Pulse Crops for Health

- How is the consumption of pulses linked to the consumption of whole grains?
- Pulses are a rich source of proteins, dietary fiber, complex carbohydrates, resistant starch, and a bevy of vitamins and minerals, such as folate, potassium, selenium, and zinc. They are low in fat and, being a plant food, contain no cholesterol.
- Why is it important to promote and incorporate the consumption of pulses as part of a healthy diet?

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Many consumers try to eat healthier foods, use natural medicines, and make lifestyle changes in the quest to feel good, maintain body weight, reduce the risk of chronic disease, and live healthier, longer lives.

Globally, unhealthy diets and physical inactivity are two of the leading causes of major chronic diseases. According to the World Health Organization (WHO), non-communicable chronic diseases, such as heart disease, stroke, cancer, chronic respiratory diseases, and diabetes, are by far the leading cause of mortality in the world, representing 60% of all deaths (62).

In 2004, the 192 member states of the WHO endorsed the "Global Strategy on Diet, Physical Activity, and Health" (62), addressing these two main risk factors. Countries around the world are monitoring the prevalence of chronic "lifestyle" diseases and developing strategies to treat, prevent, and reduce the incidence of disease in future years. Health professionals are promoting dietary changes, including the increased consumption of plant foods, to combat nutritional deficiencies and chronic disease risk.

One plant food high on the health promotional list is "pulses." Pulses, also known as grain legumes, include many types of common beans, as well as peas, lentils, and chickpeas. The term pulses is limited to crops harvested solely for dry grain and excludes legumes used for oil extraction (soybean and groundnuts) or those harvested green for food (green peas, green beans) (19). Pulses are important food crops in many countries due to their high levels of protein and essential amino acid content.

A Healthy Choice

Legumes are a powerhouse of nutrients. They are a rich source of proteins, dietary fiber, complex carbohydrates, resistant starch, and a bevy of vitamins and minerals, such as folate, potassium, selenium, and zinc. They are low in fat and, being a plant food, contain no cholesterol (Table I).

The 2005 Dietary Guidelines for Americans (54), developed by the USDA, recommend eating 3 cups of legumes (dry beans) per week. The USDA defines dry beans to include beans, lentils, peas, and chickpeas (garbanzo beans). Both Health Canada's Eating Well with Canada's food guide (22) and the USDA's food pyramid (my pyramid) (52) include pulses.

Pulses also contain enzyme inhibitors, lectins, oligosaccharides, polyphenols, phytates, and saponins—also known as antinutritional factors (ANFs)—that affect the digestibility and bioavailability of nutrients in humans and animals (12). The processing of pulses inhibits or reduces the activity of these compounds. In this new

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era of intense bioactive research, these same ANFs are undergoing a reappraisal. Many of the nonnutritive bioactive factors have been found to have positive health effects associated with consumption (14).

The consumption of pulses provides health benefits rivaled by few other foods. Ongoing research is examining how whole pulses, and the individual components, offer protective and therapeutic effects to such chronic health conditions as obesity, cardiovascular disease, diabetes, and cancer (Table II). Eating legumes could potentially let people live longer (16).

Cardiovascular Health

Coronary heart disease (CHD) is the leading cause of death in North America and in most Western countries (3). Nutritional strategies are recognized as an effective and noninvasive approach to manage and reduce the risk of cardiovascular disease. Populations with diets rich in carbohydrates tend to have reduced risk for CHD. It appears that intact fruits, vegetables, pulses, and whole grains are the best sources of carbohydrate most recommended in diets to reduce the risk of CHD (28). These foods have been shown to decrease serum LDL-cholesterol and triglycerides (two major risk factors for CHD), as well as affect other risk factors, such as hypertension, diabetes, and obesity. Epidemiological data suggest that pulse consumption could reduce the risk of cardiovascular disease (5,7,59). Pulses could be considered a heart-healthy food.

In numerous clinical trials, consumption of pulses has shown to significantly reduce serum lipid levels. Total serum cholesterol was reduced by 7%, LDL-cholesterol by 6%, and serum triacylglycerols by more than 17% with no significant changes in HDL-cholesterol in a recent meta-analysis of 11 clinical trials investigating the effects of pulse intake on serum lipids (4). While this effect was primarily attributed to the content of soluble dietary fiber (DF), the cardioprotective effect of pulses could also be due to the synergistic action of the pulse protein, resistant starch, oligosaccharides, vitamins, minerals, and phytochemicals. For instance, the B-vitamin folate has been shown to reduce homocysteine concentrations, where elevated homocysteine levels have been identified as a significant risk factor for increased cardiovascular disease risk (10). Food form also appears to affect the ability of pulses to act as cholesterol-lowering agents. Consuming a diet with whole pulses, compared with a diet containing ground pulses, significantly reduces total cholesterol and LDL-cholesterol (24).

