Pea

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Abstract

Pea is a nutritious leguminous crop widely cultivated across the globe, with the potential to withstand freezing temperatures. With 10.53% area under production, India occupies fourth position in area under pea cultivation and 5th in pea production (6.96%). It is one of the most significant agricultural commodities owing to its numerous health benefits. It is utilized in soups, pastas, health foods, breakfast cereals, and processed meats apart from being processed in the form of flour, starch, and pea protein concentrates. Pea seeds also contain pivotal nutrients such as proteins, carbohydrates, vitamins, minerals, as well as fiber. The non-nutrient compounds comprise phenolics such as flavonoids, condensed tannins, and

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simple phenolic compounds in high concentration primarily in the varieties having seed coats with dark color. There is a dearth of data regarding the phenolic profile of pea seed coats, with the available data confined to a few varieties only. The fiber present in the seed coat as well as the cell walls of the cotyledon maintain the gastrointestinal health and functioning as well. The peel or the seed coat of peas strengthens not only the chemical but also physical barrier mechanism of the seeds as well as act as potential cancer-preventive agents.

Keywords

Pea · Flavonoids · Tannins · Health benefits · Antioxidant activity

1.1 Introduction

Botanical name/Common name- *Pisum sativum* (L.)/Garden pea

1.1.1 History

Pisum sativum, commonly known as *garden pea/field pea*, pertaining to family *Leguminosae* has proven to be a boon to ecology owing to its immense contribution in fixation of nitrogen present in the atmosphere as well as serving as a break crop, diminishing the need for external intake (Smykal et al. 2012).

The ancestral origin of this crop is in the Middle East, which subsequently extended toward Europe and North America as well (Barzegar et al. 2015). The wild species *Pisum fulvum* of the genus *Pisum* originated in Lebanon, Jordan, Syria, and Israel, whereas the cultivated species such as *Pisum abyssinicum* find their origin in Yemen and Ethiopia (Ellis et al. 2011). Food and Agriculture Organisation (FAO) has also referred Ethiopia along with western Asia as one of the prime locations of peas diversity, whereas Mediterranean region and South Asia have been designated as the secondary centres (Department of Agriculture, Forestry & Fisheries, South Africa).

Pisum sativum is one of the most ancient domesticated crops (Zohary and Hopf 2000). The consumption of peas dates back to 9500 years, and cultivation dates back to 8500 years (Elzebroek and Wind 2008). The ancient Greek as well as the Roman writers mentioned this crop, but the varieties got acknowledged after the sixteenth century (Simmonds 1976). The widespread cultivation of peas is prevalent in temperate zones (Maxted and Ambrose 2001; Zohary and Hopf 2000). Western Asia has been the first area of cultivation of peas from where it extended to Europe, China, and India. It is one of the most prominent legumes which is cultivated across the globe (Salunkhe and Kadam 1999).

Mature and ripened seeds which are used as unbroken or as dal are utilized in various ways for human consumption. Peas are either grown as single or in combination with cereals to be utilized as green fodder as well as silage (Elzebroek and

Wind 2008). Due to their rapid growth and nitrogen contribution to the soil, these are cultivated in the form of green manures and crops which are meant for enriching the soil (Ingels et al. 1994). The consumption of peas is also prevalent as roasted, boiled, and split dal in some parts of the world (Aggarwal et al. 2015).

1.1.2 Production (India, World)

The production of *Pisum sativum* is mainly prevalent at higher altitudes in temperate regions in cold weather in the world (Elzebroek and Wind 2008). Pea peel is considered as a significant agricultural waste (Rehman et al. 2015). The annual production of pea was 57,000 tons in 2010–2011 (Pakistan economics survey 2010). The first cultivation of peas took place in Western Asia followed by Europe, China and India (Department: Agriculture, Forestry & Fisheries, South Africa). Yellow field peas are prominently grown in western Canada, which makes Canada as one of the leading exporters in the world (Wang et al. 2003). Peas can be grown on various types of soils out of which fertile sandy loam soils which are well irrigated are considered the best one for the crop. Globally, pea ranks third most prominent pulse crop after dry bean and chickpea. Along with this, it is also positioned at the third place in terms of the most significant rabi pulse of India after chickpea and lentils. One of the most important global commodities is the yellow field pea seed (Pulse Canada 2009). In 2007–2008, Canada held the top-most position in production and export of dry pea stock, with a credit of around 30% production on annual basis in the world (Agriculture and Agri-Food Canada 2009).

There is an extensive consumption of peas (*Pisum sativum* L.) and broad beans (*Vicia faba* L.) in the entire world, with a production of 8.3 and 3.6 million tons of peas and broad beans in 2008, respectively (http://faostat.fao.org/site/567/default.aspx#ancor). The by-products of these two legumes were approximated to be 67% and 70%, respectively (Basterrechea and Hicks 1991). The harvesting process has been estimated to produce 5.6 and 2.4 MT of by-products of pea and broad bean, respectively. These by-products generated from several agro-industries can be promising ingredients to serve as functional or bioactive components (Mateos-Aparicio et al. 2012). Pea mainly grows in the temperate climatic regions, being consumed in the form of either a legume or vegetable across the globe in order to satisfy human consumption and animal fodder as well (Upasana and Vinay 2018).

