ weights in Wistar strain albino rats (age 24–30 months)

Treatments	Body weight (g)		Liver (g)	Spleen (g)	Heart (g)	Lung (g)	Kidney (g)
	Initial	Final					
Commercial rat diet (GI)	266.8	271.4 ^a	12.6	0.71	1.0	1.53	2.23
Wheat based composite mix (GII)	263.4	267.6 ^b	12.5	0.70	1.0	1.51	2.21
Finger millet based composite mix (GIII)	264.2	269.3 ^c	12.6	0.71	1.0	1.52	2.22
Fenugreek powder + Wheat based composite mix (GIV)	266.8	271.68 ^a	12.6	0.71	1.0	1.53	2.24
Fenugreek powder + Finger millet based composite mix (GV)	267.9	272.5 ^d	12.7	0.71	1.0	1.53	2.25
F-value	NS	**	NS	NS	NS	NS	NS
SEM±	—	0.243	—	—	—	—	—
CD at 0.01%	—	0.977	—	—	—	—	—

** Significant at 0.01% level

a, b, c, d means bearing the same superscript within the same column do not differ significantly ($p < 0.01$)

Clinical and biochemical observations

Hematological parameters

Hematological parameters are those parameters that are related to the blood and blood-forming organs (Waugh and Grant 2001). The hematological and serum examination is among the methods which may contribute to the detection of some changes in health status, which may not be apparent during physical examination but which affect the fitness of the animals (Kronfeld and Medway 1969). In addition, hematological indices in animals are important to determine the toxicity risk since the changes in the blood system have a higher predictive value for human toxicity (Adinortey et al. 2012). Data in Table 3 show the concentration of RBC, Hb content, PCV, MCV, MCH, MCHC, platelets count, WBC, neutrophils and lymphocytes of all groups. The above mentioned hematological parameters were significantly lower ($P \leq 0.01$) in basal diet. Diets supplemented with fenugreek (Group IV) caused a significant increase ($P \leq 0.01$) in Hb content. However, the Hb values were significantly higher in all groups when compared to control ($P \leq 0.01$). In the present study the values for different hematological parameters were normal as reported in the manual of laboratory technique published by National Institute of Nutrition (Raghuramulu 2003). The increase in hemoglobin in test groups is mainly due to the addition of flax seeds powder, dehydrated green leafy vegetables, herbs and fenugreek seeds powder used in the composite blend. All these food stuffs contain higher iron content than either ragi or wheat. According to Hurrell and

Egli (2010) all non haem iron is absorbed to same extent depending on the balance between absorption inhibitor and enhancers. Presence of phytates in cereals is considered the main inhibitor. Brune et al. (1992) demonstrated a dose dependent inhibitory effect of phytate in a human study. Haemoglobin levels are an output measure to determine iron nutriture. The results in this study support this. Higher Hb values in Group IV are due to the higher iron and lower phytin phosphorous contributed by wheat (Gopalan et al. 2000).

Serum biochemical parameters

Dietary changes may lead to series of reactions which can cause disruption of normal physiological activity bringing changes in biochemical constituents of the body fluid of test animals (Schilter et al. 2003). Blood biochemical screening is a useful indicator for nutritional research (Singh et al. 2002). Clinical pathological evaluation is being used as one of the safety assessment tools when some novel food sources are exploited for their appraisal as safe human food ingredient (Malley et al. 2007). Effect of wholesome grain based functional foods on serum biochemical parameters such as total protein, albumin, BUN, ALP, AST, ALT, GGT and amylase in Wistar strain albino rats are presented in Table 4. The total protein was significantly highest in Group III ($P \leq 0.01$) followed by Group I, Group II, Group IV and least was observed in control diet. Total albumin was found to be lower in Group I and highest was observed in Group II. The concentration of BUN was found to highest in Group I and lowest in

Table 3 Effect of wholesome grain based functional foods on Hematological analysis in Wistar strain albino rats (age 24–30 months)

Treatments	RBC (10 ⁶ / μl)	Hb (g/ dl)	PCV (%)	MCV (fl)	MCH (pg)	MCHC (g/dl)	Platelet count (10 ³ / μl)	WBC (10 ³ / μl)	Neutrophil (%)	Lymphocytes (%)
Commercial rat diet (GI)	7.24 ^a	14.2 ^a	43.35 ^a	50.27 ^a	18.24 ^a	35.37 ^a	1191.0 ^a	10.29 ^a	23.56 ^a	82.16 ^a
Wheat based composite mix (GII)	8.45 ^b	14.94 ^b	43.81 ^b	50.42 ^b	19.09 ^b	36.4 ^a	1144.5 ^b	11.13 ^b	22.25 ^b	83.23 ^b
Finger millet based composite mix (GIII)	8.87 ^c	14.36 ^c	43.29 ^c	50.55 ^c	18.96 ^c	36.74 ^a	1212.0 ^c	11.24 ^c	22.75 ^c	83.64 ^c
Fenugreek powder + Wheat based composite mix (GIV)	8.60 ^d	15.22 ^d	44.27 ^d	50.59 ^c	19.19 ^b	36.15 ^a	1182.0 ^d	11.20 ^d	22.87 ^d	83.82 ^d
Fenugreek powder + Finger millet based composite mix (GV)	8.92 ^e	15.68 ^e	44.21 ^e	50.67 ^d	19.08 ^b	36.53 ^a	1221.0 ^e	11.28 ^e	23.23 ^e	84.23 ^e
F-value	**	**	**	**	**	**	**	**	**	**
SEM±	0.213	0.021	0.004	0.025	0.004	2.109	0.632	0.005	0.0211	0.0242
CD at 0.01	0.049	0.086	0.018	0.101	0.19	8.484	2.544	0.023	0.0849	0.0974

