Nutritional Benefits of Winter Pulses with Special Emphasis on Peas and Rajmash

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Abstract

Currently, half of the global population is experiencing the severity of nutritional insecurity. In this context, food legumes lie central to the strategies established to combat against the problem of micronutrient malnutrition. Among *rabi* food legumes, peas and rajmash offer a wide range of health benefits which are attributed to their inherent qualities including higher protein content and enhanced concentration of essential nutrients. The health benefits of these two crops are also evident from the fact that a regular supplementation of diets with peas and rajmash helps in reducing the risks associated with coronary heart diseases and cardiovascular health problems. Similarly, higher fibre content in these pulses prevents unreasonable rising of blood sugar level in the human beings. This article outlines the growing importance of peas and rajmash especially in combating global malnutrition with their potential health benefits through consumption and biofortification and also explores the possibilities to shift the dietary pattern/habits to enhance the nutritional status of the population worldwide.

Keywords

Biofortification • Health benefits • Nutritional composition • Peas • Rajmash

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6.1 Introduction

Peas (*Pisum sativum* L.) are one of the important cool season food legume crops in the world with 6.59 million hectares area and 9.83 million tons annual production (FAOSTAT 2013). Peas, more specifically the yellow or green cotyledon varieties, are known as dry peas or field peas and

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are grown around the world for human and animal consumption (Dahl et al. 2012). The dry grains are consumed in various forms such as *soup*, *chat*, *chhola*, *dal*, *stew*, *snacks*, vegetables and flour. Dry pea flour is valued not only as an important dietary protein source but also for its industrial utilization like a thickening agent in certain food industries. Green seeds are used as fresh, frozen or canned vegetables. Pea is among the oldest pulse crops that underwent human-mediated domestication and is recognized as an inexpensive readily available source of protein, complex carbohydrates, vitamins and minerals. The higher nutrient density in dry peas makes them a valuable international food commodity, capable of fulfilling the dietary requirements of millions of undernourished individuals worldwide (FAOSTAT 2011).

Like peas, kidney bean (*Phaseolus vulgaris*) is another important food legume which is popularly known as rajmash, French bean, field bean, wax bean, etc. Rajmash is grown worldwide in different climatic regimes. It is a well-known food legume that is pervasively used globally in the preparation of varieties of dishes, mainly in rice, curries, salads and toppings. In particular, kidney beans are the prime constituents in the Mexican food, which is most popular worldwide. Indeed, like other food legume crops, it is also a potential source of high-quality protein, which offers an easily accessible and affordable alternative to meat or other animal proteins especially concerning the resource-poor people in the developing world. In addition to a source of lysine- and tryptophan-rich protein for human consumption, it also supplements adequate quantities of other important minerals and micronutrients including folate, potassium, iron, manganese, copper and zinc (Kutos et al. 2003; Costa et al. 2006; Singh et al. 2013).

From the human health perspectives, peas and rajmash offer a range of health benefits that are not restricted just to a part of the body but improve the overall health. The extended knowledge of health benefits of peas and rajmash encourages people to use these as integral constituents in daily diets. Taking the above facts into consideration, the present article aims to provide an overview of the potential health benefits associated with pea and rajmash consumption.

6.2 Peas

6.2.1 Nutritional Composition

6.2.1.1 Protein

Given the higher protein content coupled with the absence of major anti-nutritional factors, peas remain one of the most preferred sources of digestible protein for both human and livestock use. However, the protein content of seeds is reported to be influenced by various factors including genetic as well as environmental effects. In general, the protein concentration in peas ranges from 21.2 % to 32.9 % of seed DM (Table 6.1). The majority of proteins in round-seeded peas belong to storage or globulins type, and the rich amino acid profile (particularly high Trp and Lys) of these proteins determines their greater nutritional value (Bourgeois et al. 2011; Boye et al. 2011). Also, it is a good source of arginine, valine and methionine for humans (Tomoskozi et al. 2001).

