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Health benefits of queen of pulse: Pea (*Pisum sativum* L.): A review

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Abstract
Peas, have long been important components of the human diet due to their content of starch, protein and other nutrients. The health benefits other than nutrition associated with pulse consumption have engrossed much interest. The focus of the present review paper is to discuss about the potential health benefits associated with the consumption of peas, Pisum sativum L., specifically green and yellow cotyledon dry peas, also known as smooth peas or field peas. These health benefits are mainly derived from properties of starch, protein, fibre, vitamins, minerals and phytochemicals in peas. Fibre from the seed coat contributes to gastrointestinal function and health, and reduces the digestibility of starch in peas. The vitamin and mineral contents of peas may play important roles in the prevention of deficiency-related diseases, specifically those related to deficiencies of Se or folate. Pea protein, when hydrolysed, may yield peptides with bioactivities, including angiotensin I-converting enzyme inhibitor activity and antioxidant activity. Peas contain a variety of phytochemicals once thought of only as antinutritive factors. These include polyphenolics, in coloured seed coat types in particular, which may have antioxidant and anticarcinogenic activity, saponins which may exhibit hypocholesterolaemic and anticarcinogenic activity, and galactose oligosaccharides which may exert beneficial prebiotic effects in the large intestine.

Keywords: Peas, *Pisum sativum* L, health benefits

Introduction
Pulses are defined by the FAO as legumes harvested solely for their seed which is consumed directly. Peas, more specifically the yellow or green cotyledon varieties known as dry, smooth or field peas, are the naturally dried seeds of *Pisum sativum* L. and are grown around the world for human and animal consumption. A total area of 9.01 lakh hectares and a total production of 8.49 lakh tonnes were recorded. (2017). The major producers being Canada, the Russian Federation, China, the USA and India Food and Agriculture Organization (2011) [9]. In Uttar Pradesh the production of peas is 2,511.38 tonnes. Peas are readily available source of protein, complex carbohydrates, vitamins and minerals. The high nutrient density of peas makes them a valuable food commodity, capable of meeting the dietary needs of the estimated 800–900 million undernourished individuals worldwide Food and Agriculture Organization (2011) [9]. The majority of the US population consumes less than the recommended serving, with only 7·9% of adults consuming dry beans or peas on any given day Mitchell DC *et al*. (2009). Limitations of current research and recommended future directions are discussed to encourage advancement in the field. The purpose of the present paper is to provide a comprehensive review of the demonstrated and potential health benefits associated with pea consumption.

Composition
Carbohydrates
Starch and fibre are major components of peas, 46 and 20% of seed DM, respectively, on average Tzitzikas *et al*. (2006) [22]. Starch is composed of amylose, a linear glucan with few branches, and amylopectin, a larger and more highly branched molecule. Pea starch, like that of most other starchy pulses, contains an intermediate level of amylose, which is reflected in its unique functionality and its higher levels of enzyme-resistant starch and slowly digestible starch as compared with cereal, root and tuber starches, most of which are lower in amylose Hoover *et al*. (2010) [13]. Perera *et al*. (2010) [18] concluded that variety, processing method and analytical methodology all affected starch digestibility, specifically levels of resistant starch, in peas and other pulses. Starch isolated from the same three genotypes consisted of 18·2–23·8,

53·7–59·0 and 8·1–12·6% of rapidly digestible starch, slowly digestible starch and resistant starch, respectively Chung *et al.* (2008) [3]. The effect of treatment on starch digestibility was variety dependent, and with all treatments, gelatinisation of starch converted essentially all of the slowly digestible starch, and in some cases most of the resistant starch, to rapidly digestible starch. The amylose content of pea starch has been reported to vary widely among varieties and mutant lines. Wrinkled pea starch has been reported to contain 76·8% amylose and 4·5–17·7% of resistant starch, as compared with 27·8% amylose and 2·1–6·3% resistant starch in smooth peas, with the concentration of both amylose and resistant starch dependent on variety and the growth environment. Dostalova *et al.* (2009) [6]. Hood-Niefer *et al*. (2012) [12] saw no effect of variety or environment on the amylose content of pea starch. However, this study did not include wrinkled pea varieties. The properties of both their starch and fibre constituents make peas a low-glycaemic index food, and hence beneficial in the prevention and management of type 2 diabetes Trinidad *et al.* (2010) [23]. Peas, like other legumes, contain significant concentrations of raffinose-family and other galactose-containing oligosaccharides.

