



# Lentil's (*Lens culinaris* L.) functional properties in prevention and treatment of non-communicable chronic diseases: A review

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**Abstract:** *Background:* using functional food in diet planning and diet therapy is one of the newest approaches in prevention and treatment of non-communicable chronic diseases. Lentil has many bioactive and functional compounds and we have reviewed the influence of lentil in prevention and treatment of chronic diseases in this review study. *Materials and methods:* In order to do search about mentioned objective key words including Lentils (*Lens culinaris*L.), functional foods, bioactive peptides, nutritional value, health polyphenol in combination with glycemic index (GI), insulin resistance, diabetes, cancer and hypertension, the sources in PubMed database were examined in the years between 1986-2013. Key words such as lentils (*Lens culinaris*L.), functional foods, bioactive peptides, nutritional value, diabetes, cancer and hypertension were studied with access to Persian sources of Scientific Information Database (SID). Cell studies, animal models, clinical studies and review articles were used with favorable quality. *Results:* Lentils are rich sources of fibers, resistant starches, prebiotic compounds, phytochemicals, proteins and bioactive peptides, phenolic acids and antioxidants. Lentil has the highest total antioxidant capacity among other foods including apples, dates, raspberries, cherries, figs, oranges, garlic, cabbage and peanuts. High content of fibers and other phytochemicals are found in lentils that could improve glycemic response in diabetic patients, lipid and lipoprotein metabolism and weight management. Lentils may have favorable effects in prevention of diabetes, cancer and cardiovascular diseases (CVD<sub>s</sub>) prevalence. *Conclusion:* Increased dietary intake of lentils is considered as an important key in prevention and treatment of chronic diseases, especially type 2 diabetes, cardiovascular and cancer diseases.

**Keywords:** Lentils (*Lens Culinaris* L.), Functional Foods, Bioactive Peptides, Nutritional Value, Health Polyphenols

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## 1. Introduction

In recent decade, science and technology have been improving and we have seen changes in life style and results of disease and death. Non-communicable diseases are replaced contagious and infectious diseases [1]. Today, 47% of the burden of chronic diseases is included in the region of Middle East [2], which are the reason of 80% of the deaths in low and middle-income countries [3]. Increasing Chronic diseases such as diabetes, cancers and coronary diseases (CVD<sub>s</sub>) increased rates of hospitalization due to them and the high cost of health care (60% of all admissions). So, health systems are faced with serious challenge [4]. According to

side effects of drugs, use of supplementary treatments and diet modification are good ways to improve chronic diseases. Many studies have confirmed that legumes consumption effects on health promotion, control and protection against CVD<sub>s</sub> and diabetes [5, 6, 7]. Lentils are functional foods among legumes that are convenient for human consumption. High amount of protein and drought resistant put them among important plants [8, 9]. Lentils are mainly cultivated in Indian subcontinent, the Mediterranean region and North American [10]. Lentils were cultivated in 244000 hectares and its production is 166000 tons in Iran, so it has the second place after the production of chickpea [11]. Thus, the current article is a comprehensive review that addresses nutritive

value, and functionality of lentils. In addition, impacts of lentils are investigated on high blood pressure, diabetes, CVDs and cancers.

In order to search the mentioned objective key words including Lentils (Lens culinarisL.), functional foods, bioactive peptides, nutritional value, health polyphenol in combination with glycemic index (GI), insulin resistance, diabetes, cancer and hypertension, they were examined in PubMed database in the years between1986-2013. Key words such as lentils (Lens culinarisL.), functional foods, bioactive peptides, nutritional value, diabetes, cancer and hypertension were visited with access to Persian sources of Scientific

Information Database (SID). Cell studies, animal models, clinical studies and review articles were used with favorable quality. More than 100 documents were accessible, but only 60 of them were used in this paper. As there were a few studies about objective of this paper, it is necessary to do forward studies.

## 2. Nutritional Composition of Lentils

The nutritional composition and individual nutrients of raw lentils have been identified and are mentioned in Table 1 [12].

*Table 1. Nutrient content of whole lentil*

Nutrient	Unit	Value per 100g	Cup 192g	Tablespoon 12g
Water	g	10.4	20	125
Energy	Kcal	353	678	42
Protein	g	25.8	49.5	3.1
Total fat	g	1.1	2.4	0.1
carbohydrate	g	60.1	115.4	7.2
Fiber	g	30.5	58.6	3.7
sugar	g	2.03	3.9	0.2
Minerals				
Calcium, Ca	mg	55	108	7
Iron, Fe	mg	7.5	14.5	0.9
Magnesium, Mg	mg	122	234	15
Phosphorus, P	mg	451	866	54
Potassium, K	mg	955	1,834	115
Sodium, Na	mg	6	12	1
Zinc, Zn	mg	4.8	9.2	0.6
Vitamins				
Vitamin C, total ascorbic acid	mg	4.4	8.4	0.6
Thiamin	mg	0.9	1.7	0.1
Riboflavin	mg	0.2	0.4	0.03
Niacin	mg	2.6	5	0.3
Vitamin B-6	mg	0.5	1	0.1
Folate, total DFE	µg	479	920	57
Vitamin B-12	µg	0.00	0.00	0.00
Vitamin A, RAE	µg	2	4	0
Vitamin A, IU	IU	39	75	5
Vitamin E (a-tocopherol)	mg	0.5	0.9	0.1
Vitamin D	IU	0	0	0
Vitamin K (phylloquinone)	µg	5	9.6	0.6
Lipids				
Fatty acids, total saturated	g	0.2	0.3	0.02
Fatty acids, total monounsaturated	g	0.2	0.4	0.02
Fatty acids, total polyunsaturated	g	0.5	1	0.1
Cholesterol	mg	0	0	0
Other				
Caffeine	mg	0	0	0