6.2.1.2 Carbohydrates, Starch and Fibre

Carbohydrates are the major component found in peas and accounting up to 56–74 % of the dry matter. Starch content in peas ranges from 36.9 % to 49.0 % of the seed dry matter. Concerning the elemental composition, pea starch contains 20.7–33.7 % amylase, which imparts higher levels of enzyme resistance and is responsible for slow digestion of starch. The extent to which pea starch is slowly digestible is remarkable. However, to improve the digestibility, various treatments have been reported so far like annealing and heat-moisture treatment and gelatinization of starch that convert it to a rapidly digestible starch (Chung et al. 2009, 2010). Peas are also source of both soluble and insoluble fibre (Table 6.1). The seed coat and cotyledon are the dietary fibre-rich part of seed. The seed coat contains largely water-insoluble polysaccharides, primarily cellulose, whereas

Table 6.1 Nutritional composition of peas and rajmash

S.N.	Component	Concentration (%)	
		Peas (*Pisum sativum* L.)	Rajmash (*Phaseolus vulgaris*)
1	Protein (%N × 6.25)	21.2–32.9	17.5–28.7
2	Total carbohydrates	56–74	54.4–76
3	Starch	36.9–49.0	31.8–45.3
4	Amylose	20.7–33.7	19.9–29.6
5	Total dietary fibre	14–26	23–32
6	Insoluble fibre	10–15	20–28
7	Soluble fibre	2–9	3–6
8	Total lipid	1.2–2.4	2.0
9	Ash	2.3–3.4	3.6–4.28

the cotyledon fibre comprises of polysaccharides, viz. hemicelluloses, pectins and cellulose, that have various degrees of solubility (Reichert and MacKenzie 1982; Guillon and Champ 2002; Tosh and Yada 2010).

6.2.1.3 Minerals and Vitamins

Among the major minerals in peas, potassium (1.04 % of dry, dehulled weight) is the most prominent element, followed by phosphorus (0.39 %), magnesium (0.10 %) and calcium (0.08 %). The quantities of other seven trace minerals are reported as 97 (ppm) iron, 42 ppm selenium, 41 ppm zinc, 12 ppm molybdenum, 11 ppm manganese, 9 ppm copper and 4 ppm boron (Reichert and MacKenzie 1982). Importantly, the high selenium content of peas may be extremely beneficial in those areas where Se deficiency is prominent (Reichert and MacKenzie 1982). Additionally, peas supplement considerable quantity of folate with 101 μg per 100 g (Dang et al. 2000). Likewise, Hedges and Lister (2006) have reported the presence of substantial amount of vitamins in pea, viz. vitamin C, thiamine (vitamin B1) and vitamins B6, B3 and B2.

6.2.1.4 Other Phytochemicals

Like other pulse crops, peas contain a variety of phytochemicals, viz. carotenoids (including lutein and zeaxanthin) and β-carotene, chlorophyll, phenolic compounds, some flavonoids, saponins and oxalates (Campos-vega et al. 2010).

Carotenoids

In addition to carotenoids like xanthophylls, lutein and zeaxanthin that are well documented, peas also contain the carotenes, α- and β-carotene. The carotenoids are a group of yellow-orange-red pigments, and it cannot be synthesized in the human body and hence become available solely as a result of intake either from a plant source itself or product of animal that has consumed that plant source. The interesting point remains the boiled frozen peas have much more β-carotene than is usually found in raw peas, the reason being freezing and boiling processes break down cell structure, thereby releasing the compounds that were previously bound to other components. Interestingly, the concentrations of lutein and zeaxanthin in peas are several folds higher than that of observed in other food legumes (Hedges and Lister 2006).

Phenolics

Phenolics represent a group of over 4000 compounds occurring vastly in the plant kingdom. Among these, the two classes which are found in substantial amount and have immense dietary relevance are flavonoids and phenolic acids. The phenolic compounds are mostly present in the seed coat and cotyledon of peas. Several researchers have noticed enhanced phenolic compounds and their marked antioxidant activity in coloured seed coat (Duenas et al. 2004; Xu et al. 2007; Campos-vega et al. 2010). On the other hand, tannins having very high antioxidant activity property are detected only in dark seed coat (Hagerman et al. 1998). Isoflavones constitute a subgroup of the flavonoid class compounds which is also present in pea in appreciable amount (Hedges and Lister 2006).