The most prominent pea-producing countries are India, France, Russia, Canada, China, and United States of America (Food and Agriculture Organization 2012). As far as the United States of America is concerned, peas are grown primarily in Montana, North Dakota, and Washington (USDA-National Agricultural Statistics Service 2011). India holds the second place in the world in the production of vegetables, with credit of 40 million tons and area of 4 million hectares (Singla et al. 2006). India occupies an area of 10.53% and production is 6.96% which gives it 5th rank in pea prodution in the world (FAO Stat. 2014). The major pea-producing state in India is Uttar Pradesh, which alone produces about 49% of pea produced in India along with Bihar, Madhya Pradesh, and Maharashtra as the other major pea-producing states (DES, 2015–2016). In India, the area under green peas increased at a constant rate from 1,777,000 hectares in 1991–1992 to 2,726,000 hectares in 1999–2000, respectively (Singla et al. 2006).

India stands next to China as far as the production of green peas is concerned (Adeyeye 2002). It is a salient leguminous crop in the world. The origin of this crop was in the Middle East, followed by its cultivation in North America along with Europe. FAO statistics has reported that in the year 2013, the green pea production in the world was 18.5 million tons approximately (Safaryan et al. 2016). The prominent countries leading in green pea production are India, the United States, China, France, and Algeria (FAO 2016). According to historical Roman and Greek authors, the cultivation of this crop was primarily carried out for serving as a pulse and a fodder crop (Department: Agriculture, Forestry & Fisheries, South Africa).

Peas and other leguminous crops are utilized in crop rotations owing to the fact that they help in improving soil microbe diversity, breaking up pest cycles, providing nitrogen, improving soil assemblage, and in the conservation of soil and providing economic diversity as well (Chen et al. 2006). There are various types of peas which are meant for serving various purposes. The harvesting of garden peas is done before the seed attains maturity for fresh-pack market (Elzebroek and Wind 2008). The inner pod fiber is absent in snow peas as well as in sugar snap peas, and they also undergo harvesting prior attaining maturity for fresh-pack market (McGee 2012). In countries like Africa, garden pea and sugar pea are regarded as exotic plants, with the former consumed more in Anglophone countries whereas the latter more in Francophone countries (Department: Agriculture, Forestry & Fisheries, South Africa).

The production of green peas has significantly enhanced to 3.20 million tons in 2003–2004 from 1.30 million tons in 1991–1992 (www.fao.org). In 2008, around 8.3 million tons of peas were produced in the world. Peas (*Pisum sativum* L.) have widespread consumption and production all over the world (FAO Statistical Yearbook 2014). Peas can be grown on all kinds of soils, except heavy soils, with an optimum pH range of soils ranging between 6.0 and 7.5 and temperature for optimum germination of peas is 18–22 °C, whereas seed germination decreases at temperature of 25 °C and above (Singh and Dhall 2018).

Pea is a significant cool-season and nutritious leguminous vegetable that has widespread cultivation in the entire world. As of now, this crop is seen in all temperate countries as well as in most tropical highlands (Department: Agriculture, Forestry & Fisheries, South Africa). In India, the cultivation area occupied by peas is 459,000 hectares, which makes it up to 21% production of the world, out of which Punjab being the fifth in pea production in India and accounts for 6.7% of India's production (Singh and Dhall 2018).

1.1.3 Botanical Description

Pisum sativum is a perennial member of the legume family (Fabaceae) (Aggarwal et al. 2015). It is a leguminous crop having a taproot system with lean, hollow, and succulent stem (Department of Agriculture, Forestry & Fisheries, South Africa). It is an annual vine with a soft appearance which can go up to 9 feet long. The stem of the pea plant is hollow one and anchoring is required to climb the taller cultivars (Elzebroek and Wind 2008). The flowers exhibiting various colors ranging from white, red, or purple undergo the process of self-pollination, with cylindrical pods comprising 5–11 seeds (Department of Agriculture, Forestry & Fisheries, South Africa). The top-most petal, the two petals smaller in size in the center which are fused together, and the two petals in the bottom are referred as a "standard," "keel," and the "wings," respectively (Elzebroek and Wind 2008). The shape of the ripened or mature pea seeds can be round or wrinkled and exhibit wide variations in color ranging from red, yellow, green, beige, blue-red, dark violet, to black (Pavek 2012).

Botanically, it is categorized as a fruit-bearing seeds developed from the ovary of the flower with a life span of 1 year (Saha et al. 2014). Garden peas being erect have a plant height of 30 cm, whereas field peas having a tendency to climb can be of a height of 75 cm (Department of Agriculture, Forestry & Fisheries, South Africa). Despite the fact that it is botanically a fruit, yet it is utilized as a vegetable for cooking purpose (Aggarwal et al. 2015). Garden pea bears white flowers and seeds can be round or wrinkled with their seed color as green or yellow, whereas field pea (*Pisum sativum* var. *arvense*) bears purple or other colored flowers with round seeds (Singh and Dhall 2018).

1.2 Antioxidant Properties and Characterization of the Chemical Compound(s) Responsible for Antioxidant Properties

Plants are regarded as one of the most valuable sources of natural antioxidants, mainly comprising the compounds which belong to the class of end product of secondary metabolism, including a handful of phenolic compounds (Stanisavljevic et al. 2015). Legume seeds are also nutritionally dense in starch, protein, dietary fiber, fatty acids, and micronutrients (Troszynska and Ciska 2002). The chemopreventive action of legumes has been acknowledged as the driving force for the analysis of their bioactive compounds and their action mechanism which could act as a boon in cancer research (Stanisavljevic et al. 2016). Due to ever-increasing interest in the consumption of food-derived antioxidants, thorough investigations are being carried out in order to explore the antioxidative value of legumes and beans as well (TroszynHska et al. 2002).