Protein hydrolysates possess antimicrobial, antihypertensive, antioxidant, and immunomodulatory activity. Pea, chickpea, and mung bean protein hydrolysates have shown to have angiotensin-converting enzyme (ACE) inhibitory activity. Since ACE plays a key role in modulating blood pressure, ACE inhibitors, including those derived from pulses, may improve cardiovascular health (2,38,56).

Diabetes

Diabetes mellitus is defined by elevated circulating glucose concentrations in the blood and is associated with an increased risk of heart disease, blindness, kidney disease, and nerve damage (44). In individuals with type 1 diabetes, the pancreas is unable to produce insulin. With type 2 diabetes, individuals either produce too little insulin or are unable to effectively use the insulin produced. Insulin is a hormone that enables the body to control the level of glucose in the blood (13).

Obesity and reduced physical activity are risk factors for the development of type 2 diabetes. A diet consisting of excess energy intakes, high saturated and trans fatty acids, and fiber-depleted refined grain foods is also a contributing factor. Lifestyle intervention programs, involving exercise, weight management, and dietary advice, reduce the incidence of type 2 diabetes (51). Inclusion of pulses in a healthy diet can benefit those with diabetes and help prevent healthy people from becoming diabetic (44).

The glycemic index (GI) of foods is one factor affecting the overall quality of a diet. The GI of a food is a ratio of how much the blood glucose rises after consuming a standard amount of available carbohydrate compared with a standard, either glucose or white bread, assigned a value of 100 (60). Foods can be classified based upon the postprandial glucose response. Consumption of low-GI foods (<55) results in moderate levels of glucose and minor insulin input as opposed to high-GI foods (>70), which cause rapid elevations in blood glucose and insulin. How much the glucose levels rise after the consumption of different foods or a meal is also dependent on the quantity of carbohydrates consumed.

Table I. Proximate composition of dry pulses (g/100 g)[a]

Scientific Name	Common Name	Protein	Carbohydrate	Fiber (total dietary)	Fat	Ash
Lens culinaris	Lentils	25.8	60.1	30.5	1.06	2.7
Pisum sativa	Split peas	24.6	60.4	25.5	1.16	2.7
Cicer arietinum	Chickpeas (garbanzo, bengal gram)	19.3	60.7	17.4	6.04	2.5
Phaseolus vulgaris	Kidney beans	22.5	61.3	15.2	1.06	3.4
	Pinto beans	21.4	62.6	15.5	1.23	3.5
	Navy beans	22.3	60.8	24.4	1.5	3.3
	Black beans	21.6	62.4	15.2	1.42	3.6
Vicia fava	Broadbeans (fava beans)	26.1	58.3	25.0	5.7	3.1

[a]Source: U.S. Department of Agriculture, Agricultural Research Service (52).

Table II. Examples of potential health benefits of nutrients and bioactive factors in pulses

	Weight Management	Cardiovascular Disease	Diabetes	Cancer
Nutrients				
Protein and protein hydrolysates	•	•		
Resistant starch	•	•	•	•
Nonstarch polysaccharides (fiber)	•	•	•	•
Oligosaccharides	•	•	•	•
Folate		•		•
Potassium		•		
Selenium				•
Zinc				•
Bioactive factors				
Protease inhibitors		•		•
Amylase inhibitors	•		•	•
Saponins		•		•
Phytosterols		•		•
Lectins			•	•
Phytates		•	•	•
Phenolic acids (lignans, tannins, flavonoids)	•	•	•	•

Pulses are a low-glycemic food with GI values ranging from 28 to 52 (using glucose as the reference) (6). The low GI is due to the abundance of nonstarch polysaccharides, resistant starch, and oligosaccharides (31). These components delay the gastric emptying rate and slow digestion of starch in the small intestine. A decrease of blood glucose (and insulin) response has also been attributed to phytic acid, lectins, amylase inhibitors, or polyphenol compounds (44).

Hemoglobin (Hb) A_{1c}, a glycolated protein, is used as an indicator of how much glucose is in the blood. Diabetic individuals have higher levels of circulating Hb A_{1c} than nondiabetics. Jenkins et al. (25) showed that a low-GI diet resulted in moderately reduced levels of Hb A_{1c} in the blood. A meta-analysis of 11 studies revealed that low-GI diets resulted in a decrease in mean blood glucose levels, a decrease in Hb A_{1c}, and improved plasma lipid parameters compared with high-GI diets (11). Low-GI diets that include pulses have been found to be effective metabolic stabilizers in type 1 and type 2 diabetic patients (44).