Saponins

Saponin is a diverse group of biologically active glycosides distributed widely in the plant kingdom (Curl et al. 1985). A wide range of saponins have been isolated in peas with soyasaponin I being the most predominant (Murakami et al. 2001). Savage and Deo (1989) have noticed the saponin content of green peas as 2.5 g/kg. In a similar way, Daveby et al. (1997) evaluated several varieties of field peas and found that soyasaponin I content ranged from 0.82 to 2.5 g/kg in different varieties. Though saponins are reported to be heat-sensitive and water-soluble compounds (Shi et al. 2004), a short time cooking with minimal water would enable maximum retention of these compounds.

6.2.2 Health Benefits

6.2.2.1 Prevention and Management of Type 2 Diabetes

The high fibre content of peas may mediate the glycaemic response as compared with low-fibre foods having the equal carbohydrate proportions. The quality of both starch and dietary fibre makes peas a low glycaemic index (GI) food, and hence it is beneficial in the prevention and management of type 2 diabetes (Marinangeli et al. 2009). The use of whole peas and fractioned peas flour has been reported to reduce the fasting insulin level by 13.5 and 9.8 %, respectively, compared with baseline (Marinangeli and Jones 2011). Similarly, the bread containing 17 % pea hull fibre was reported to cause significant reduction in glycaemic response (Lunde et al. 2011).

6.2.2.2 Cholesterol Control

The soluble dietary fibre of peas may also be useful in reducing and stabilizing blood cholesterol by means of decreasing the reabsorption of bile acids (Ekvall et al. 2006). The niacin content in peas helps to reduce the production of triglycerides and very low-density lipoprotein (VLDL), which results in less bad cholesterol, increased HDL (good) cholesterol and lowered triglycerides. Saponins are phenolic compound believed to have an advantageous impact on human health particularly in terms of reducing cholesterol level (Daveby et al. 1998). It is considered that saponins usually cause adsorption of bile acids onto the dietary fibre in the intestine, which is subsequently eliminated from the body with the faecal matter. To redress this loss, serum cholesterol is converted by the liver into bile acids, thus lowering levels of cholesterol in the blood (Savage and Deo 1989).

6.2.2.3 Cardiovascular Health

It is well documented that fibre-rich diets are shown to lower blood pressure, improve serum lipid levels and reduce indicators of inflammation (Slavin 2008). Some flavonoids are also beneficial against heart disease because they inhibit blood platelet aggregation and provide antioxidant protection to LDL (Frankel et al. 1993). Peas are a reliable source of omega-3 fats in the form of alpha-linolenic acid (ALA), which is also useful in the prevention and management of cardiovascular health (Singh et al. 2013).

6.2.2.4 Cancer

Antioxidant flavonoids may act to prevent cancer through inducing detoxification enzymes, inhibiting cancer cell proliferation and promoting cell differentiation (Kalt 2001). The predominant flavonoid in peas is quercetin, which is found in the form of glycoside (with an attached sugar molecule). Like other flavonoids, it is also believed to have a number of cancer-combating properties. For instance, it inhibits growth of malignant cells, boosts up self-destruction of the cancerous cells and is also known to interfere with proliferative activities of certain cancer cells. Compared with other legumes, peas contain low levels of isoflavones (Kleijn et al. 2001; Boker et al. 2002). Isoflavones are capable of reducing the risk for hormone-related cancers, since the proliferation of these kinds of cancer cells is oestrogen dependent (Steer 2006).

Saponins are also believed to combat against cancer, by breaking down the cholesterol-rich membranes of cancer cells. Because saponins are not well absorbed into the blood stream, they are thought to be most useful in exerting a localized effect in the intestinal tract, such as fighting colon cancer (Joseph et al. 2002).

6.2.2.5 Weight Management

Lunde et al. (2011) investigated the impacts of a hypoenergetic diet rich with pea fibre and found that consumption of bread enriched with pea fibre resulted in an increased duration of satiety as compared to regular bread.

