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Fenugreek Seed

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Abstract: ***Fenugreek (Trigonella foenum graecum), native to southern Europe and Asia, is anannual herb with white flowers and hard, yellowish brown and angular seeds,known from ancient times, for nutritional value beside of it medicinal effects. Fenugreek seeds are rich source of gum, fiber, alkaloid, flavonoids, saponin and volatile content. Due to it's high content of fiber, fenugreek could be used as food stabilizer, adhesive and emulsifying agent to change food texture for some special purposes. Some evidences suggest that fenugreek may also be regarded as antidiabetic, anticarcinogenic, remedy for hypocholesterolemia and hypoglycemia, antioxidant, antibacterial agent, gastric stimulant, and anti-anorexia agent. The present article is aimed to review the potential applications of fenugreek as a functional food and nutraceutical.***
Keywords: Chemical composition, Fenugreek gum, Fenugreek, Health benefits

I. INTRODUCTION

Increasing demand of consumers for healthy foods has urged the food industry to develop food products that promote health. Foods that provide significant nutrition, exert health advantages, inhibit disease and/or assist health have become more readily accepted by the industry and can be used as successful marketing tools. This has caused the emergence of functional foods that comprise a wide range of components such as probiotics, prebiotics, vitamins, minerals and dietary fiber . In this respect, some herbs have been considered for their application as an antioxidant, antimicrobial, health promotion and food development. Fenugreek (*Trigonella Foenum-gracium*) is a plant from the family of *Leguminosae* that grows annually and is widely cultivated in Mediterranean countries and Asia . The dried seeds have been traditionally used in India, China, Egypt and in some parts of Europe for their beneficial health effects such as, galactogouge, antibacterial, anti-inflammatory, insulinotropic, and rejuvenating effects. Pleasantly bitter and slightly sweet fenugreek seeds which are available in whole and ground forms are used as a source of flavoring for foods including curry powders,spice blends and teas. The seed have horny and relatively large layer of white and semi-transparent endosperm encircling central hard, yellow embryo. Wonderful functional and medicinal values of fenugreek are attributed to its chemical composition(20-25% proteins, 45-50% dietary fiber, 20-25%mucilaginous soluble fiber, 6-8% fixed fatty acids andessential oils, and 2-5% steroidal saponins. Moreover some minor components such as alkaloids (trigonolline, cholin, gentianine, carpaine, etc), free unnatural amino acids (4- hydroxyisoleucine), andindividual spirostanols and furastanols like diosgenin, gitogenin and yamogenin have also been identified and determined as the main component for its various biological effects.



Fig.1.Fenugreek Plant And Seed

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II. CHEMICAL CONSTITUENTS OF FENUGREEK SEED

A. Proteins

It was found that 100 g endosperm contains protein of 43.8 g . However, 100 g of fenugreek seed contained 25.4 g protein. Table 1 presents major proteins and amino acids in fenugreek seeds. Işıklı and Karababa (2005) reported that a high proportion of protein ranging from 20 to 30% especially amino acid 4-hydroxyisoleucine in fenugreek had high potential for insulin-stimulating activity. Fenugreek protein fraction is rich of lysine and can be compared with soybean protein.

B. Vitamins and Minerals

Although fenugreek is relatively low in mineral content, some are present in good concentrations such as phosphorus and sulphur and also it has been reported that curry made from fenugreek has a high amount of calcium, iron and zinc . Table 1 provides an overview of vitamins and minerals and their levels in fenugreek seeds. From the other point of view, germinating seeds have pyridoxine, cyanocobalamine, calcium pantothenate, biotin and vitamin C.

Srinivasan (2006) reported that Fenugreek leaves contain vitamin C (52 mg per 100 g), β-carotene (2.3 mg per 100 g), thiamine (40 µg per 100 g), riboflavin(310 µg per 100 g), nicotinic acid (800 µg per 100 g) and folic acid (0 µm per 100 g), whereas the ones for seed were 43 mg, 96 µg, 340 µg, 290 µg, 1.1 mg and 84 µg, respectively. There are nearly 10.8 and 7.4%loss of the vitamin vegetables by boiling in water, orsteaming and frying respectively, and exposure of the germinating seeds to β- and γ-radiation reduces the vitamin C content.

