

# A Review of the Health Benefits Of Fenugreek (*Trigonella foenum-graecum* L.): Nutritional, Biochemical and Pharmaceutical Perspectives

Charles Ojo Olaiya<sup>1\*</sup> and Kehinde Olugboyega Soetan<sup>2</sup>

<sup>1</sup>Department of Biochemistry, College of Medicine, University of Ibadan, Ibadan, Nigeria.

\* coolaiya@yahoo.com

<sup>2</sup>Department of Veterinary Physiology, Biochemistry and Pharmacology, University of Ibadan, Ibadan, Nigeria;

## Abstract

Fenugreek (*Trigonella foenum-graecum* L.) is an annual, forage, dicotyledon leguminous crop that is commonly used as spice and herb. It is native of a region extending from Iran to Northern India, but now grown in China, North and East Africa, Ukraine and Greece. Fenugreek is one of the oldest medicinal plants recognized in recorded history; hence it is called “an old world” crop for the “new world”. It has bitter taste due to presence of alkaloids and oil component which are non toxic on consumption; however, defatted fenugreek seed are not bitter. Fenugreek genotypes differ in morphology, growth habit, biomass and seed production capability. The seed and to a lesser extent the leaves contain three very important component of significant medicinal importance namely, complex carbohydrates (Galactomannan), steroidal saponins (Diosgenin) and amino acid (Isoleucine). It also contain other components like lecithin and choline that help to dissolve cholesterol and fatty substance, mineral, B-complex, iron, phosphate, para-benzoic acid, vitamins A and D. The seed is also rich in dietary fiber, its fiber content plays a major role in its ability to moderate metabolism of glucose in digestive tracts, thereby helps to lower glucose absorption in the intestines controlling blood sugar level. The higher content of the fenugreek soluble fiber enhance its strength for glucose level tolerance. Its fiber significantly increase satiety and reduced energy intake at launch thus suggesting a short term beneficial effects in obese subjects. The chemical constituents of this unique crop have therefore made it valuable as food and medicine. Aside the organoleptic properties, fenugreek is highly nutritious and could greatly impact health when used as forage crops as well as for human consumption. Fenugreek is known to have anti-diabetic, antioxidant, anti-neoplastic, gastroprotective, hepatoprotective, hypercholesterolemic and hypoglycemic properties due to its rich composition of phytochemicals. The aim of this review is to discuss the nutritional, biochemical and pharmaceutical potentials of this unique spice crop for the good health of humans and animals. This article could be a valuable and ready source of literature review for researchers interested in nutraceuticals, natural health product and drug development as well as the improvement of fenugreek.

**Keywords:** Fenugreek, *Trigonella foenum-graecum* L.) health benefits, nutritional, biochemical, pharmaceutical

**Abbreviations:** CVDs: cardiovascular diseases; LDL: low density lipoproteins; ROS: reactive oxygen species

## INTRODUCTION

Dietary choice and medicinal herbs remains the basis for maintaining a healthy lifestyle and well-being, especially relating to chronic diseases, which include cancer, cardiovascular diseases (CVDs) and diabetes, despite the remarkable advances in medicine and combinatorial drug development. Various crop plants are nutritious, nutraceutical, functional and medicinal in nature. Fenugreek is one of plants that combine these attributes and a well known spice crop in human diets. It is known and cultivated majorly as a spice crop and for other purposes, which include food (feed) and medicinal purposes. Fenugreek (*Trigonella foenum-graecum* L.), an annual legume crop belonging to the family of Fabaceae is native to an area extending from Iran to northern India [1]. The crop has now been introduced to parts of Africa, Mediterranean Europe, West and South Asia, North America, South America and parts of Australia [2]. The distinctive cuboid, yellow-to-amber colored fenugreek seeds are used both whole and in powdered form and often roasted to reduce their bitterness and enhance their flavour, they are frequently encountered in the cuisines of the Indian subcontinent. The seeds are used in the preparation of pickles, vegetable dishes, daals, and in recent trend as a spice adjunct. The appetizing fragrance and seasoning sweet flavor has been of great values and will still continue to enhance food intake [3]. The fresh leaves, sprouts, and microgreens are used as vegetables and are an ingredient in some Indian curries. The sprouted seeds and microgreens are used in salads and they provide natural food fiber and other nutrients required in human body [4]. The high levels of fiber make fenugreek beneficial to digestion and it also has the ability to modify food texture. Furthermore it is widely used for the associated therapeutic and chemopreventive activities