There are various bio-active compounds such as polyphenols present in the seed coat which act as potent antioxidants protecting against oxidative damage (Osawa et al. 1985). Over the years, the phenolic contents as well as the antioxidant profile of raw and processed pea seeds have been extensively studied (Han and Baik 2008). These polyphenolics exhibit tremendous reducing power as well as free-radical scavenging activity which makes the by-products of legumes such as broad beans and peas a sustainable source of valuable ingredients (Mateos-Aparicio et al. 2011). There is no dearth of the literature highlighting the phenolic and other antioxidative compounds present in pulse hulls (Amarowitcz et al. 2005; Troszynska and Ciska 2002). The antioxidative potential of pea grains and pea pods is reported to be due to various amino acids as well as ring compounds (Saha et al. 2014).

It is the seed coats which play a major part to strengthen the chemical and physical barrier system of the seeds as they get exposed to oxidative deteriorative phenomena such as oxygen, ultraviolet light, and various other environmental factors (Chaudhary et al. 2015). The seed coats of peas are embedded with rich polyphenolic compounds, which have led to their vast exploitation (Innocentini et al. 2009) as well as ensuring cost-effective way for their utilization (Stanisavljevic et al. 2016).

Many studies have highlighted the chemopreventive and therapeutic values of seed coats of peas verified on animal models (Sanchez-Chino et al. 2015). The hulls of peas and lentils have been well evaluated for total phenolic content (TPC) as well as in vitro antioxidant potential (Oomah et al. 2011). The antioxidative values of pea hulls are attributed to flavones, flavonols, and pro-anthocyanidins whereas flavonoid catechin is responsible for the antioxidative value of cotyledon of pea (Duenas et al. 2006). The seed coats of peas are enriched in condensed tannins such as hydroxybenzoic and hydroxycinnamic acids besides luteolin, flavonols, flavones, apigenin, quercetin, kaempferol, and stilbenes (Stanisavljevic et al. 2016).

Matscheski et al. (2006) analyzed the escalation of cells apart from the synthesis of progesterone in trophoblast tumor cells and concluded that seeds of both the green and yellow pea exhibited high levels of isoflavones apart from promising phytoestrogens that have the potential to reduce in vitro multiplication and production of progesterone in trophoblast tumor cells.

Mateos-Aparicio et al. (2010) evaluated the polyphenolic content of broad bean pods and pea pods and reported that the extractable polyphenols were significantly greater in former (30.8/kg) than in latter (4.2/kg). However, the antioxidant activity measured as ferric reducing antioxidant power (FRAP) was also significantly greater in pods of broad bean than pea. The polyphenols extracted also exhibited high reducing power and free-radical scavenging attribute.

Aggarwal et al. (2015) investigated the antioxidant activity of the ethanolic extract of *Cajanus cajan and Pisum sativum* determined by FRAP method. The maximum antioxidant power (5.86 μM) in peas was shown by ethanolic extract at a concentration of 25 μg and increased with the increase in extract weight. Duenas et al. (2004) reported the presence of phenolics prevalent in the seed coats of two pea varieties bearing dark color. The major compounds detected in the seed coat were glycosides of flavones, tetrahydroxy dihydrochalcone, flavonols, and hydroxybenzoic acids. It was also observed that the composition of the seed coats produced a huge impact on the phenolic profiles.

In a significant study by Amarowicz and Troszyñska (2003), extraction of phenolic compounds and tannins from pea seeds was done with aqueous acetone (80) and water–acetone (1:1; v/v) as mobile phases (Table 1.1). The antioxidant and antiradical characteristics of the phenolic compounds in extract were evaluated. The major phenolic compounds detected in the crude extract were *p*-coumaric, caffeic, ferulic, quercetin, vanillic, sinapic acids, and kaempferol. Total antioxidant activity

Table 1.1 Various phenolic compounds and their content in crude extract of peas

Phenolic compounds	Content [mg/g]
Vanillic acid	0.07
Caffeic acid1	0.02
p-Coumaric acid1	0.06
Ferulic acid1	0.32
Sinapic	0.07
Quercetin2	0.14
Kaempherol2	0.51
Procyanidin B2	3.85
Procyanidin B3	3.22

Source: Amarowicz and Troszyñska (2003)

of tannin fraction, extract, and fraction I came out to be 2.48, 0.30, and 0.22 μmol Trolox/mg, respectively. Fraction II exhibited the highest total phenolics (113 mg/g).

Stanisavljevic et al. (2015) investigated the phenolic content of seed coats in four varieties of pea with different colors (*Pisum sativum* L.). The compounds detected were hesperetin, rutin, galangin, naringin, rosmarinic acid, and pinocembrin along with 10 flavonol glycosides. The maximum antioxidant activity and total phenolic content were exhibited by genotypes MBK 168 and MBK 173 having dark color. The antioxidant activities as well as the amino acid profile of peptide fractions of a pea protein hydrolysate were evaluated. Higher contents of hydrophobic apart from aromatic amino acids were observed in the fractions that eluted later from the column in comparison to the ones that eluted early (Pownall et al. 2010).