6.2.2.6 Gastrointestinal Function and Homeostasis

The water-attracting ability of insoluble fibres of peas may assist in reducing the transit time through the gut. This quality of peas fibre is important in prevention of constipation, diverticulitis and bowel cancer. For example, the addition of pea hull fibre in food resulted in a significant increase (7.5–24 %) in bowel movement frequency (Dahl et al. 2003; Flogan and Dahl 2010). Like other legumes, peas have significant amount of raffinose family and other galactose-containing oligosaccharides which may exhibit prebiotic effects in the large intestine (Tosh and Yada 2010; Fernando et al. 2010). Pea proteins in human gastrointestinal tract significantly increase the intestinal autochthonic bacterial population (*Bacteroides, Lactobacillus* and *Bifidobacterium*) leading to an increase in their metabolic activity and production of short-chain fatty acids (SCFA). SCFAs offer several beneficial effects, including generating energy for colonic mucosa. Besides SCFAs provide protection against various diseases of the colon like cancer and prevent the transformation of primary bile acids to cocarcinogenic secondary bile acids by lowering the colonic pH.

6.2.2.7 Antioxidant Activity

Antioxidants cause deactivation of free radicals and other oxidants, thus rendering them harmless. By nature, free radicals are highly unstable molecules that are usually generated in body either as induced from external stimuli (e.g. pollution, smoking, carcinogenic compound) or from internal sources as an outcome of physiological processes. It is important to note that free radicals developed in uncontrolled way can severally damage cell components, thereby impairing vital life processes. For example, antioxidant-led DNA damage often causes cancer, or they oxidize fats in the blood, which ultimately leads to severe health problems like atherosclerosis and heart disease. However, the human body produces antioxidants by its own and it has other defence mechanisms. Antioxidants supplemented to human diets also play a crucial role.

Vitamin C, the carotenoids and various phenolic compounds constitute the major antioxidants found in peas. Phenolic compounds are natural antioxidants that provide protection against many diseases including cancer and various inflammatory-related diseases. By virtue of their chemical properties, they are very efficient scavengers of free radicals and are also metal chelators (Shahidi and Naczk 1995). In addition to the antioxidant characteristics of flavonoids, other potential health-promoting bioactivities include anti-allergic, anti-inflammatory, antimicrobial and anticancer properties (Cody et al. 1986; Harbourne 1993). Antioxidant activity of isoflavones is also known to trigger anticarcinogenic response including inhibition of free radical reactions, cell mutation, cell proliferation and angiogenesis (Steer 2006).

6.3 Rajmash

6.3.1 Nutritional Composition

6.3.1.1 Carbohydrates, Starch and Dietary Fibre

Up to 50–60 % of the dry matter of kidney bean is primarily composed of carbohydrates found in good amounts (Vargas-Torres et al. 2004; Reynoso-Camacho et al. 2006; Ovando-Martinez et al. 2011). Structurally, starch and non-starch polysaccharides constitute the major proportion of carbohydrate together with considerable amounts of carbohydrate derivates such as oligosaccharides (Bravo et al. 1998; Reynoso-Camacho et al. 2006). Amylose and amylopectin are the two major forms of starch available in kidney beans. Dietary fibres are also found in sizeable proportions and comprise of edible parts or plant analogous carbohydrates such as cellulose, hemicellulose, pectins, oligosaccharides and lignins. Collectively these compounds resist digestion and absorption in the small intestine but are eventually fermented (partially or completely) in the large intestine (Hughes and Swanson 1989; Hughes 1991; Costa et al. 2006).

6.3.1.2 Source of Protein

Owing to the presence of high-quality dietary proteins, kidney bean plays an important role in alleviation of human malnutrition by complementing the traditional cereal-based food (Butt and Batool 2010). Nutritionally, kidney beans are equivalent to animal protein with the seed protein content ranging between 17.5 % and 28.7 % (Table 6.1). In contrast to other food legume proteins which generally show low quantities of glutelins (7–15 %), rajmash contains considerably higher amounts of glutelins (20–30 %) (Seena et al. 2005; Slupski 2010). Concerning the protein composition, globulins constitute the major fraction, i.e. up to 50–70 % of total protein. Like other legume proteins, the greater quality of kidney bean protein is attributable to the presence of essential amino acids particularly lysine that is otherwise deficient in cereal-based diets.