C. Fibers and Gums

Fenugreek seeds are rich source of soluble dietary fiber. The 100 g of seeds provides more than 65% of dietary and contains saponins, hemicelluloses, mucilage, tannins and pectin, which help to decrease the level of low density lipoprotein cholesterol (LDL) in blood by decreasing bile salts reabsorption in the colon. Also, it has been reported that fenugreek fiber bound to toxins in the food and helped to protect the colon mucus membrane from cancer toxins as well as lowering the rate of glucose absorption in the intestines controlling blood sugar levels. Furthermore, the fibers can exhibit prebiotic effects via beneficial health effects on the health of the host through modulation of the intestinal flora.

Chemical composition		Nutrient value (per 100 g)
Protein & amino acids		
	Globulin	-
	Albumin	-
	Lecithine	Totally 25.4 g
	Histidine	-
	lysine	-
	4-hydroxyisoleucine	-
vitamins		
	Vitamin A	1040 IU
	Vitamin C	12 mg
	Niacin	6 mg
	Pyridoxine	0.6 mg
	Thiamine	0.41 mg
	Riboflavin	0.36 mg
	Nicotinic acid	1.1 mg
	Folate	57 µg
Minerals		
	Calcium	176 mg
	Iron	33.5 mg
	Zinc	2.5 mg
	Phosphorus	296 mg
	Magnesium	191 mg
	Manganese	1.22 mg
	Selenium	6.3 µg

Table.1. Chemical Composition Of Fenugreek Seeds

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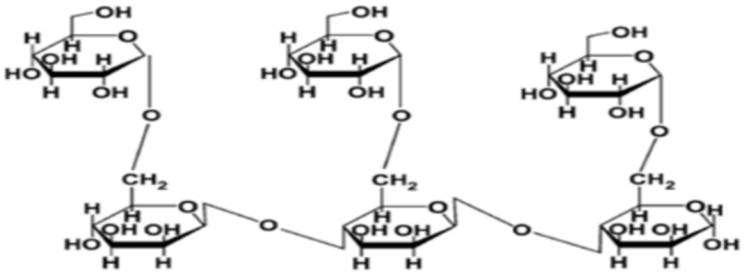


Fig.2.Fenugreek Galactomannan Structure

D. Alkaloid, Flavonoids and Saponin

Fenugreek contains different alkaloids, flavonoids and saponins that the latter one is in the highest concentration . Alkaloid and volatile constituentsof fenugreek seeds are the two major components which cause bitter taste and bad odor . The level of flavonoid in fenugreek is more than 100 mg per g of seed . The main alkaloids, flavonoids and saponons are shown in figure 3 . Benayad *et al* (2014) investigated the phenolic compounds of fenugreek crude seeds from Morocco by HPLC–DAD–ESI/MS. Analysis most of the identified compounds were acylated and non-acylated flavonoids with apigenin, luteolin and kaempferol as aglycons. The quantitative analysis of the identified compounds showed that the phenolic composition of the studied crude fenugreek seeds was predominantly acylated and non-acylated flavone derivatives with apigenin as the main aglycon . The alkaloids, flavonoids and saponins of fenugreek showed pharmacological effect. They have antilipidemic, hypoglycaemic and cholagogic properties and their use could manage diabetes mellitus, hypercholesterolemia due to clinical evidence which shows serum cholesterol level reduction. Beside of useful properties it should be carefully taken in order to avoid minor gastrointestinal symptoms and allergic reactions.

E. Volatile Compounds

Volatile oils in fenugreek are in small quantities . There were 39 different compounds that were identified by Girardon et al. (1985), including n-alkanes, sesquiterpenes and some oxygenated compounds, in the volatile oil of fenugreek seeds. The main components are n-hexanol,heptanoic acid, dihydroactiniolide, dihydrobenzofuran, tetradecane, a-muurolene, b-elemene and pentadecane. The dominant aroma component is a hemiterpenoid-γ- lactone, sotolon (3-hydroxy-4,5-
dimethyl- 2(5H)-furanone), which is present in concentrations up to 25 ppm . Blank et al. (1997) also detected some odorous compounds in fenugreek seeds are implied in Table 2.