Saha et al. (2014) conducted a chromatography technique for the analysis of *Pisum sativum*, which reported that both the pea pod and pea cotyledon comprised of equal amounts of antioxidants and bioactive compounds. In the evaluation of antioxidant potential of spinach, peas, and sweetcorn, Bajcan et al. (2013) estimated the highest antioxidant activity in sweet corn (0.970 mmol Trolox/g), whereas the lowest activity was found out in peas. On the contrary, the total polyphenol content was found the highest in spinach (285.1 mg GAE/kg), whereas peas exhibited the lowest one.

In a pivotal work, pea peels, flaxseed, and aloe vera peels were analyzed for their antioxidative properties. The total phenolic content, total flavonoid content, and antioxidant activity was exhibited at the highest level by flaxseed at extraction temperature of 60 °C, ethanol concentration (70%), and extraction time of 120 min and at pH 4–6. Similarly, pea peels were reported to exhibit the highest total phenolic content, total flavonoid content, and antioxidant activity at methanolic concentration of 90%, extraction time of 75 min, extraction temperature of 40 °C and pH 2–4, whereas aloe vera peels exhibited maximum total phenolic content, total flavonoid content, and amino acid content at methanolic concentration (90%), extraction time, extraction temperature, and pH of 60 min, 60 °C, and pH 8, respectively (Chaudhary et al. 2015).

Hadrich et al. (2014) identified the antioxidant as well as antimicrobial components of pea peel. The total phenolic content, total flavonoid content of peel

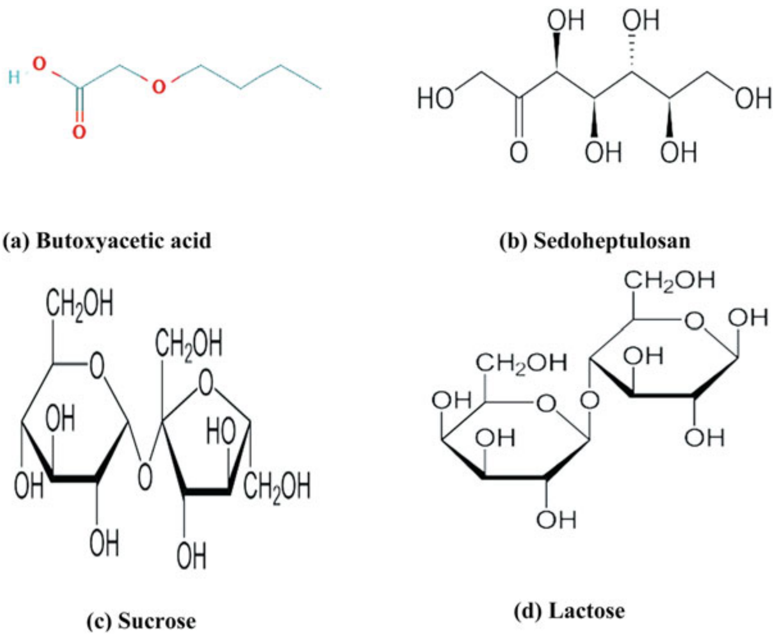

Fig. 1.1 Compounds reported in grains of *Pisum sativum*. (Source: Saha et al. 2014)

extract of peas, aqueous extract, methanolic extract, and ethyl acetate extract as well was evaluated to estimate the antioxidative value. It was reported that the ethyl acetate extract exhibited the highest antioxidant activity. The total polyphenolic content, total flavonoid content, and antimicrobial activities of crude aqueous extract, a methanolic extract, and an ethyl acetate extract were evaluated. The antioxidant potential of the extracts was reported to be fairly high.

Saha et al. (2014) evaluated the antioxidant potential of *Pisum sativum* and found a wide range of bioactive compounds in pod as well as cotyledons (Figs. 1.1 and 1.2). There is less work reported on the phenolic compounds which impart anticarcinogenic and antioxidant properties to pea seed coat extracts. The anticarcinogenic potential of the extracts of pea seed coat and in vitro cytotoxic activity was evaluated on selected human was described by the method of Singleton and Rossi (1965).

The antibacterial activities of skin and seeds of *Pisum sativum*, juices of leaves and stem of *Mentha piperita*, and skin and pulp of *Momordica charantia* were evaluated for various species of Gram-negative bacilli: *Escherichia coli*, *Klebsiella pneumoniae*, *Pseudomonas aeruginosa*, *Salmonella typhi*, *Salmonella paratyphi A*, *Salmonella paratyphi B*, *Proteus mirabilis*, *Proteus vulgaris*, *Enterobacter aerogenes*, *Shigella dysenteriae*, and *Yersinia enterocolitica*. The highest antibacterial activity was exhibited by leaves of *M. piperita* while the stem was reported to have least antibacterial activity. A fairly high level of antibacterial

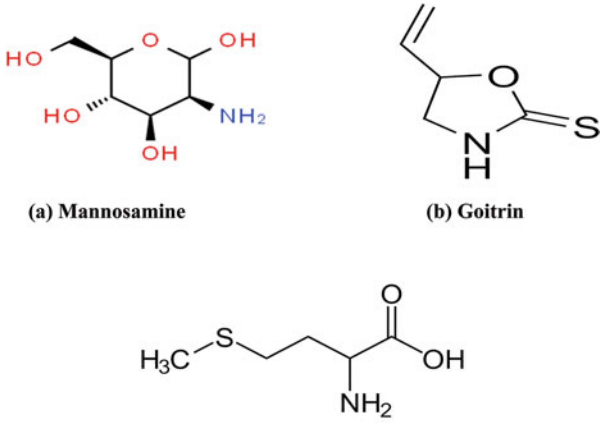

Fig. 1.2 Compounds reported in pods of *Pisum* sativum. (Source: Saha et al. 2014)

activity was reported by skin and seeds of *P. sativum* as well as skin and pulp of *M. charantia* (Saeed and Tariq 2005).