Protein

Peas are a valuable source of protein for both man and animals. The chemical and physico-chemical characteristics, processing and use of proteins from pulses, including peas, were reviewed recently by Boye *et al*. (2011) [2]. The majority of pea proteins are storage proteins, or globulins, and the amino acid profile of these proteins determines their nutritional value. Boye *et al*. (2011) [2]. The amino acid profiles of all products were similar overall, with the greatest contributions from glutamine, followed by aspartic acid, arginine and lysine, and the lowest contributions from methionine, tryptophan and cysteine. Products from peas tended to be higher in arginine, valine and methionine, and lower in glutamic acid and cysteine, than those from lupin and soyabeans. The *in vitro* digestibility of raw pea protein is reduced by the presence of protease inhibitors, although the digestibility of pea protein has been reported to be higher than that of soyabean and several other pulses Boye *et al*. (2011) [2]. The ability of peas to improve CVD and promote weight loss may be attributable to their high protein content Abete *et al.* (2009) [1]. In that review, the negative physiological and nutritional effects of lectins and protease inhibitors in pulses are described, as are the potential nutraceutical effects of lectins, which include anticancer and immunomodulatory properties. Hydrolysis of pea and other pulse proteins generates peptides with a variety of bioactivities *in vitro*, including angiotensin I-converting enzyme inhibitor activity, which has an antihypertensive effect, and antioxidant activity. Roy *et al.* (2009) [19].

Vitamins and minerals

Gawalko *et al*. (2009) [10] determined that yellow peas from Canada contained higher levels of Fe, Mg and Mn, but lower levels of K, compared with green peas. In another study, Se was found to exceed the maximum residue level established by the People's Republic of China in 56% of the samples analysed. However, Se is considered an essential element, and this maximum residue level value is currently being re-evaluated. The authors suggested that peas produced in Canada may be beneficial for areas of the world where Se deficiency is prominent. Despite the high mineral content of peas, bioavailability may be poor due to high phytate concentrations. A study by Trinidad *et al*. (2010) [23] found that phytate content affected Fe but did not influence Zn and Ca availability in pulses. In fact, these authors concluded that when Fe availability was low, Ca and Zn availability was high. Dang *et al*. (2000) [5] reported that peas contained 101mg folate per 100g. Han & Tyler (2003) [11] determined that the concentration of folate in two yellow pea genotypes grown in six locations in 1 year in Saskatchewan, Canada, ranged from 23·7 to 55·6mg/100g DM, as determined by a microbiological assay; concentrations of folate in two green pea genotypes grown in three locations in each of two growing seasons ranged from 24·9 to 64·8mg/100g DM. Low dietary folate levels have been associated with anaemia and neural tube defects in humans Han & Tyler (2003) [11].

Health Benefits

Glycaemic response and insulin resistance

A study by Marinangeli *et al*. (2009) [16] investigated the use of whole yellow pea flour to create foods with a lower glycaemic index than comparable foods made from whole wheat flour. The results demonstrated that foods made with whole yellow pea flour reduced postprandial glucose responses in individuals and, thus, may have a role in the management of type 2 diabetes. Marinangeli & Jones (2011) [15] compared the use of whole pea flour (WPF) and fractionated pea flour (FPF; pea hulls) on insulin resistance. Homeostatic model assessment of insulin resistance (HOMA-IR), a method used to quantify insulin resistance and b-cell function, revealed that insulin resistance was reduced by 25% in both the WPF and the FPF groups compared with the control group receiving white wheat flour. HOMA-IR showed no difference in b-cell function among groups. Lunde *et al*. (2011) [14] found that bread containing 17% pea hull fibre significantly reduced glycaemic response; however, the fibre breads also contained higher protein.