such as antibacterial, anticancer, antiulcer, anthelmintic, hypocholesterolemic, hypoglycemic, antioxidant, and antidiabetic effects. From literature search, there seems to be insufficient information on the health benefits of fenugreek from the nutritional, biochemical and pharmaceutical points of view. The present article reviews the nutritional/nutraceutical constituents of fenugreek, impacts on digestion, modulatory action on enzyme and metabolic syndrome, use in food processing, all in view of promotion of health and well-being of humans and animals.

## NUTRIENTS/ NUTRACEUTICAL CONSTITUENTS OF FENUGREEK

Fenugreek is a unique functional food crop [5]. The chemical constituents of both seed and leaves have made them valuable as food and medicine, in addition to being a rich source of nutrients (macronutrients and micronutrients), it delivers various phytochemicals (non-nutritive plant chemicals that have protective or disease preventive properties) which confer the medicinal values as well as impart the popular spicy flavor. The nutritional value includes several aspects that may be grouped into two categories: organoleptic properties and nutritious contents.

Fenugreek seeds are known and popular for their strong spicy flavour, in addition the high fiber contents [6]. The dried leaves of the fenugreek are used as a quality flavour for meat, fish and vegetable dishes. Sotolon is the major chemical responsible for fenugreek's distinctive sweet smell. Fenugreek seed contains volatile oil and fixed oil in small quantities [7]. Gas chromatography has helped to detect various odour active compounds which give buttery, mushroom - like, metallic, roasty/earthy, pungent, paprika-like, flowery, sweaty/rancid, musty, spicy, seasoning - like flavor; these compounds include: Olfactometry

diacetyl; 1-Octene-3-one; (Z)- 1,5-Octadiene-3-one; 3-isopropyl-2-methoxypyrazine; acetic acid; 3-Isobutyl-2-methoxypyrazine; linalool; butanoic acid; isovaleric acid; caproic acid; eugenol; 3-Amino-4,5-dimethyl-3; 4-dihydro-2(5H)-Furanone. Of all these compounds, sotolon is found predominantly (95 %) in fenugreek [8]. This flavor content could be highly beneficial in promoting the eating quality and intake of foods for proper health maintenance.

Aside the organoleptic properties, fenugreek is highly nutritious, and could greatly impact health when used as forage crops as well as for human consumption. As it has been widely used as traditional food, functional food and nutraceuticals, it provides natural food fiber and other nutrients required in body [4]. In terms of protein contents, fenugreek has a chemical composition that mimics milk in its ratio between protein and amino acids contents [9]. Fenugreek endosperm is rich in protein such as globulin, histidine, albumin and lecithin [10]. The fenugreek protein fraction is lysine-rich and comparable in quality to that of soybean protein [11]. Fenugreek could functionally promote health because of the high content of amino acid 4-hydroxyisoleucine which has high potential for insulin-stimulating activity [12]. This high protein content and quality should be looked into in qualitative and quantitative improvement of this crop which could greatly impart population with low protein intake especially in some developing countries.

Fenugreek seeds are rich in carbohydrates and especially mucilaginous fiber which is comprised mainly of galactomannans. Fenugreek seed is actually popular for its fiber and a rich source of soluble dietary fiber content. It contains 50 % fiber (30 %

soluble fiber and 20 % insoluble fiber) [6]. Non-starch polysaccharides constitute fiber content of the fenugreek. The biochemical benefits of fibers present in fenugreek include: binding to toxins in the food and helps to protect the colon mucus membrane from cancer causing toxins; facilitating insulin secretion as a result of 4-hydroxyisoleucine; helping to lower rate of glucose absorption in the intestines controlling blood sugar levels and water retention capacity for easy bowel movement. Non-starchy polysaccharides increase the bulk of the food and augments bowel movements. Also, non-starchy polysaccharides assist in smooth digestion whereas high fiber of fenugreek helps in relieving constipation ailments. Fenugreek contains saponins, hemicelluloses, mucilage, tannins and pectin and these compounds help to decrease the level of low density lipoprotein-cholesterol (LDL) in blood by inhibiting bile salts re-absorption in the colon. Also, fenugreek husk is a valuable source of dietary fiber and phenolic acids; therefore, it could be an effective source of natural antioxidants and natural ingredients in functional foods [10].