The phytochemical profile including the antioxidant activities and antimicrobial activities of peas extracts prepared with *Debaryomyces hansenii* were analyzed. Flavonoid content was detected at low level whereas the antioxidant and antimicrobial activities was high. The remarkable antibacterial and antifungal potential of the fatty acid extracts of peas inhibited several microbes. The extracts were reported to be less effective against *Escherichia coli*, *Staphylococcus aureus*, and *Candida albicans*. The fatty acid extract of peas prepared with *Debaryomyces hansenii* inhibited the growth of *Bacillus megaterium* and *Escherichia coli*. The peas extracts containing *Debaryomyces hansenii* also exhibited antifungal activity (Erecevit and Kirbag 2017).

1.3 Health Benefits

In accordance with history, *Pisum sativum* has been an integral component of the diet of human beings owing to their cheap cost, ready availability, and high nutritional constitution (Martens et al. 2017). The protein content and starch content of peas varies between 15.5–39.7% and 36.9–48.6%, whereas amylase content is 34% of seed weight in peas. The two main limiting amino acids in peas are methionine and cystine. Fresh and frozen form of peas are an adequate source of pivotal vitamins such as thiamine (vitamin B_1), ascorbic acid (vitamin C), folic acid along with protein and fiber as well (Erecevit and Kirbag 2017). These are also the storehouse of biologically active ingredients that impart health and therapeutic effects primarily decrease in LDL-cholesterol and prevention of degenerative diseases like coronary heart disease and various types of cancer (Roy et al. 2010). The various significant nutritional requirements are supposed to be met by the extract obtained from pea owing to high amount of dietary fiber and other nutrients

Table 1.2 Nutritional value of garden pea (per 100 g fresh weight basis)

Nutrient	Value
Energy	81 Kcal
Protein	5.4 g
Carbohydrates	14.5 g
Dietary fiber	5.1 g
Fat	0.4 g
Vitamin A equiv.	38 μg
Beta-carotene	449 μg
Lutein and zeaxanthin	2593 μg
Thiamine (Vit. B1)	0.3 mg
Riboflavin (Vit. B2)	0.1 mg
Niacin (Vit. B3)	2.1 mg
Pantothenic acid (Vit. B5)	0.1 mg
Vitamin B6	0.2 mg
Folate (Vit. B9)	65 μg
Vitamin C	40.0 mg
Calcium	25.0 mg
Iron	1.5 mg
Magnesium	33.0 mg

Source: Dahl et al. (2012)

(Mateos-Aparicio et al. 2010). Peas with high fiber content is also an abundant source of prebiotics (Erecevit and Kirbag 2017).

The nutritive value of pea is very high, comprising of carbohydrates; fats; digestible proteins; pivotal minerals such as calcium (Ca), phosphorus (P), and magnesium (Mg); and vitamins such as A, B, and C (Dahl et al. 2012) (Table 1.2). These are an inexpensive source of essential amino acids such as tryptophan and lysine, soluble and insoluble fiber, complex carbohydrates, vitamins and minerals like iron, potassium, and calcium, as well as overall digestible nutrients (86–87%) without sodium as well as fat content (Tiwari and Singh 2012). Apart from this, these are also abundant in sulfur-rich amino acids (Wang et al. 2003).

The protein content of peas varies between 15% and 35% with high level of the essential amino acids such as tryptophan and lysine (Elzebroek and Wind 2008). There is an ever-increasing demand for pea starches and flours to be utilized in extruded food products, crackers, frozen foods, cookies, and soups as well. In addition to high quality protein, starch, vitamins, minerals, and dietary fiber, peas also comprise of numerous phytochemicals and bioactive compounds safeguarding health (Martens et al. 2017).

Yellow field peas also serve as a great storehouse of protein isolates, starches, fiber ingredients apart from abundant source of protein, starch, vitamins, and minerals which can be of immense aid in designing health and diet foods (Agboola et al. 2010). The amino acid profile of pea proteins can be fairly compared to that of other legumes (Iqbal et al. 2006). The gastrointestinal health and fiber of the seed coat contribute heavily in the starch digestibility in peas. The transitional amylose potential of starch in pea is reported to be credited for lowering down the glycemic index as well as digestibility of starch (Dahl et al. 2012).

The by-products obtained from broad beans and peas are some of the richest sources of insoluble dietary fiber and moreover they are also rich in arabinogalactans, galactans, xylo-oligosaccharides, and other oligosaccharides (Mateos-Aparicio et al. 2012). Other pivotal sources of dietary fiber powders are carrot pomace, orange waste, peels of potato, and green pea (Sharoba et al. 2013).

