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Chapter

# Pea Seed Proteins: A Nutritional and Nutraceutical Update

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## Abstract

Grain legumes are well known as staple sources of soluble protein worldwide. Pea is essentially the most quickly growing crop for immediate human consumption and has the potential for higher effect as being a protein supply for foods processing apps. Pea seeds are an essential source of plant-based proteins. The better acceptance of pea protein-rich food is due to pea manifold attributes, excellent functional qualities, high vitamin value, accessibility, and comparatively small cost. Pea proteins are not merely nutritional amino acids but are an indispensable source of bioactive peptides that offer health benefits. This chapter focuses on the present information of isolation methods, extraction, and of seed proteins in pea. Overall, we believe that analogous research and advancement on pea proteins would be required for further more substantial increase in pea protein utilization is envisaged.

**Keywords:** pea, proteins, food processing, nutritional, health

## 1. Introduction

Vegetable seed proteins are widely used as ingredients in the food industry. Peas (*Pisum sativum* L.) have grown to be an essential vegetable source of proteins in addition to a likely replacement for soybean [1]. The better acceptance of pea protein-rich food is due to pea manifold attributes, excellent functional qualities in meals programs, high vitamin value, accessibility, and comparatively small cost. Dry peas have 20–30% lysine content. Pea proteins are mainly storage protein composed of albumins and two globulins, legumin and vicilin [2]. Besides, these protein-rich foods are characterized by higher lysine content. The primary pea storage proteins referred to as legumin and pea legumin is hexamer owning a molecular sector (Mw) ~ 320 to 380 kDa. The genuinely bioavailable protein has a pile of easily digested protein, getting a gentle flavour. Unlike extra protein powders with among the top eight allergens as soy, dairy-derived whey, pea protein-rich foods are hypoallergenic; thus it's a great protein alternative for each one of those with and with absolutely no allergies [3]. Pea protein dietary supplements are made in many items. The flexible protein has a packaging that is in unflavored and flavoured blends. Additionally, the pea seeds are loaded with fibre, vitamins, along with micro and macroelements [1].

Proteins obtained from plant sources are expanding ingredient of the marketplace in part due to consumer preferences and their comparatively small cost in contrast to animal-derived proteins [4]. Pea ingredients additionally are attractive to the food market because of their low allergenicity, nutritional value and non-GMO status. While pea does consist of antinutritional components which can inhibit

digestion and may have various prospective deleterious effects pea is still viewed as a too wholesome meal as well as is linked with total health benefits beyond elementary nutrition. The health benefits of pea seed proteins derive primarily from the qualities of starch, vitamins, fibre, protein, phytochemicals and minerals in peas. In this direction, mineral contents and the vitamin of peas may play crucial roles in the protection against deficiency-related diseases, particularly those regarding deficiencies of Folate or Selenium. Peas include a range of phytochemicals previously considered just as antinutritive factors. These contain polyphenolics, in coloured seed layer sorts particularly, that contains anticarcinogenic and antioxidant activity, saponins which might exhibit anticarcinogenic and hypocholesterolemic activity, as well galactose oligosaccharides which might exert beneficial prebiotic consequences within the large intestine [5, 6]. Many strategies for the extraction of protein from pea flours have been reported. Each extraction method might select for different protein sorts which consequently influences the final composition and functionality of the isolated product. In this chapter, we have compiled the information related to pea proteins targeting isolation methods, extraction, and of the seed proteins in pea.

## 2. Protein content

Protein content in pea lies in a range of 21 to 30 per cent with an average of 23 per cent depending on genotype, growing environment and related factors [6]. The overall phenotypic expression of protein content is a result of environmental as well as genotypic components. The cultivars originating from various geographical areas show a range of protein content levels (**Table 1**). The heritability estimates show that pea protein content and quality is a heritable trait [7, 8], thus target for improvement through selection in breeding programs. Changes in environmental factors such as temperature, rainfall, soil type result in a differential response in performance of pea cultivars; thus multi-location and multi-year data is required for final estimation of protein content [9–11]. Most of the nitrogen supplies during fruit development relies on assimilation after the flowering and only a portion of

| Pea seeds | Protein content | Country | Reference |
|---|---|---|---|
| *Pisum sativum* L. cv. *Ucero* | 25.48 | Spain | [20] |
| *Pisum sativum* L. cv. *Ramrod* | 21.17 | Spain | [20] |
| *Pisum sativum* L. cv. *Agra* | 22.90 | Spain | [20] |
| *Pisum sativum* L. cv. *Maja* | 24.21 | Serbia | [21] |
| *Pisum sativum* L. cv. *Calvedon* | 27.70 | Serbia | [21] |
| *Pisum sativum* L. cv. *Miracle of America* | 22.31 | Serbia | [21] |
| *Pisum sativum* L. cv. *Sprinter* | 23.98 | Turkey | [6] |
| *Pisum sativum* L. cv. *Manuell* | 23.26 | Turkey | [6] |
| *Pisum sativum* L. cv. *Century* | 23.9 | Canada | [22] |
| *Pisum sativum* L. cv. *Trapper* | 24.5 | Canada | [22] |
| *Pisum sativum* L. cv. *Delviche Scotch Green* | 24.0 | Canada | [22] |
| *Pisum sativum* L. cv. *Ceser* | 24.9 | Canada | [22] |
| *Pisum sativum* L. cv. *CD647 4* | 24.9 | Hungry | [22] |