Fenugreek is no exception from other vegetable in high contents of vitamins and minerals; it is relatively low in mineral content when compared with the vitamin content however it has some of them in good amounts such as phosphorus and sulphur [13]. High occurrence of calcium, iron and zinc has also been reported in curry made from fenugreek [14]. With reference to micronutrient content, fenugreek is especially rich in choline. Both the seed and leaves contain high levels of vitamin C, nicotinic acid and riboflavin, while the seed is rich in thiamin and folic acid but the leaves contain little or no folic,  $\beta$ -carotene, a precursor of vitamin A is present in the leaves at relatively high amount [15]. It has

been reported that germinating seeds contain pyridoxine, cyanocobalamine, calcium pantothenate, biotin and vitamin C and that the vitamin C, calcium,  $\beta$ -carotene contents are seriously depleted in fenugreek leaves upon boiling in water, or steaming and frying [16]. These are therefore worthy of note in heat treatment during processing. It has been shown that fenugreek consumption has potentially improved body composition, in particular body fat percentage and vitamin C of fenugreek seed has an important role in this regard [17].

### PHARMACEUTICAL BENEFITS OF FENUGREEK

Nature has been a source of medicinal treatments for thousands of years, and plant-based systems continue to play an essential role in the primary health care of 80 % of the world's developing and developed countries [18]. According to the Ayurveda, plants have so many constituent which may be used for the treatment of so many diseases. Herbal drugs are easily available and have fewer side effects. People all over the world are now greatly attracted towards the herbal plant drugs. Fenugreek is easily available in our kitchen and use as drugs from oldest time. Fenugreek was used to ease childbirth and to increase milk flow, it is still traditionally used as remedy for various ailments, for instance it is taken by Egyptian women for menstrual pain and as hilba tea to ease stomach problems of tourists; Fresh fenugreek leaves for the treatment of indigestion, flatulence and a sluggish liver [19]. An infusion of the leaves is used as a gargle for recurrent mouth ulcers. A gargle made from the seeds is best for ordinary sore throat. Fresh Fenugreek leaves paste applied over the scalp regularly before bath helps hair grow, preserves natural color, keeps hair silky and also cures dandruff; Fenugreek seeds made in gruel, given to nursing mothers increase the flow

of milk; Topically, the gelatinous texture of fenugreek seed may have some benefit for soothing skin that is irritated by eczema or other conditions. It has also been applied as a warm poultice to relieve muscle aches and gout pain; Fenugreek seeds reduce the amounts of calcium oxalate in the kidneys which often contributes to kidney stones. Traditional Chinese herbalists used it for kidney problems and conditions affecting the male reproductive tract; Fenugreek is currently used as a source of the steroid diosgenin, one of its active constituents from which other steroids can be synthesized. These traditional uses have probably informed extensive study on this medicinal plant and the following biological activities have been associated with fenugreek in various studies: antidiabetic; antiplasmodic; hypolipidemic, antibacterial; anthelmintic; anti-inflammatory and analgesic activity; antioxidant, anticarcinogenic, antiulcer, antifertility, immunomodulatory effect, enzymatic pathway modifier, activities [20].