1.3.1 Health Effects of Pea Hull Fiber

During 2008, peas produced around 67% of the by-products (Basterrechea and Hicks 1991), yielding around 5.6 million tons of by-products which played an outstanding role as functional ingredients from agro-industries (Mateos-Aparicio et al. 2011). Pea peels are produced enormously as a waste to be utilized in the form of cattle feed (Babbar et al. 2014). The by-products of peas are known to be potentially abundant source of insoluble dietary fiber (Mateos-Aparicio et al. 2010). Due to the presence of significant nutrients and dietary fiber, the various functional components in this crop have been acknowledged to serve as a prominent source of food additive (Mateos-Aparicio et al. 2010). The fiber of the pea hull is composed of dietary fiber along with polyphenols and isoflavonoids, which help in curbing cardiovascular and other chronic diseases related to metabolic disorders such as diabetes (Martens et al. 2017).

Pulse hulls comprise maximum proportion (89%) of the dry matter forming dietary fiber derived from natural origin (Dalgetty and Baik 2003). Pea hulls constitute soluble and insoluble dietary fibers, with former in less proportion than the latter (Martens et al. 2017). Fitzpatrick (2007) acknowledged the beneficial effects of pea hull fiber on the health of the intestines in elderly persons. The excellent bulk, bland taste, low energy content, and fermentation tendency in pea hull have been reported to influence the fiber content in dietary patterns of human beings (Martens et al. 2017). The pods of green pea are also a great source of waste material of biological origin along with the polysaccharides obtained from them paves the way for the production polysaccharide of natural origin (Safaryan et al. 2016).

Pea hull fiber has its utilization in food as well as in feed industry to a considerable extent. In addition, it also finds its expansive usage in technological applications by improving fiber content in bakery products, pasta, and sausage production as well (Singh et al. 2008).

1.4 Conclusion

Pisum sativum is one of the most pivotal sources of proteins for both humans as well as animals. It is acknowledged as an integral part of human diet owing to rich nutrient profile, ready availability, and cost-effectiveness. Pea peels are also an abundant storehouse of active ingredients acting as antioxidants such as phenols and flavonoids. These peels are primarily utilized in the production of various value-added products and animal feed. The fibrous part of hull is a promising source of dietary fiber delivering various functional attributes. In addition to this, peas are also well known for imparting protection against free radical scavenging by virtue of the phenolic compounds. These pea polyphenols have significant reducing power as well. Much work has been cited in the literature so far exploring antiradical and antioxidative value of pea seeds.

References

Adeyeye EI (2002) Determination of the chemical composition of the nutritionally valuable parts of male and female common West African freshwater crab (Sudananautes africanus africanus). Int J Food Sci Nutr 53:189–196

Agboola SO, Mofolasayob OA, Wattsb BM, Aluko RE (2010) Some functional properties of yellow field pea (*Pisum sativum* L.) seed flours and the *in vitro* bioactive properties of their polyphenols. Food Res Int 43(2):582–588

Aggarwal A, Nautiyal U, Negi D (2015) Characterization and evaluation of antioxidant activity of *Cajanus cajan* and *Pisum sativum*. Int J Rec Adv Sci Tech 2(1):21–26

Agriculture and Agri-Food Canada (2009) Bi-weekly bulletin – dry peas: situation and outlook. Accessed from: http://www.manitobapulse.ca/pdf/market_report-DryPeasBulletin.pdf. Acessed on 1 Apr 2020

Amarowicz R, Troszyñska A (2003) Antioxidant activity of extract of pea and its fractions of low molecular phenolics and tannins. Polish J Food and Nutr Sci 12(53):10–15

Amarowitcz R, Troszynska A, Barylko-PikIelna N, Shahidi F (2005) Polyphenolics extracts from legume seeds: correlations between total antioxidant activity, total phenolics content, tannins content and astringency. J Food Lipids 11(4):278–286

Babbar N, Oberoi HS, Sandhu SK, Bhargav VK (2014) Influence of different solvents in extraction of phenolic compounds from vegetable residues and their evaluation as natural sources of antioxidants. J Food Sci Technol 51(10):2568–2575

Bajcan D, Tomas J, Uhlirova G, Árvay J, Trebichalsky P, Stanovic R, Simansky V (2013) Antioxidant potential of spinach, peas, and sweet corn in relation to freezing period. Czech J Food Sci 31:613–618

Barzegar M, Zare D, Stroshine RL (2015) An integrated energy and quality approach to optimization of green peas drying in a hot air infrared-assisted vibratory bed dryer. J Food Eng 166:302–315

Basterrechea M, Hicks JR (1991) Effect of maturity on carbohydrate changes in sugar snap pea pods during storage. Sci Hort 48:1–8

Chaudhary K, Agarwal M, Abid M, Chauhan VS, Ali Khan MMA, Naqvi MS, Panwar P, Maheshwari RK (2015) Experimental optimization of extraction conditions of phenolic compounds from Flaxseed, Pisum peel, Aloe vera peel. J Biol Chem Res 33(1):1–23

Chen C, Miller P, Muehlbauer F, Neill K, Wichman D, McPhee K (2006) Winter pea and lentil response to seeding date and micro- and macro-environments. Agron J 98:1655–1663

Dahl WJ, Foster LM, Tyler RT (2012) Review of the health benefits of peas (*Pisum sativum* L.). Br J Nutr 108(Suppl 1):S3–S10