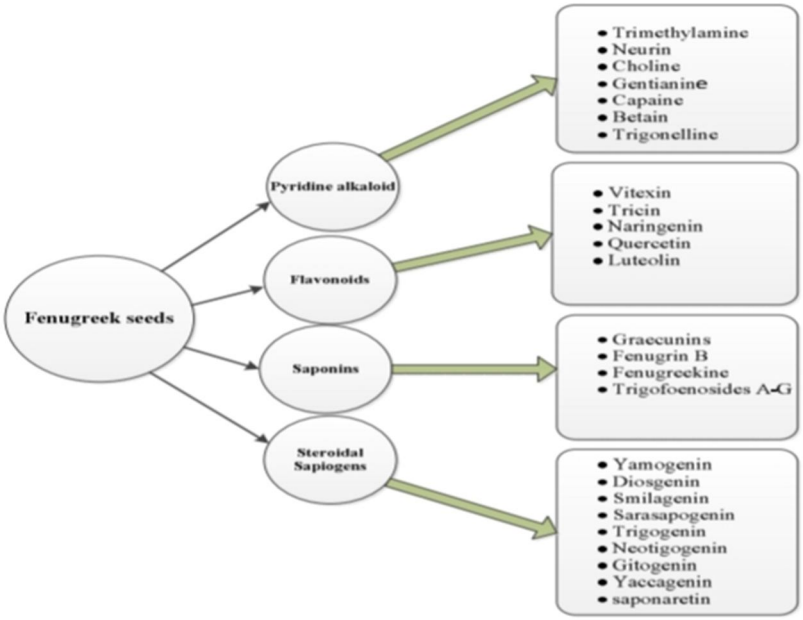


Fig.3.The main alkaloids, flavonoids, saponins & steroidal sapiogens in fernugreek seeds.

Odorous compound	Aroma quality
1-Octen-3-one	Mushroom-like
(*Z*)-1,5-Octadiene-3-one	Metallic
3-Isopropyl-2-methoxy pyrazine	Roasty, earthy
Acetic acid	Acidic, pungent
3-Isobuty-2-methoxy pyrazine	Roasty, paprika-like
Linalool	Flowery
Butanoic acid	Sweaty, rancid
Isovaleric acid	Sweaty, rancid
Caproic acid	Musty
Eugenol	Spicy
3-Amino-4,5-dimethyl 3, 4-dihydro-2-(5*H*) furanone	Seasoning-like
Stolon	Seasoning-like

Table.2.Odorous compounds detected in aroma extract of fenugreek seeds

III. HEALTH AND THERAPEUTIC BENEFITS OF FENUGREEK SEED

A. Diabetes Management

There are a significant number of works that have been carried out to show the efficacy of fiber, especially the soluble part of the fenugreek dietary fiber on blood and serum glucose management and insulin production. It was reported that adding 100 g fenugreek powder containing 50 percent dietary fiber for a period of 10 days decreased 25 percent blood glucose level among the type II diabetes patients. It has been shown that soluble fiber fraction reduced postprandial elevation in blood glucose level of Type 2 model diabetic rats by hindering the digestion of sucrose.

Administering fenugreek soluble fiber orally twice daily at a dose of 0.5 g/ kg for 28 days resulted in reducing the serum fructosamine level with no significant change in the insulin level when compared with the control. It is concluded that soluble fiber had a beneficial effect on dyslipidemia and it could inhibit platelet aggregation in Type 2 model diabetic rats. Moreover, it has been reported that soluble fiber of fenugreek postpones digestion and absorption of carbohydrate resulting improvement of glucose homeostasis. It could be explained by the extensive gel formation and low viscosity of the resulting gels inside the intestine, which may result in delaying the gastric emptying and decreasing the intestinal transit time of the food mass. Trapping the glucose inside the gel may leach out slowly and prevent the sudden rise of the blood glucose level. The viscous and gel-forming properties of soluble dietary fiber prevent macronutrient absorption, reduce postprandial glucose response and beneficially affect certain blood lipids. It is claimed that oral glucose tolerance in normal, type 1 or type 2 diabetic rats could be remarkably improved by administration of soluble dietary fiber (SDF) fraction. It is found that amount of unabsorbed sucrose in the gastrointestinal tract of non-diabetic and type 2 diabetic rats increased after oral consuming of sucrose.