#### Antidiabetic activity

Preliminary animal and human trials suggest possible hypoglycaemic and anti-hyperlipidemic properties of fenugreek seed powder taken orally. Fenugreek has been well known to be used as antidiabetic remedy for both type I and II diabetes and has been extensively used as a source of antidiabetic compounds, from its seeds, leaves and extracts in different model systems [21, 22] About 25-50 g fenugreek seeds were given to diabetic patients daily in diet to prevent and manage long term complications of diabetes and studies have been made about the glycemic index of fenugreek recipes which showed that the soluble fenugreek fiber has significantly reduced the glycemic index [23]. On the other hand, water extract of fenugreek seeds has higher hypoglycemic and antihyperglycemic potential and for this

reason it may be used as a supplementary medicine to treat the diabetic population by significantly reducing the dose of standard drugs. Since fenugreek seeds are a source of protein, they can replace pulses in the diets of diabetics. 25-50 g fenugreek in the diet of diabetic patients (taken daily) can be an effective supportive therapy in the management of diabetes [24]. The bioactive compounds with respect to diabetic conditions include the galactomannan-rich soluble fiber fraction of fenugreek which may be responsible for the antidiabetic activity of the seeds [25].

### **Antilipidemic activity**

Fenugreek seeds have been shown to exhibit hypocholesterolemic effects, lowered serum cholesterol, triglyceride and low-density lipoprotein in hypercholesterolemia suffering patients and experimental models [26]. In obesity suffering rats fenugreek consumption in diet reduced triglyceride accumulation in the liver while fecal bile acid and cholesterol excretion were increased by fenugreek administration [25]. This may be secondary to a reaction between the bile acids and fenugreek-derived saponins causing the formation of micelles too large for the digestive tract to absorb.

### **Antioxidant activity**

Fenugreek contains phenolic and flavonoid compounds which help to enhance its antioxidant capacity [27]. It has been suggested that fenugreek has powerful antioxidant property that has beneficial effect on liver and pancreas; since antioxidant properties have been linked to health benefits of natural products; such properties are studied with germinated fenugreek seeds which are observed to be more beneficial than dried seeds because of the fact that germinated seed increases the bioavailability of different constituents of

fenugreek [28]. An aqueous fraction of fenugreek exhibits the highest antioxidant activity compared to other fractions and the quantity of phenolic and flavonoid compounds are related to antioxidant activity. Studies have revealed significant antioxidant activity in germinated fenugreek seeds which may be due to the presence of flavonoids and polyphenols. Furthermore, mustard and fenugreek seeds showed hypoglycemic and antihyperglycemic activity in diabetic mice and this may be due to the presence of antioxidant carotenoids in those spices [29].

### **Anticarcinogenic activity**

Fenugreek is a promising protective medicinal herb for complementary therapy in cancer patients under chemotherapeutic interventions because fenugreek extract shows a protective effect by modifying the cyclophosphamide induced apoptosis and free radical-mediated lipid peroxidation in the urinary bladder of mice [30]. Diosgenin is a crystalline steroid saponin found in fenugreek and used as a starting material for the synthesis of steroid hormones such as cortisone and progesterone. It has been found to be potentially important in treatment of cancer [31]. It has the ability to prevent invasion, suppress proliferation and osteoclastogenesis through inhibition of necrosis factor NF-kappa B-regulated gene expression and enhances apoptosis induced by cytokines and chemotherapeutic agents [32]. The seed powder in the diet due to the presence of fiber, flavonoids and saponins decreased the activity of  $\beta$ -glucuronidase significantly and prevented the free carcinogens from acting on colonocytes whereas mucinase helped in hydrolysing the protective mucin. Intra-peritoneal administration of the alcohol seed extract before and after inoculation of *Ehrlich ascites* carcinoma cell in mice prevented tumor cell growth and this treatment

enhanced peritoneal exudates and macrophage cell counts [33]. Protodioscin of fenugreek exhibited a strong inhibitory effect against leukemic cell line HL-60 and a weak growth inhibitory effect on gastric cell line KATO-III [34]. Diosgenin in fenugreek prevented cell growth and induced apoptosis in the H-29 human colon cancer cell line and fenugreek seed was found to have hepatoprotective properties [35].