### 2.1. Carbohydrate

Lentils have up to 60 g/100g carbohydrates [12], such as resistant starches (RS). Many studies have confirmed that RS improve insulin sensitivity in patients with metabolic syndrome [13]. RS resist against digestive enzymes and reach the large intestine [14]. Prebiotics are indigestible carbohydrates which have some beneficial effects on host healthy by stimulating the growth and activity of one or number of bacteria in the intestinal tract and follow by health

promotion [15]. In a healthy body, 80- 90% of these carbohydrates are broken down to CO2 (carbon dioxide), hydrogen, methane and short chain fatty acids by colon bacteria's. Short chain fatty acids increase the uptake of water and sodium, colonic cell proliferation, production of metabolic energy, and the production of gastrointestinal hormones. They also stimulate blood flow to the colon and the autonomic nervous system [16]. Lentils have 13gr/100gr probiotic carbohydrates [17]. Fructooligosaccharids and galactooligosaccharids are well-known for their prebiotic

action [18]. The functional significance of these carbohydrates arises from their ability to promote the growth of beneficial gut microbes such as bifidobacterias [19].

## 2.2. *Fibers*

Lentils are considered as a valuable source of total dietary fibers, most of which (93–99.7 %) is insoluble and less than 7 % soluble [20, 21]. Dietary fibers have considerable effects on the physiological processes. Insoluble fibers increase water retention capacity of non-absorbed material and increase the volume and frequency of waste disposal. They also carry out gel formation in the gut tract and make complex formation with cholesterol which reduces their absorption [16]. Dietary fibers can regulate blood glucose, insulin sensitivity and reduce body weight [22]. American Diabetes Association recommends daily intakes of 20-35 grams of fibers [23]. Lectins and saponins are complex carbohydrates that are found in lentils. Lectins or haemagglutinins are carbohydrates attaching to proteins [19] and are naturally detected in lentils. These compounds have inhibitory effects on growth of cancerous cells of liver [24]; some of them could reduce carcinogenic properties by attachment to cancerous cells [25]. Several studies have demonstrated that lectins reduce rate of cell division in cancerous cells and increase macrophage numbers. Subsequently, they increase cancerous cells sensitivity to macrophage attacks, and finally improve immune system in human [26]. Lentils are among the best sources of saponins. Saponins include a diverse group of compounds characterized by their structure containing a steroid or triterpenoid aglycone [27]. There are many studies about the ability of saponins in complex formation with cholesterol [28].

## 2.3. *Proteins*

Lentils contain 28.7- 31.5% proteins, which is considerable among legumes [29]. Lentils are a rich source of peptides with high biological activity such as protease inhibitor proteins, angiotensin 1-converting enzyme (ACE) inhibitor and defensins [30]. Major protease inhibitor in lentils is Bowman-Birk type trypsin inhibitor (BBI) [31]. One of the positive effects of protein protease inhibitor is anti-inflammatory property [32]. BBI administration significantly reduced inflammation in rats with ulcerative disease [33]. Protease inhibitor proteins have an important role in treatment of cancer by mechanisms such as change in proteolytic and hydrolyze activity and altered expression of oncogenes (genes have important role in carcinogenesis) [34]. ACE inhibitor destroys materials with stimulating high blood pressure [35]. Presence of peptides has been confirmed in legumes such as chickpea and lentils [36, 37].

## 2.4. *Fat*

Ryan and colleagues have shown that lentil seeds contained a total fat of about 1.4 g/100 g distributed unevenly over the fatty fractions as follow: saturated fatty acids (SFA),

16.7 %; monounsaturated fatty acids (MUFA), 23.7 % and polyunsaturated fatty acids (PUFA), 58.8% [38].

## 2.5. *Minerals and Vitamins*

Minerals and vitamins of lentils are presented in Table 1. Lentils have 7.5 mg/100gr Iron. Bioavailability of iron can be reduced by inhibitors naturally present in the seed; this adverse effect could be minimized by cooking, germination and fermentation of lentils [39].

Zinc is an essential element for the body. Zinc is presented in more than 300 metalloenzymes, translation factors [40], metabolic pathways in protein synthesis and metabolism of carbohydrates, lipids and nucleic acids [41]. Some studies have shown the low level of zinc serum and high level of zinc excretion in diabetic people [42].