B. Cholesterol Lowering Effect

There are different important scientific information and clinical data done on the efficacy of dietary fiber, especially the soluble counterpart such as beta-glucans or galactomannans in the management of hypercholesterolemia. Fenug-reek derived galactomannans, due to its unique structure of galactose to mannose 1:1 ratio, have shown to have the maximum efficacy in lowering the plasma cholesterol level. Furthermore, soluble fiber fractions reduce only the dangerous low-density lipoproteins and triglycerides intake, whereas keeping the good high-density cholesterols intac.

In a study which was done on 60 individuals with diabetes and high cholesterol and triglycerides level, who regularly received 25 g of fenugreek fiber powder containing nearly 50 percent fiber content, a significant decrease in blood glucose, LDL cholesterol and triglycerides level up was shown whereas HDL level had no decrease . The biochemical mechanism of soluble fiber as a hypolipidemic agent can be explained primarily by its capacity to bind bile acids, which are therefore excreted rather than recycled to the blood reduced blood cholesterol. Fermentation of soluble fiber may be done by bacteria in the clone which produce short-chain fatty acids can reduce cholesterol synthesis.

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C. Effect on Constipation and Irregularity

Fenugreek fiber could be useful for treating constipation and hinder the development of diverticulosis and diverticulitis. Fenugreek fiber promotes the normal location due to imperfect fermentation in in the large intestine. It can make the waste bulky, soften the stool by holding water and minimize the transit time through the intestine; hence, it helps to keep constant and steady stool time .Effect on body weight and obesity: It was observed that the food rich in dietary fiber and protein could increase secretion of the anorexigenic and insulinotropic hormone, glucagon-like peptide-1 (GLP-1) to improve glucose tolerance and reduce weight gain. It has been indicated in some studies, that fenugreek seed extract supplementation is effective in reducing the body and adipose tissue weight.

D. Anticarcinogenic Effect and Antioxidant Activity

Cancer is a very serious and complicated disease created by out of control and irregular growth of cell, whose prevalence is remarkably increasing. Except for genetic defects which contribute to 5 to 10% of cancer incidences, the rest (90% to 95%) can be limited by changing lifestyle, increasing physical activity, avoiding smoking and utilizing nutritionally balance diet together with the foods free from contaminants. Low consumption of fiber in a diet can induce colon cancers and irritable bowel syndromes. Anaerobic bacterial fermentation of dietary fiber produces short-chain fatty acids like butyrate, which is thought to protect against colon carcinogenesis. The anticarcinogenoic activity of fenugreek has been reported in several studies. Incorporation of fenugreek seed in the diet modulates the activities of β-glucoronidase and mucinase and inhibit coloncarcinogenesis. Activity of β-glucor-onidase significantly decreased the free carcinogens which were not affective on colonocytes. Mucinase helped in hydrolysing the protective mucin and this was correlated with the presence of fibre, flavanoids and saponins. Since the antioxidant activity of a plant is due to its active phytochemicals, it has been announced that fenugreek possesses a great antioxidant property that has a beneficial effect on the liver and pancreas because of its phenolic and flavonoid compound. It has been stated that fenugreek seed extract reduces lipid peroxidation and hemolysis in RBC. Dixit et al. 2005 have shown that the aqueous fraction of fenugreek exhibit higher antioxidant activity compared with other fractions. Fenugreek extract scavenges hydroxyl radicals and inhibits H2O2 induced lipid peroxidation in rat liver mitochondria.

IV. APPLICATION AS A GALACTAGOGUES

Since ancient times herbs and natural substances have been traditionally used to improve milk production. Fenugreek is one of the most frequently used galactagogues that stimulate breast milk secretion. It is speculated that fenugreek induces sweat production and since the breast is a modified sweat gland, affect breast milk secretion. It may be synthetic, plant-derived, or endogenous. It has also been demonstrated that it has esterogenic activity that is effective on breast milk production. Sreeja et al. (2010) proposed that fenugreek seeds contain estrogen-like compounds which stimulate pS2 expression in MCF-7 cell lines.

Turkyılmaz et al. (2011) stated that phytoestrogens and diosgenin of fenugreek appear to account for the increase in milk flow .A report summarized the anecdotal account of approximately 1200 women over 6 years, who were supplemented with commercially available fenugreek. They used 2 to 3 capsules (580 or 610 mg) 3 times a day. It was reported that most women experienced an increase in milk supply within 24 to 72 hours of use. In another study, seventy-five puerperal women consumed fenugreek herbal tea or palm dates and the effect on breast milk production was evaluated. Milk amount was measured on the third postpartum day. Infants were weighed on days 0, 3, 7, and14, using an infant scale.