### **Immunomodulatory effect**

An agent that intensifies or diminishes the immune responses is known as immunomodulator and such effect is called as immunomodulatory effect. Immunomodulatory substance interferes with three basic areas of the immune responses directly or indirectly; the mucosal barrier function, the cellular defense function and the local or systemic inflammatory response. Research work in this effect of fenugreek is scanty but stimulatory immunomodulatory effect has been shown (as evidenced from body weight, relative thymus weight, cellularity of lymphoid organs, delayed type of hypersensitivity response, plaque forming cell assay, haemagglutination titre, quantitative haemolysis assay, phagocytosis, lymph proliferation and a significant increase in phagocytic index and phagocytic capacity of macrophages) of aqueous extract of fenugreek at three doses 50, 100 and 200 mg per kg of body weight for 10 days on the immune system of Swiss albino mice [36].

### **FENUGREEK IN FOOD PROCESSING**

In addition to the nutritional/nutraceutical constituents of fenugreek, it has the ability to modify food texture and impart flavour. The texture of foods has a substantial influence on consumers' perception of 'quality' and during chewing (or 'mastication'); information on the changes

in texture of a food is transmitted to the brain from sensors in the mouth, from the sense of hearing and from memory, to build up an image of the textural properties of the food. Fenugreek owes this ability to modify food texture to the high content of proteins and fibers, especially a type of 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 flavour components modulate the organoleptic properties of foods. In general fenugreek is beneficial to food processing as food stabilizer, food adhesive, food emulsifier and gum [14]. The molecular weight of fenugreek gum is increased by removing the attached proteins. Viscosity of fenugreek gum increases with increasing gum concentration or with reduction of the residual protein attached. However, residual proteins played an important role in decreasing the tension at the oil-water interface, and proteinaceous matter does not have any significant effect on the surface activity of the fenugreek gum [37, 38].

### **BENEFITS ON ENZYME ACTIVITY AND METABOLIC SYNDROME**

Metabolic syndrome refers to the clustering of several cardiovascular and metabolic risk factors including dyslipidaemia, hyperglycaemia and increased blood pressure, where abdominal obesity and insulin resistance represent core parameters of these clusters [39]. The aetiology of metabolic syndrome involves many complex biochemical pathways. Different mechanisms linking the symptoms have been postulated, all possibly hampering normal cardiovascular function. Increased levels of Reactive Oxygen Species (ROS), non-esterified fatty acids, LDL and lipotoxicity may be related to insulin resistance [40]. Inflammation have been proposed as the critical process of initiation of the symptoms of metabolic syndrome and

the pro-inflammatory state of obesity and metabolic syndrome is probably initiated by an excessive caloric intake in a high carbohydrate diet [41]. Adipose tissue releases numerous bioactive mediators, including pro-inflammatory cytokines that not only influence body weight homeostasis, but also induce changes in cardiovascular structure and function, glucose metabolism, blood pressure, lipid metabolism, coagulation and inflammation leading to endothelial dysfunction and atherosclerosis [40]. It is common and sometimes routine to quantify the build-up of certain metabolites or modulation in the enzyme activity associated biochemical pathways in question.

The ability of fenugreek to restore to some extent the actions of key enzymes in particular lipids and carbohydrate in human subject and animal model has been widely reported [42, 43]. Fenugreek administration in rats restored the changed enzyme activities and partially normalized hyperglycemia [44]. Altered levels of superoxide dismutase, antioxidant enzymes catalase and glutathione peroxidase in liver and kidney of diabetic rats were corrected by treating with insulin, vanadate, fenugreek and the combined dose of vanadate and fenugreek [44]. Furthermore the activities of glucose-6-phosphatase and fructose-1, 6-biphosphatase in the liver and kidneys of diabetic rats are reduced by administration of fenugreek. While fenugreek seed polyphenol extract administered per day reduced the levels of lipid peroxidation products and protein carbonyl content, it promoted mode of action of antioxidant enzymes, and restored content of thiol groups; this shows a high antioxidant capacity of fenugreek. Combined treatment of fenugreek and sodium-orthovanadate, activities of nicotinamide adenine dinucleotide phosphate-linked enzymes such as glucose-6-phosphate dehydrogenase,

malic enzyme, isocitrate dehydrogenase, and the activities of lipogenic enzymes such as adenosine triphosphate-citrate lyase and fatty acid synthase were found to decrease significantly in liver diabetes as compared to those of control [43].

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