Assessing the benefits of pulses from current nutritional information is difficult due to the relatively low intake of legumes by North American and European populations. Also problematic is the limited number of studies that separately evaluate pulse intake. However, evidence is building to support the role of pulses in the prevention and management of diabetes (55,57). Adding dry beans, dried peas, or chickpeas to diets improved the glycemic and insulin response compared with the ingestion of liquid glucose, brown rice, or potatoes (33,40,46). The intake of vegetables and pulses was associated with a significantly reduced risk of all-cause mortality associated with diabetes (34). While not conclusive, greater legume consumption may be associated with lower body mass index, lower body weights and weight circumferences, and improved satiety as compared with nonconsumers of legumes (36,58). As diabetes is often associated with being overweight or obese, consumption of pulses may be of benefit to type 2 diabetic patients.

In addition to consumption of whole pulses, the bioactive alpha-amylase inhibitor, derived from *Phaseolus vulgaris* species, is used as a starch blocker to control postprandial glucose release in diabetics (8,14). These proteins inhibit the action of those enzymes involved in the digestion and absorption of carbohydrates (20,32).

Consumers appear to understand the importance of dietary fiber in a diet, by increasing whole grain consumption. The similarity of pulse composition (high fiber and complex carbohydrates) to whole grain cereals bodes well for greater promotion and consumption of beans, peas, lentils, and chickpeas in the North American diet.

Cancer

Significant evidence links diets rich in plant foods, including pulses, with a reduced risk of numerous types of cancer (61). Pulses possess many of the nutrients and bioactive factors associated with anticarcinogenic activity: dietary fiber, oligosaccharides, folate, selenium, protease inhibitors, phytic acid, lignans, phenolic acids, saponins, and isoflavones (30).

Epidemiological studies have shown the protective effects of dietary fiber against the development of colorectal cancer (35,43). The relatively high concentrations of dietary fiber (15–30% DF) in pulses, as well as other nonnutritive factors, could contribute to its protective effect. The nondigestible carbohydrates in pulses (insoluble DF, oligosaccharides, resistant starch) are potential prebiotics (29,31), stimulating growth and/or activity of "good" bacteria, such as bifidobacteria and lactobacilli in the colon, resulting in the increased formation of butyrate, a short-chain fatty acid, with demonstrated antitumor and anti-inflammatory activity (27). In addition, pulses, particularly beans, contain a myriad of polyphenols with antioxidant and antimutagenic activities that could inhibit the formation of tumors (9,17,21,45).

Inverse correlations between pulse consumption and colon cancer mortality and risks of prostate cancer, gastric cancer, and pancreatic cancer have been found in various epidemiological studies (23,47,48). A report from the Nurses Health Study (1) indicated that bean or lentil intake is associated with a lower risk for breast cancer. Confirming this observation, researchers (50) found a dose-dependent inhibition of mammary carcinogenesis in rats fed increasing concentrations of dry beans.

Potential anticarcinogenic properties have been noted for some vitamins, protease inhibitors, phytic acid, phytoestrogens, and saponins present in pulses. Pulses are an excellent source of the B-vitamin folate with values ranging from 247 µg/100 g in split peas to 557 µg/100 g for chickpeas (52 53). While still under investigation, folate may play a protective role against colorectal, cervical, breast, and pharyngeal cancers (26,39,41,63). Recently, a new study provided insight into how severe folate deficiencies are associated with changes in DNA in human colonocytes, thus increasing the risk for colon cancer (18).

Pulses grown on selenium-rich soils of the western United States and Canada are good sources of selenium (49). Selenium, primarily due to its potent antioxidant effect, appears to have a protective effect against colorectal, prostate, and lung cancers (37). Pulses are a major source of saponins, found in peas, chickpeas, lentils, and fava beans, as well as in soybeans and peanuts. Saponins have antioxidant effects, exhibit direct and selective cytotoxic action against cancer cells, act as immune stimulants, and also regulate cell proliferation (42). Pea protease inhibitors also show promise as cancer chemopreventative agents (15).

Human clinical trials and ongoing research are investigating and substantiating the role of pulses in cardiovascular disease, diabetes, and cancer. Promoting and incorporating pulses as part of a healthy diet in North America and encouraging increased physical activity could lead to reduced risks of these "lifestyle" diseases, resulting in healthier, more active consumers.

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