Lentils have 479µg/100g folate. Various evidences have suggested that folate deficiency in pregnant women has associated with spontaneous abortions and birth complications such as preterm labor. Some studies have released that folate has a protective effect against cancers such as breast cancer, colorectal, pancreas and esophagus [43].

## 2.6. *Phytochemicals*

Lentils have high amount of phytochemical compounds like Polyphenols. Polyphenols are secondary metabolites that have major role in tissue protection against free radicals; therefore lentils may drop the rates of cancer, diabetes, Parkinson, heart failure and Alzheimer [37]. Among polyphenols, tannins and tannin-related compounds are principal components in lentils, which mainly concentrated in the testa. Lentils are being among the richest legume seeds in their condensed tannin content, up to 915 mg/100 g (1). On the other hand, flavonoids and 3-O-glucoside distribute in the seed coat. The coat also contains glycosides of flavonols and proanthocyanidins [37, 45]. It has been found that the darkness of the coat of colored pulses such as lentils are correlated with their phenolic compounds [46]. Green or red lentils have a significantly higher phenolic content and antioxidant capacity than that of the pale colored pulses [47]. Seed coat represents only a small percentage of the entire lentil seed weight, ranging from 8 to 11 %, but provides significant contribution to the benefits of lentils [48]. The concentration of simple polyphenols determined in the cooked lentils 2404µg/100 [49]. Lentils have the highest antioxidant capacity among pulses [50]. Lentils had higher oxygen radical absorbing capacity (ORAC) value than most of the common fruits and vegetables including apples, plums, blackberries, cherries, figs, peaches, pears, oranges, garlic, cabbage and almonds [51].

# 3. *Favorable Effects of Lentils*

## 3.1. *Body Weight Regulation*

The high fiber content and low glycemic response of lentils have been looked as a means of increasing satiety,

reducing food intake and thus controlling body weight [52]. Some observational studies have consistently showed an inverse relationship between pulses consumption and body mass index (BMI) or risk for obesity [53].

### 3.2. Cardiovascular Diseases

In a meta-analysis of eleven clinical trials that examined the effects of pulses on serum lipoproteins, results reported that intake of non-soya pulses, including lentils, was related with reduction in serum total cholesterol (TC), low density lipoprotein cholesterol (LDL-C), triglycerides (TG) and an improvement in high density lipoproteins cholesterol (HDL-

C). The reviewers described that the hypocholesterolemic effects of pulses are related with presence of soluble dietary fiber, vegetable proteins, oligosaccharides, isoflavones, fatty acids, saponins and other factors [37].

### 3.3. Diabetes

Lentils have low glycemic index (GI), which slowly release glucose into the bloodstream and create a constant insulin response. According to these results, lentils are recommended for patients with type 2 diabetes and CVD<sub>s</sub> [54]. Some studies have demonstrated effects of lentils on rats [55] and humans with type 2 diabetes [56] (Table 2).

Table 2. Studies were conducted about effect of lentil.

Researcher (year)	Study design	Intervention / treatment	Findings
Tibi et al performed in 2010 [55]	Animal models/40 male rats	Rats were nourished by whole cooked lentil, whole raw lentil, without raw testa lentil, without cooked testa lentil for 6-weeks.	HDL-C was significantly higher in rats which consumed whole cooked lentil. Serum glucose was significantly lower in rats which consumed without cooked testa lentil.
Shams et al excuted it in 2010 [56].	Clinical trial/30 patients with type 2 diabetes	Participants received 50 gr/d cooked lentils for 6 weeks	Serum glucose and total cholesterol significantly decreased.
Faris et al did this research [59].	In one animal experiment, 60 male rats undertake intervention 5 weeks, after they were experienced cancer by azoxymethan administration.	Each group received whole raw lentil, whole cooked lentils, split raw lentil, split cooked lentil or raw soy. Rats in control group continue their normal life.	Aberrant crypt focus significantly decreased in rats which received raw soy, whole cooked lentil, split lentil compared with control group.
Adebamowo et al excuted this study in 2005 [60].	In a prospective study 90,630 women who were premenstrual and aged 26-46. They were followed up during 8 years.	Flavanol intake of participants was examined by food frequency questionnaires.	There was significant inverse association with intake of beans or lentils with breast cancer risk.

**Cancer:** lentils have some bioactive components with anti-carcinogenic properties including lectins and defensins which can improve statue of patients with colorectal cancer [57]. The incidence of breast, prostate and colon cancer is low in populations that have higher amount of lentils in their diet [58]. Preventive and treatment effects of lentils are showed in patients with cancers (Table 2) [59, 60]. Anti-carcinogenic mechanisms of lentils are including hormones modulation and improvement in the level of antioxidants such as glutathione peroxidase, increase in the level of E-2 prostaglandin, reduction in amplification of the protooncogens and apoptotic programmed cell dead [59, 60].

## 4. Conclusion

Due to the components such as high fibers, prebiotics, unsaturated fatty acids, bioactive peptides, vitamins, minerals and polyphenol compounds, lentils are important functional foods. Lentils have a major role in health improvement and protection against non- communicable diseases. Further investigations as human clinical studies are needed to obtain the optimum dose and duration of lentil consumption in diabetic patients.

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