** Significant at 0.01% level

RBC red blood cells, Hb haemoglobin, PCV packed cell volume, MCV mean corpuscular volume, MCH mean corpuscular haemoglobin, MCHC mean corpuscular haemoglobin concentration, WBC white blood cells

a, b, c, d, e means bearing the same superscript within the same column do not differ significantly ($p < 0.01$)

Table 4 Effect of wholesome grain based functional foods on serum values in Wistar strain albino rats (age 24–30 months)

Treatments	Total protein (g/dl)	Albumin (g/dl)	BUN (mg/dl)	ALP (IU/L)	AST (IU/L)	ALT (IU/L)	GGT (IU/L)
Commercial rat diet (GI)	7.1 ^a	4.8 ^a	19.4 ^a	143.6 ^a	188.1 ^a	79.3 ^a	2.3 ^a
Wheat based composite mix (GII)	7.3 ^b	4.6 ^b	21.4 ^b	147.7 ^b	187.1 ^b	79.2 ^a	3.1 ^b
Finger millet based composite mix (GIII)	7.2 ^c	4.7 ^c	20.9 ^c	145.7 ^c	185.5 ^c	77.0 ^a	2.0 ^c
Fenugreek powder + Wheat based composite mix (GIV)	7.3 ^b	4.7 ^c	21.2 ^d	146.8 ^d	186.9 ^d	78.4 ^a	2.9 ^d
Fenugreek powder + Finger millet based composite mix (GV)	7.2 ^c	4.7 ^c	20.9 ^c	144.4 ^e	183.3 ^e	74.3 ^b	2.6 ^e
F-value	**	**	**	**	**	**	**
SEM±	0.006	0.006	0.013	0.049	0.085	0.756	0.006
CD at 0.01	0.023	0.025	0.051	0.007	0.343	3.040	0.023

** Significant at 0.01% level

BUN blood urea nitrogen, ALP alkaline phosphatase, AST aspartate amino transferase ALT alanine amino transferase, GGT gamma glutamyl transferase

a, b, c, d, e means bearing the same superscript within the same column do not differ significantly ($p < 0.01$)

Fig. 1 Effect of the grain based wholesome functional foods on blood glucose, cholesterol and triglyceride levels in the Wistar albino rats (age 24–30 months), Control-commercial rat diet, Group I-wheat

based composite mix, Group II-Finger millet based composite mix, Group III-Fenugreek powder + Wheat based composite mix, Group IV-Fenugreek powder + Finger millet based composite mix

control. Liver enzymes exhibited significant decrease in AST, ALT, GGT concentration in the Group IV ($P \leq 0.01$) followed by Group I, Group III and Group II diet fed rats and least was observed in control fed rats. ALP concentration was highest in Group III and lowest in control fed diet. In this study, the difference in the some parameters of serum biochemistry of either sex among control and experimental rats is attributed that to individual alterations and diet formulations (Kilic and Akay 2008). The better biochemical outcomes predict a health promoting role of the combination of ingredients that were used in this study.

Effect of wholesome grain based functional foods on serum cholesterol, glucose, triglycerides, creatinine, urea

and globulin are showed in Table 5 and Fig. 1. Serum cholesterol was significantly reduced in Group IV fed group ($P \leq 0.01$), followed by Group II, Group III, Group I when compared with standard rat diet. Normal value for cholesterol in rats is between 10–54 mg/100 ml (Raghu-ramulu 2003). In present study cholesterol level in blood was highly significantly reduced in finger millet based composite mix + fenugreek ($P \leq 0.01$). Fenugreek supplementation brought about an insignificant reduction in cholesterol levels compared to their respective non supplemented ragi and wheat mixtures suggesting a role of fenugreek in reducing cholesterol levels. The effects of feeding composite mix on triglyceride levels were more

Table 5 Effect of wholesome grain based functional foods on Blood glucose, cholesterol and others in Wistar strain albino rats (age 24–30 months)