V. APPLICATION OF FENUGREEK IN FOOD

Fenugreek can modify food texture owing to the high content of proteins and fibers, especially a soluble dietary fiber called gum (about 20.9 g/100 g in the seed), and also neutral detergent. This fiber content in addition to the flavor components modulates the organoleptic properties of foods. Soluble fibers can be utilized in nutrition and cereal bars, yogurts, dairy products and nutritional beverages. Plain powders of soluble fiber or total dietary fiber can be mixed with fruit juices, other spice mixes and seasonings. It can also be formulated as tablets or capsules along with the other vitamins and nutrients for direct supplements. It might also be applied to milk shakes, soups, dressings, sweets and candies or to fortify bakery flour for pizza, bread,pizza, bagel, muffins, cake mix, noodles, tortilla and flat bread, fried and baked corn chips . In general, fenugreek is beneficial to food processing as food stabilizer, food adhesive, food emulsifier and gum. The molecular weight of fenugreek gum is increased by removing the attached proteins. Viscosity of fenugreek gum increases with increase in gum concentration or with a reduction of the residual protein attached. However, residual proteins played an important role in decreasing the tension at the oil-water interface, but they do not have any meaningful impact on the surface activity of the fenugreek gum. It was reported that the emulsifying activity of soy protein isolate with fenugreek gum was four times higher than that of soy protein isolate with fenugreek gum or fenugreek gum alone.

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It was also observed that solubility and emulsifying properties of soy protein isolate with fenugreek gum dispersions were stable over a wide range of pH, ion strength and high temperature.

Hooda and jood (2004) noted that the addition of 10% of fenugreek flour to wheat flour increased protein content, fiber, total calcium and total iron; this indicates that fenugreek can be incorporated to prepare acceptable biscuits, and may also be mixed with cereals as a supplement for some limiting amino acids and hence for improving their protein quality through amino acid balance. Losso et al. (2009) understood that there were no significant differences in color, texture, proximate composition, firmness, and flavor intensity between the fenugreek and wheat bread, whereas glucose and insulin was found to be lower in the bread with fenugreek. The substitution of 2.5, 5, 7.5 and 10% seed powder was evaluated on textural and quality characteristics of vermicelli. The stress value increased from 0.03 to 0.037 N/m2, although the stickiness level declined from 67 to 48 g with the increase in fenugreek level, respectively. The data on sensory quality characteristics of vermicelli showed that there was an improvement in appearance and strand quality as fenugreek increased. However, at 10% substitution,the mouthfeel and flavor were affected. The highest overall quality score was related to vermicelli with 7.5% fenugreek and it had slightly thicker matrix than the control according to surface scanning electron micrographs.