Dalgetty DD, Baik BK (2003) Isolation and characterization of cotyledon fibers from peas, lentils, and chickpeas. Cereal Chem 80(3):310–315

Dhall RK (2017) Pea cultivation. Punjab Agricultural University, PAU Printing Press, Ludhiana, Bulletin No. PAU/2017/Elec/FB/E/29

Duenas M, Hernandez T, Estrella I (2004) Occurrence of phenolic compounds in the seed coat and the cotyledon of peas (*Pisum sativum* L.). Eur Food Res Technol 219:116–123

Duenas M, Hernández T, Estrella I (2006) Assessment of in vitro antioxidant capacity of the seed coat and cotyledon of legumes in relation to their phenolic contents. Food Chem 98:95–103

Ellis THN, Hofer JI, Timmerman-Vaughan GM, Coyne CJ, Hellens RP (2011) Mendel, 150 years on. Trends Plant Sci 16:590–596

Elzebroek T, Wind K (2008) Guide to cultivated plants. CAB International, Oxfordshire

Erecevit P, Kirbag S (2017) Determining the phytochemical parameters of *Pisum sativum* (peas) and effects on the development of *Debaryomyces hansenii*. Indian J Pharm Educ Res 51(4S): S637–S644

FAO Statistical Year Book (2014) Asia and the Pacific Food and Agriculture Accessed from: http://www.fao.org/3/a-i3590e.pdf. Accessed on 17 Apr 2020

FAO. Browse Data-By Doman (2016) Accessed from: http://faostat3.Fao.Org/browse/q/qc/e. Accessed on 15 Apr 2020

Fitzpatrick K (2007) Novel fibers in Canada: regulatory developments. Cereal Foods World 52 (1):22–23

Food and Agriculture Organization (2012) Accessed on: http://faostat.fao.org. Accessed 24 Apr 2020

Hadrich F, El Arbi M, Boukhris M, Sayadi S, Cherif S (2014) Valorization of the peel of pea: *Pisum sativum* by evaluation of its antioxidant and antimicrobial activities. J Oleo Sci 63 (11):1177–1183

Han H, Baik B (2008) Antioxidant activity and phenolic content of lentils (*Lens culinaris*), chickpeas (*Cicer arietinum* L.), peas (*Pisum sativum* L.) and soybeans (Glycine max), and their quantitative changes during processing. Int J Food Sci Tech 43:1971–1798

Ingels CM, VanHorn RL, Bugg Miller PR (1994) Selecting the right cover crop gives multiple benefits. Calif Agric 48(5):43–48

Innocentini MDM, Barizan WS, Alves MNO, Pisani R Jr (2009) Pneumatic separation of hulls and meats from cracked soybeans. Food Bioprod Process 87:237–246

Iqbal A, Khalil IA, Ateeq N, Sayyar KM (2006) Nutritional quality of important food legumes. Food Chem 97:331–335

Martens LG, Nilsen MM, Provan F (2017) Pea Hull fibre: novel and sustainable fibre with important health and functional properties. EC Nutr 10(4):139–148

Mateos-Aparicio I, Redondo-Cuenca A, Villanueva-Suarez MJ (2010) Isolation and characterisation of cell wall polysaccharides from legume by-products: Okara (soymilk residue), pea pod and broad bean pod. Food Chem 122:339–345

Mateos-Aparicio I, Redondo-Cuenca A, Villanueva-Suarez MJ (2011) Broad bean and pea by-products as sources of fibre-rich ingredients: potential antioxidant activity measured in vitro. J Sci Food Agric 92(3):697–703

Mateos-Aparicio I, Redondo-Cuenca A, Villanueva-Suarez MJ (2012) Broad bean and pea by-products as sources of fibre-rich ingredients: potential antioxidant activity measured in vitro. J Sci Food Agric 92:697–703

Matscheski A, Richter DU, Hartmann AM, Effmert U, Jeschke U, Kupka MS, Abarzua S, Briese V, Ruth W, Kragl U, Piechulla B (2006) Effects of phytoestrogen extracts isolated from Rye, green and yellow pea seeds on hormone production and proliferation of trophoblast tumor cells Jeg3. Horm Res 65:276–288

Maxted N, Ambrose M (2001) Peas (*Pisum* L.). In: Maxted N, Bennett SJ (eds) Plant genetic resources of legumes in the Mediterranean, Current Plant Science and Biotechnology in Agriculture, vol 39. Springer, Dordrecht

McGee R (2012) USDA-ARS. Personal communication

Oomah BD, Caspar F, Malcolmson LJ, Bellido AS (2011) Phenolics and antioxidant activity of lentil and pea hulls. Food Res Int 44:436–441

Osawa T, Ramarathnam N, Kwakishi S, Namiki M, Tashiro T (1985) Antioxidative defence systems in rice hull against damage caused by oxygen radicals. Agric Biol Chem 49:3085–3087

Pakistan economics survey (2010–2011) Economic Advisor's wing finance division government of Pakistan, Islamabad. Accessed at www.finance.gov.pk. Accessed on 12 Mar 2020

Pavek PLS (2012) Plant guide for pea (*Pisum sativum* L.). USDA-Natural Resources Conservation Service, Pullman