Treatments	Cholesterol (mg/dl)	Glucose (mg/dl)	Triglyceride (mg/dl)	Creatinine (mg/dl)	Urea (mg/dl)	Globulin (g/dl)
Commercial rat diet (GI)	104.5 ^a	111.5 ^a	40.5 ^a	0.7 ^a	42.7 ^a	3.8 ^a
Wheat based composite mix (GII)	103.0 ^a	110.5 ^a	31.5 ^b	0.6 ^b	41.6 ^a	3.7 ^b
Finger millet based composite mix (GIII)	100.5 ^b	108.5 ^{ab}	33.5 ^b	0.7 ^a	41.7 ^a	3.6 ^c
Fenugreek powder + Wheat based composite mix (GIV)	102.0 ^{ab}	110.0 ^a	32.5 ^b	0.6 ^b	41.2 ^a	3.7 ^b
Fenugreek powder + Finger millet based composite mix (GV)	96.5 ^c	105.5 ^c	34.66 ^{bc}	0.7 ^a	41.9 ^a	3.5 ^d
F-value	**	**	NS	NS	NS	**
SEM±	0.577	0.577	0.557	0.036	0.437	0.058
CD at 0.01%	2.322	2.322	2.243	0.052	1.761	0.023

** Significant at 0.01% level

a, b, c, d means bearing the same superscript within the same column do not differ significantly ($p < 0.01$)**Table 6** Effect of the wholesome grain based functional foods on mineral values in Wistar strain albino rats (age 24–30 months)

Treatments	Calcium (mmol/l)	Sodium (mmol/l)	Inorganic phosphorous (mmol/l)	Potassium (mmol/l)	Chlorine (mmol/l)
Commercial rat diet (GI)	11.4 ^a	150.5 ^a	6.6 ^a	5.6 ^a	107.4 ^a
Wheat based composite mix (GII)	11.0 ^b	149.5	6.6 ^a	5.5 ^b	105.4 ^b
Finger millet based composite mix (GIII)	11.5 ^c	148.0	6.8	5.3 ^c	106.7 ^c
Fenugreek powder + Wheat based composite mix (GIV)	11.5 ^c	148.5	6.8	5.5 ^b	105.7 ^d
Fenugreek powder + Finger millet based composite mix (GV)	11.7 ^d	149.5	7.0	5.4 ^d	106.7 ^c
F-value	**	NS	**	**	**
SEM±	0.019	–	0.006	0.006	0.051
CD	0.076	–	0.023	0.025	0.20

** Significant at 0.01% level

a, b, c, d means bearing the same superscript within the same column do not differ significantly ($p < 0.01$)

marked in all the groups. Group I showed lowered triglyceride value followed by Group II, Group III and Group IV compared to standard rat fed group and there was no significances in triglyceride levels among the test diet groups. Flax seeds powder used in the composite blends may have contributed to the anti hyperlipedemic effect. Flax seed contains ALA, phytosterol and mucilage. An evaluation of published literature by (Saravanan and Ignacimuthu 2015) on soy proteins and flax seeds indicted that these supplements had an anti hyperlipedemic effect. A marginal reduction in glucose levels after consumption of test diets was observed. However, glucose level was significantly reduced in Group IV diet fed group ($P \leq 0.01$) followed by Group II, Group III, and Group I when compared with standard rat diet. Hypoglycemic effect was more pronounced in mixtures containing fenugreek. Hypoglycemic effect of fenugreek has been well documented (Annida and Prince 2004). Fenugreek contains trigonelline; an alkaloid, known to reduce blood sugar

level. The consumption of finger millet based composite flour brought about a highly significant reduction in blood glucose levels ($P \leq 0.01$).

Effect of wholesome grain based functional foods on serum minerals such as calcium, sodium, inorganic phosphate, potassium and chlorine values are presented in Table 6. Results showed that significant differences ($P \leq 0.01$) for calcium, inorganic phosphate, potassium and chlorine but no differences were found for sodium among the all test diet groups. The levels were within a narrow and healthy range suggesting the safety of the developed mixes in this respect.

Conclusion

There are many claims that wholesome grain based functional foods helps to prevent non communicable diseases. Physiological, psychosocial and architectural changes and

presence of NCDs contribute to the special dietary needs in geriatric population. In this direction, the present study was undertaken to develop and evaluate grain based wholesome functional food for geriatric population. Normal levels of serum hematological and biochemical values were observed in composite mix fed rats in comparison with standard diet fed rats. Reduction in serum cholesterol, glucose levels was observed in finger millet based composite mixes. The body weight remained same at the end of study and there was no difference between groups in organ weights. A moderate hypoglycemic and hypercholesterolemic effect was observed in composite mix fed rats. It may be concluded that the composite mixes especially the finger millet based have hypercholesterolemic and hypoglycemic effect on the geriatric animal model. The present study validates the hypoglycemic and hypercholesterolemic effect of the combinations of ingredients studied. This study clearly justifies the recommendation to use wholesome grain based functional foods for geriatric population.

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