6.3.1.3 Lipids

The lipid content in kidney bean is estimated to be up to 2 % (Table 6.1) with valuable composition of unsaturated fatty acids (Mabaleha and Yeboah 2004). Kidney bean is a rich source of polyunsaturated fatty acids consisting of 71.1 g/100 g.

6.3.1.4 Minerals and Vitamins

Compared to cereals, kidney beans have greater levels of micronutrients, viz. minerals and vitamins (Welch et al. 2000). Noticeably, kidney beans have the highest level of mineral content than the other legumes. The levels of iron, zinc, copper, phosphorus and aluminium are appreciable, while other minerals are also present in reasonable amounts (Broughton et al. 2003; Shimelis and Rakshit 2005). The iron content, mostly present in nonheme form, is the highest in beans that ranges from 62.0 to 150 μg/g (Elhardallon and Walker 1992; Vadivel and Janardhanan 2000).

Kidney bean is also considered an important source of vitamins and variations in vitamin concentration are observed (Augustin et al. 2000). It also provides considerable quantities of folate, tocopherols, thiamine, riboflavin, niacin, biotin and pyridoxamine (Broughton et al. 2003; Campos-Vega et al. 2010). Kadam and Salunkhe (1989) have envisaged that the folate content (400–600 μg) of beans is sufficiently high to meet 95 % of the daily requirement.

6.3.1.5 Phenolics Compounds

Given the antioxidant and anticarcinogenic properties of kidney bean phytochemicals, these have a great potential as functional and nutraceutical ingredients (Cardador-Martianez et al. 2002; Dinelli et al. 2006). Phenolic compounds include variety of flavonoids such as anthocyanins, flavonol, proanthocyanidins, tannins, glycosides as well as a wide range of phenolic acids (Beninger and Hosfield 2003; Aparicio-Fernandez et al. 2005).

6.3.2 Health Benefits

6.3.2.1 Cardiovascular Disease

There are plenty of health benefits related to consumption of kidney beans as daily diet since it keeps people healthy in the long run. As reported by Anderson and Major (2002), the higher magnesium content and rich dietary fibres in kidney beans are responsible for lowering blood cholesterol levels and also important in combating against risks of stroke, heart attack and peripheral vascular disease. Magnesium is regarded as nature's own calcium channel blocker. In the vicinity of enough magnesium, the resistance is lessened (within veins and arteries) and it eventually improves the flow of blood, oxygen and nutrients throughout the body. Moundras et al. (1997) observed that dietary fibres facilitate lowering of the cholesterol by restraining the intestinal absorption of neutral steroids, bile acids and total steroid excretions. Resistant starch and dietary fibre content of kidney bean are mainly responsible in the management of metabolic syndrome by delaying the degree of glucose as fuels, changing fat utilization and controlling appetite through increased satiety, thus lowering the risk of cardiovascular diseases (Anderson et al. 2002; Park et al. 2004). It has been reported that intake of 100 % of the daily value (DV) of folate would, by itself, reduce the number of heart attacks. Several epidemiological and clinical studies have portrayed positive effects of kidney bean consumption in reducing the risk of coronary heart diseases and cardiovascular diseases (Finley et al. 2007; Winham and Hutchins 2007).

6.3.2.2 Diabetes Mellitus

The consumption of wholegrain food like kidney bean and other legumes has shown protectiveness, not only in the development of diabetes but also in the management of people suffering from type 2 diabetes mellitus. The ingestion of three or more servings of wholegrain foods per week reduces the risk of diabetes mellitus by 20–35 % (Campos-Vega et al. 2010). The rich fibre content and slow digestibility due to fibre prevent elevated glucose levels leading to reduced insulinemic and glycaemic responses (Zhou et al. 2004; Campos-Vega et al. 2010). Several studies indicate that consumption of low glycaemic index (GI) foods is beneficial in the reduction of diabetes mellitus and obesity (Rizkalla et al. 2002; Jenkins 2007). In addition to lowering cholesterol, kidney beans' high fibre content prevents blood sugar levels from rising too rapidly after a meal, making these beans an especially good choice for individuals with diabetes, insulin resistance or hypoglycaemia. As a high-potassium, low-sodium food, it may also helpful in reduction of blood pressure.