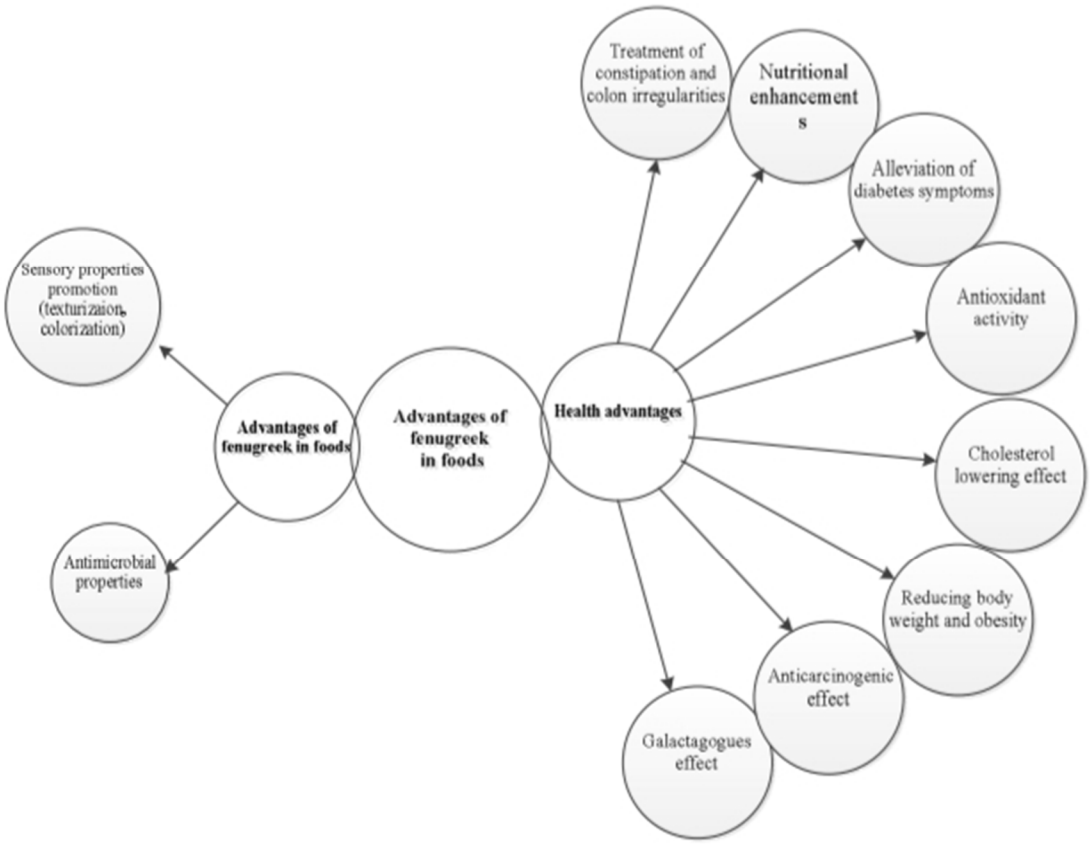


Fig.4.Advantages Of Fenugreek addition To Foods

VI. EVALUATION TEST FOR FENUGREEK SEED

Randomized case control study was undertaken in Department of Biochemistry, Grant medical college and Sir J. J. groups of Hospitals, Mumbai in 34 control and 34 subjects of metabolic syndrome with age

(30 to 60 years) and sex matched. Patients received adjunct therapy of 1.32gm/day aqueous extract of fenugreek seeds for 3 months. Initially small doses were given to the patients as adjunct therapy and doses were increased slowly with careful monitoring for side effects including risk of hypoglycaemia for 3 months. Approval of the ethical committee of the institute was obtained for the study. Informed consent was taken from the subjects. Subjects with serious hepatic or renal impairment, diabetes, cardiovascular co–morbidities,psychiatric disorders, human immune deficiency virus infection, pregnancy, addicts i.e. drugs, alcohol and tobacco were excluded from studies.

A. *Plant Extract*

Aqua soluble extract of fenugreek tablets were supplied by FDA approved ayurvedic manufacturer Sheetal Medicare.Fenugreek seeds purchased from local market were certified by botanist. Material was tested and certified as per Agmark standards for pesticides, fertilizers, toxins and heavy metals residues. Seeds were washed, dried, powered and decoction was prepared from which tablets were made by the standard procedure in text book of Indian medicine, 'SharangdharSamhita'.

Aqueous extract of Fenugreek was made in 1:10 ratio. Gum Acacia was used as binder and filler. One tablet contained 330 mg extract. 1. 32gm extract was equivalent to 13. 2gm Fenugreek seed powder. Our optimum dose was 4tablets/day. During the 1st week only 1 tablet/day was administered 5-10 minutes before breakfast. In the 2ndweek, 2tablets/day were given each before breakfast and dinner. The dosage was further increased in the 3rd week with a total of 4 tablets/day, 2 tablets before breakfast and 2 tablets before dinner.

B. *In Vitro Digestive Behaviour*

As a potential prebiotic for rabbits, the in vitro digestive behaviour of FSG was evaluated, both in pure form and when included up to 20 g/kg in diets rich in soluble or insoluble fibre. From a basal diet, two experimental diets were formulated to differ in their content in soluble and insoluble fibre provided by directly adding 100 g/kg of beet pulp (diet SF) or 100 g/kg of grape seeds (diet IF) to the basal diet respectively, but maintaining minerals and premix supply.

C. *Chemical Analysis*

A preliminary qualitative phytochemical screening was carried out. Using an aqueous extract of the FSG obtained, the presence of steroids, terpenoids, flavonoids, tannins,alkaloids, saponins, coumarins and reducing sugars (Benedict's test were determined.FSG was analysed for DM, ash, CP and sugar content, as well as for amino acids and monomers profileof their protein and sugars, respectively. The diets were analysed for DM, ash, CP, NDF, acid detergent fibre (ADF) and acid detergent lignin (ADL), as well as for total dietary fibre (TDF) and soluble fibre in IF and SF diets

D. *Statistical Analysis*

Statistical analysis (Mean and Standard Deviation) was done using Mini-tab 17 software with 95% confidence interval.