Pownall TL, Udenigwe CC, Aluko RE (2010) Amino acid composition and antioxidant properties of pea seed (*Pisum sativum* L.) enzymatic protein hydrolysate fractions. J Agric Food Chem 58:4712–4718

Pulse Canada (2009) Canada's pulse industry – a global leader. Accessed at: http://www.pulsecanada.com/uploads/16/52/165249e456e5a0437270fcbb88b80ee8/PulseIndustry-Brochure Accessed on 20 Apr 2020

Rehman A, Gulfraz M, Raja GK, Haq MIU, Anwar Z (2015) A comprehensive approach to utilize an agricultural pea peel (*Pisum sativum*) waste as a potential source for bio-ethanol production. Rom Biotechnol Lett 20(3):10422–10430

Roy F, Boye JI, Simpson BK (2010) Bioactive proteins and peptides in pulse crops: pea, chickpea and lentil. Food Res Int 43:432–442

Saeed S, Tariq P (2005) Antibacterial activities of Mentha Piperita, Pisum Sativum and Momordica Charantia. Pak J Bot 37(4):997–1001

Safaryan MJ, Ganjloo A, Bimakr M, Zarringhalami S (2016) Optimization of ultrasound-assisted extraction, preliminary characterization and in vitro antioxidant activity of polysaccharides from green pea pods. Foods 5(78). https://doi.org/10.3390/foods5040078

Saha H, Prakash A, Venkat kumar S, Manimegalai S, Devi Rajeswari V (2014) Evaluation of antioxidant activity of *Pisum sativum* (pod and grain) and detection of its bioactive compounds by GCMS analysis. Pharm Lett 6(6):359–365

Salunkhe DK, Kadam SS (1999) CRC handbook of world food legumes: nutritional chemistry. In: Processing technology and utilization. CRC Press, Boca Raton, pp 215–251

Sanchez-Chino X, Jimenez-Martınez C, Davila-Ortiz G, Alvarez-Gonzalez I, Madrigal-Bujaidar E (2015) Nutrient and nonnutrient components of legumes, and its chemopreventive activity: a review. Nutr Cancer 67(3):401–410

Sharoba AM, Farrag MA, Abd El-Salam AM (2013) Utilization of some fruits and vegetables waste as a source of dietary fiber and its effect on the cake making and its quality attributes. J Agroaliment Process Technol 19(4):429–444

Simmonds NW (1976) Evolution of crop plants. Longman, Inc., New York

Singh G, Dhall RK (2018) Heterotic potential & combining ability of yield and quality traits in garden pea (*Pisum sativum L.*). Veg Sci 45(1):7–13

Singh OP, Singh JN, Bharti MK, Kumari S (2008) Refrigerated storage stability of chicken nuggets containing pea flour. J Food Sci Technol 45:460–462

Singla R, Chahal SS, Kataria P (2006) Economics of production of green peas (Pisum sativum L.) in Punjab. Agric Econ Res Rev 19:237–250

Singleton VL, Rossi JA (1965) Colorimetry of total phenolics with phosphomolybdic-phosphotungstic acid reagents. Am J Enol Vitic 16:144–153

Smykal P, Aubert G, Burstin J, Coyne CJ, Ellis NTH, Flavell AJ, Ford R, Hybl M, Macas J, Neumann P, McPhee KE, Redden RJ, Rubiales D, Weller JL, Warkentin TD (2012) Pea (*Pisum sativum* L.) in the genomic era. Agronomy 2:74–115

Stanisavljevic NS, Ilic M, Jovanovic ZS, Cupic T, Dabic DC, Natic MM, Lj Z, Radovic SS (2015) Identification of seed coat phenolic compounds from differently colored pea varieties and characterization of their antioxidant activity. Arch Biol Sci Belgrade 67(3):829–840

Stanisavljevic NS, Ilic MD, Matic IZ, Jovanovic ZS, Cupic T, Dabic DC, Natić MM, Tesic ZL (2016) Identification of phenolic compounds from seed coats of differently colored European varieties of pea (*Pisum sativum* L.) and characterization of their antioxidant and in vitro anticancer activities. Nutr Cancer 68(6):988–1000

Tiwari BK, Singh N (2012) Pulse chemistry and technology. United Kingdom: the Royal Society of Chemistry. ISBN 10:1849733317/ISBN 13:9781849733311

TroszynHska A, Estrella I, Lopez-Amores ML, HernaHndez T (2002) Antioxidant activity of pea (*Pisum sativum*) seed coat acetone extract. LWT-Food Sci Tech 35:158–164

Troszynska A, Ciska E (2002) Phenolic compounds of seed coats of white and coloured varieties of pea (*Pisum sativum* L.) and their total antioxidant activity. Czech J Food Sci 20(1):15–22

Upasana, Vinay D (2018) Nutritional evaluation of pea peel and pea peel extracted byproducts. Int J Food Sci Nutr 3(1):65–67

USDA-National Agricultural Statistics Service (2011) Press release. Accessed at: http://www.nass.usda.gov/Statistics_by_State/Washington/Publications/Current_News_Release/pealent11.pdf. Accessed on 20 Apr 2020

Wang TL, Domoney C, Hedley CL, Casey R, Grusak MA (2003) Can we improve the nutritional quality of legume seeds? Plant Physiol 131:886–891

Zohary D, Hopf M (2000) Domestication of plants in the old world. Oxford University Press, Oxford