6.3.2.3 Cancer

The fact that the incidence of cancer could be reduced by changing the dietary pattern is well established. Compelling evidences are there suggesting a relation between intake of bean-rich diets and reduced incidence of numerous types of cancer, viz. colon, breast and prostate cancer (Cardador-Martinez et al. 2006; Patterson et al. 2009). The anticarcinogenic activity of beans is related to the presence of resistant starch, soluble and insoluble dietary fibre, phenolic compounds as well as other micro-constituents such as phytic acid, protease inhibitors and saponins (Hangen and Bennink 2003; Patterson et al. 2009). It also contains saponins, which are known to restrict the growth of abnormal crypt foci in the colon (Koratkar and Rao 1997).

6.3.2.4 Source of Energy

Among the food legumes, rajmash serves as an excellent source of energy, since it contains high amount of carbohydrate and iron which are essentially required for increasing body metabolism and energy. Iron helps in the circulation of oxygen throughout the body. Kidney bean can increase energy by helping to replenish iron stores. Mainly for menstruating women, who are more at risk of iron deficiency, boosting iron stores with kidney beans is a good idea – especially because, unlike red meat, another source of iron, kidney beans are low in calories and virtually fat-free. The manganese content in kidney beans also contributes to the production of energy in the human body.

6.3.2.5 Weight Management/Calorie Count

The amount of calorie found in rajmash is moderate and can be eaten by all the age group. Ingestion of kidney beans as a salad or low-calorie soup during lunch will be a good choice. At the same time, it can be used for weight management, since beans α-amylase inhibitor is known to have antiobesity effect as α-amylase inhibitory action to starch digestion causes energy restriction resulting in mobilization of body fat reserves (Obiro et al. 2008).

6.3.2.6 Good for the Brain

This pulse offers outstanding benefits for the brain. It contains appreciable amount of vitamin K which provides essential nutrition for both the brain and nervous system. Kidney beans are also a good source of thiamine or vitamin B1, which is essential for brain cells. It nourishes the brain nerves and cells which prevents age-related disease like Alzheimer's.

6.3.2.7 Improvement in Digestion

The soluble as well as insoluble fibre present in kidney beans help in maintaining healthy bowel movements. If it is eaten in the right quantity, it helps in cleansing the digestive tract. Regular bowel movements are associated with a lowered risk of colon cancer (Costa et al. 2006). Thiamine participates in enzymatic reactions central to energy production and is also critical for brain cell/cognitive function.

6.3.3 Other Benefits

The kidney bean is a very good source of folate as compared to cereals. It may be useful in significant reduction in the incidence of neural defect, some cancer and stroke. In adult a particular type of anaemia can result from long-term folate deficiency. Therefore, the high folate diets and supplemental folic acids may help to overcome the problem. Kidney beans are an excellent source of the trace mineral, molybdenum, an integral component of the enzyme sulphite oxidase, which is responsible for detoxifying sulphites.

6.4 Conclusion

Peas and rajmash are important source of various nutritional components as well as polyphenolic compounds with potential health benefits and antioxidant activity. Despite their high nutritive value, bioavailability may be poor due to high phytate content and some other anti-nutritional factors. However, special emphasis deserves to be placed towards crop-based biofortification and to extend the understanding of the effects of food processing techniques on bioavailability. If phytate is degraded or reduced through biofortification and food processing techniques, both the above said pulses could be considered a significant source of various minerals. Potentially mitigating risks of chronic diseases such as cardiovascular disease, obesity, diabetes and cancer, consuming pea and rajmash could be a cost-effective approach for improving human health. Therefore, strategic scientific research needs to be directed to experimentally verify the available findings and to further explore the potential health benefits of pea and rajmash.

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