Digested, fermented and neither digested nor fermented FSG fractions were calculated in DM basis. The indigestible and unfermented fractions were calculated concerning the DM of the initial FSG and the indigestible fraction, respectively. Data on gas production kinetics were analysed using a general linear model (GLM) procedure of SAS, with a model including the urea addition (0 and 0.5 g/L) as a fixed effect.

VII. RESULT

Anthropometric Parameters	Control Mean ± SD	Metabolic Syndrome Mean ± SD
Age (Years)	43.24 ± 10.32	43.27 ± 10.26
Weight (kg) Baseline	72.77 ± 9.37	73.00 ± 8.05
Weight (kg) After 3 months	72.77 ± 8.56	69.41 ± 7.77
BMI Baseline	27.26 ± 3.67	27.50 ± 3.22
BMI After 3 months	27.25 ± 3.47	25.92 ± 3.48
Waist/Hip ratio Baseline	0.87 ± 0.03	0.87 ± 0.03
Waist/Hip ratio After 3 months	0.87 ± 0.03	0.82 ± 0.03

Table.1. Anthropometric parameter in control & metabolic syndrome .

Safety Parameters	Control Mean ± SD	Metabolic Syndrome Mean ± SD
Hemoglobin % Baseline	13.85 ± 1.41	13.68 ± 1.41
Hemoglobin % After 3 months	13.92 ± 1.23	13.79 ± 1.42
Urea Baseline	21.23 ± 4.99	20.91 ± 4.96
Urea After 3 months	19.20 ± 2.80	19.29 ± 3.31
Creatinine Baseline	0.80 ± 0.12	0.78 ± 0.11
Creatinine After 3 months	0.90 ± 0.13	0.94 ± 0.12
ALT Baseline	20.33 ± 7.25	26.53 ± 4.82
ALT After 3 months	20.67 ± 8.31	25.65 ± 4.70

Table.2. Biochemical Parameters in control & metabolic syndrome

Biochemical Parameters	Control Mean ± SD	Metabolic Syndrome Mean ± SD
Fasting Glucose Baseline	99.97 ± 3.91	105.21 ± 3.98
Fasting Glucose After 1 month	-----	87.47 ± 4.55
Fasting Glucose After 3 months	98.4 ± 5.16	76.94 ± 4.08
Insulin Baseline	19.65 ± 9.22	21.41 ± 17.68
Insulin After 3 months	18.82 ± 7.00	14.72 ± 6.30
HOMA IR2 Baseline	2.53 ± 1.1	2.45 ± 0.92
HOMA IR2 After 3 months	2.56 ± 0.8	1.8 ± 0.73
C-peptide Baseline	3.06 ± 1.2	3.17 ± 1.54
C-peptide After 3 months	3.04 ± 1.01	2.68 ± 1.15
HbA1C Baseline	5.17 ± 0.75	5.68 ± 0.59
HbA1C After 3 months	5.2 ± 0.73	5.03 ± 0.67
Total Cholesterol Baseline	225.2 ± 13.82	227.26 ± 15.53
Total Cholesterol After 3 months	227.87 ± 13.35	194.26 ± 13.07
Triglyceride Baseline	173.13 ± 9.81	180.65 ± 11.08
Triglyceride After 3 months	175.53 ± 11.49	145.65 ± 11.45
HDL Baseline	39.00 ± 3.54	35.26 ± 1.75
HDL After 3 months	39.33 ± 3.06	47.79 ± 1.7
LDL Baseline	157.98 ± 13.53	160.48 ± 16.44
LDL After 3 months	160.48 ± 12.92	131.07 ± 14.27
MDA Baseline	4.28 ± 0.49	5.98 ± 0.9
MDA After 3 months	-----	4.13 ± 0.42
SOD Baseline	826 ± 62.23	627.7 ± 96.64
SOD After 3 months	-----	811 ± 86.11