Gastrointestinal function and homeostasis

Flogan & Dahl (2010) [8] showed that the addition of pea hull fibre to snack foods, in combination with an inulin fibre supplement, provided to children with constipation significantly increased bowel movement frequency; no adverse symptoms were reported. Veenstra *et al*. (2010) [24] investigated the effect of consuming 100g dry weight of peas per d for 4 weeks and found no differences in bowel movement frequency or perceived flatulence, bloating, cramping and intestinal discomfort compared with potatoes, with the exception of increased cramping in the early phase of the treatment with peas. Dahl *et al*. (2003) [4] demonstrated that the addition of 4g pea hull fibre per d resulted in a significant increase in bowel movement frequency in residents of a long-term care facility, particularly in those with the lowest frequency. A study by Swiatecka *et al*. (2010) [21] demonstrated that glycosylated pea proteins may escape enzymic breakdown early in the small intestine and may have an impact on the homeostasis of the large intestine by modulating the activity of the microbiota. Although peas contain potential prebiotic oligosaccharides as well as resistant starch and fermentable fibre, limited research has been carried out on the effects of consumption of peas and pea fractions on gastrointestinal microbiota and related health outcomes. Pea proteins often undergo spontaneous glycosylation during storage and processing due to the high concentration of lysine. Researchers concluded that pea proteins could be used to improve intestinal microbiota homeostasis. Research is needed to explore the potential impacts of consumption of peas and pea fractions on gastrointestinal microbiota and wellness.

Cardiovascular health
Sandstro *et al*. (1994) [20] investigated the effect of fibre preparations made from pea cell wall fibre on cardiovascular health. Fibre-rich diets have been shown to lower blood pressure, improve serum lipid levels and reduce indicators of inflammation. Subjects placed on the pea fibre diet showed a trend for lower postprandial TAG responses compared with subjects on a low-fibre diet matched in macronutrient content. However, no changes were seen in fasting lipid concentrations. In a randomised, cross-over intervention study. Trinidad *et al*. (2010) [23] found no differences in serum total, LDL- or HDL-cholesterol after 2 weeks of consumption of cooked, cooled peas. The failure to affect serum cholesterol may have been due to the short length of follow-up (2 weeks).

Antioxidant activity
Duen *et al*. (2004) [7] confirmed the presence of phenolic compounds in the seed coat and cotyledon of peas. Condensed tannins, which have been shown to have very high antioxidant activity, were detected only in the coloured seed coats. The phenolic compounds were extracted with acetone and methanol, and the liposome system was used to measure antioxidant activity via the extent of peroxidation of phosphatidyl choline. The antioxidant activity in the acetone extract from the coloured seed coats was significantly higher than in the white coat extract. These properties were slightly altered by cooking the seeds for 30, 60 or 90min. More research should be done to investigate the heat stability of polyphenols in peas. Intervention studies are needed to investigate the efficiency of pea antioxidant activity in providing health benefits to humans.

Weight management
Lang *et al*. (1998) showed no effect of pea protein on satiety, 24h energy or macronutrient intakes, or on postprandial plasma glucose and insulin concentrations when compared with egg albumin, casein, gelatin, soya protein and wheat gluten. Lunde *et al. (*2011) [14] found that pea fibre-enriched bread increased duration of satiety, when compared with intake of regular bread. Research is needed to understand how peas specifically may influence weight management, with body weight, BMI or waist circumference as primary endpoints.

Future Scope
Currently there is limited understanding of how food processing methods affect the physiochemical properties of peas, as well as a need for research looking at the effects of various pea fractions (i.e. fibre, protein, starch) on relevant health outcomes. In addition, further research is needed to identify whether different genotypes of peas are more effective in achieving the specific health benefits discussed in the present paper.

Conclusion
The present review briefly describes the nutritional characteristics of peas, along with potential health benefits associated with their consumption. Although some health benefits, such as improved gastrointestinal function and reduced glycaemic index, have been recognised, others require further research.

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