Table.3.Safety parameters in control & metabolic syndrome

VIII. CONCLUSION

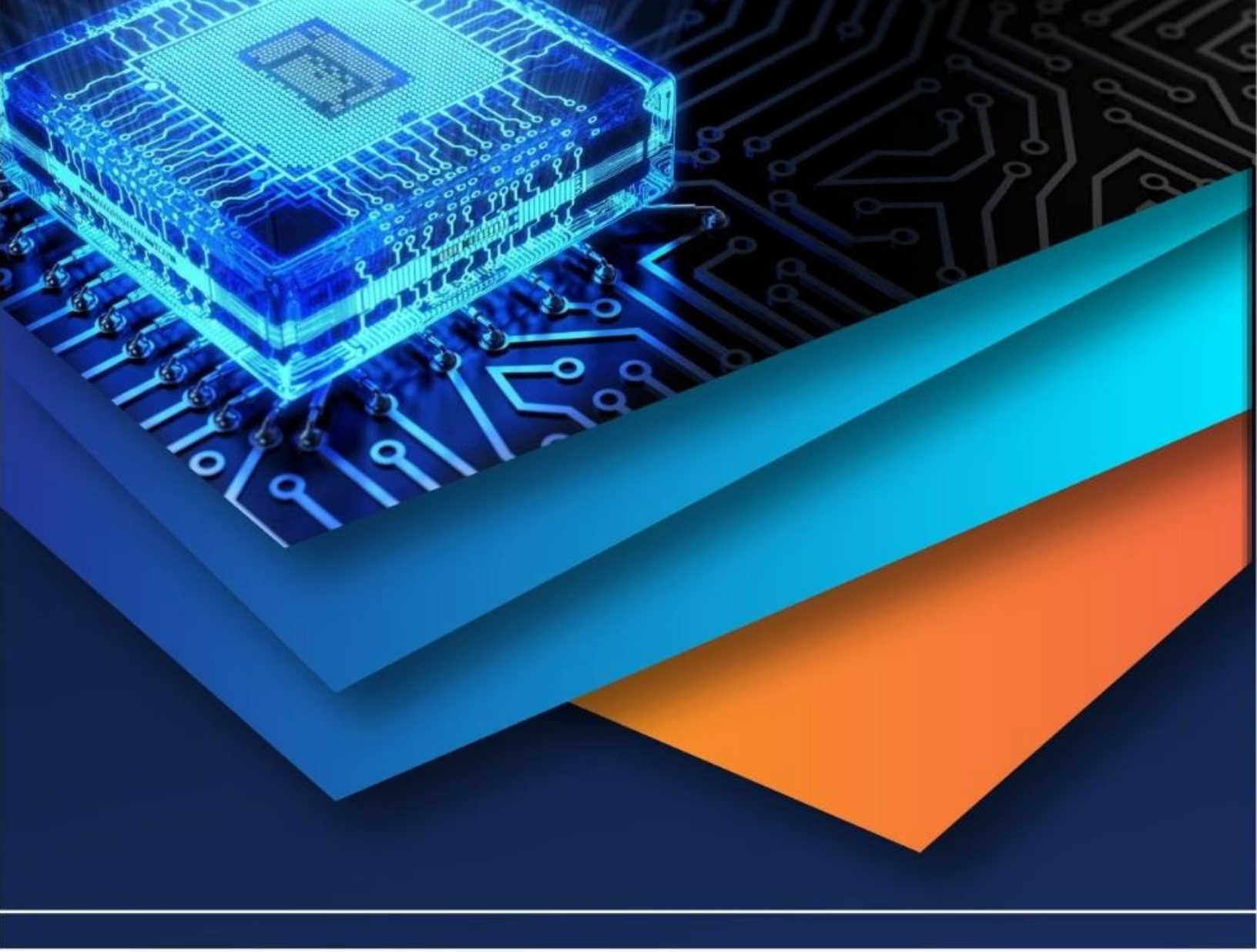
Over the last few years, several studies have been carried out on the medicinal and functional properties of fenugreek seeds. Fenugreek is rich in fiber, protein, and due to its valuable bioactive components has promising therapeutic and application. Antidiabetic, antioxidant, anticarcinogenic, hypoglycemic activity, hypocholesterolemic activity are the major medicinal properties of the fenugreek demonstrated in various studies. Based on these several healthful benefits, fenugreek can be recommended and be a part of our daily diet and incorporated into foods in order to produce functional foods.

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