**Table 1.**
*Protein content of famous pea cultivars grown in various parts of the world.*

the collection of nitrogen depends on assimilation before flower development [12]. It has been reported that low rainfall and high temperature is positively correlated with high protein content in pea genotypes [10, 13]. A total of 7% high protein content was observed in pea crop raised in dry location than another location having 209 mm higher rainfall indicating role of low rainfall has a significant influence on protein content [10]. However, in another study, there was 1.5% rise in pea protein content between the crop raised in the periodic wilting moisture content of 10 percent versus 26 per cent moisture content at field capacity [14]. In addition, seed yield is known to be negatively correlated with protein content, and these conclusions were made by various independent studies in different years and locations [11, 13, 14]. The dry matter in seed constitutes approximately 50% starch [15, 16]. The dietary fibre and total protein content account for 20 and 24% of the dry matter, respectively. Whereas, 2.5% of dry matter is contributed by lipids [17]. Protein content and starch are highly variable, but other components show little variation [15]. It was found in a study that protein content was negatively correlated with lipid, starch, ash, fibre content and soluble sugar and among these variations in starch content had a significant effect on protein content levels [18]. This study was conducted at four locations in Canada using dehulled pea cultivar, and it was observed that protein content of the cultivar was variable across locations showing levels 14.5%, 18.3%, 24.3%, and 28.5%. The starch synthesis was reported to be a critical factor in determining pea protein content as smooth seeded pea having a higher content of amylopectin and starch showing lower protein levels (23–31%) than wrinkled pea seeds (26–33%) [19]. Recessive gene account for higher protein levels in wrinkled pea seeds.

## 3. Amino acids

Peas are an excellent source of human nutrition owing to 25% protein in seeds [1], and it has a comparable amino acid (AA) profile to other legumes. Pea protein contains a lesser amount of sulphur amino acids, i.e., methionine and cystine and lower levels of tryptophan AA, whereas high levels of lysine AA [23]. The bioactive peptides of pulses are popularized due to affordable prices when compared with animal protein [24]. During the processing of food, microbial agents or digestive enzymes cause the hydrolysis of large proteins and release bioactive peptides which are usually 3–20 AA long [25]. Nutritional and functional properties food protein are studied using bioactive peptides obtained by hydrolysis through enzymatic action [26]. AA composition of a peptide is the key to its biological activity [24]. Oxidative stress damage in human beings can be prevented by developing nutraceuticals and foods using such peptides. High levels of antioxidants in natural foods can be even more appealing than synthetic counterparts [24, 27]. In a study by Amarakoon [28] the amino acid profile of pea showed that pea grown in central Europe was rich in leucine, lysine and arginine which were sufficient for a normal diet. The amino acid profiles of pea were compared with soybean and reference FAO/WHO requirements. The essential AA content was higher in pea in comparison to soybean. The lysine content was 6.39–6.93/16gN in pea, which was also higher than soybean. Another comparison of AA profile of flour and isolates and concentrates of protein of pea, soybean and lupin was made by Tomoskozi et al. [29]. They concluded that composition of AA was the same in all compounds with the highest amount of glutamine and comparatively lower amounts of aspartic acid, lysine and arginine and smallest contributions of methionine, cysteine and tryptophan.

In comparison to soybean and lupin, pea compounds had high levels of arginine, methionine and valine and comparatively low levels of cysteine and glumatic acid.

| Amino acids | cv. *ucero* | cv. *ramrod* | cv. *agra* | *cv. terno* | *cv. Xantos* | *cv.suit* | *cv. achat* |
|---|---|---|---|---|---|---|---|
| *Non-essential amino acids* | | | | | | | |
| Asp | 10.39 | 10.08 | 9.98 | 10.87 | 10.55 | 10.69 | 10.58 |
| Glu | 17.09 | 16.49 | 15.43 | 15.07 | 16.19 | 15.96 | 16.16 |
| Ser | 4.89 | 4.80 | 4.77 | 4.23 | 4.16 | 4.05 | 4.25 |
| Gly | 8.16 | 8.26 | 7.85 | 4.11 | 4.0 | 3.98 | 3.92 |
| Arg | 5.76 | 4.93 | 4.12 | 9.36 | 8.60 | 9.68 | 8.32 |
| Ala | 5.17 | 6.35 | 5.75 | 4.19 | 3.88 | 3.83 | 3.79 |
| Pro | 3.62 | 3.64 | 3.52 | 3.77 | 3.57 | 3.64 | 3.63 |
| *Essential amino acids* | | | | | | | |
| His | 1.07 | 1.13 | 1.03 | 2.22 | 2.16 | 2.18 | 2.16 |
| Val | 3.85 | 3.89 | 3.61 | 4.72 | 4.29 | 4.34 | 4.32 |
| Met | 0.65 | 0.70 | 0.70 | 5.0 | 1.08 | 1.05 | 0.99 |
| Cys | 0.30 | 0.37 | 0.39 | 2.01 | 2.03 | 1.9 | 1.67 |
| Ile | 3.51 | 2.64 | 2.52 | 4.23 | 3.86 | 3.77 | 3.9 |
| Leu | 5.72 | 6.51 | 7.01 | 7.11 | 6.45 | 6.33 | 6.55 |
| Phe | 5.07 | 5.06 | 4.59 | 4.87 | 4.59 | 4.33 | 4.56 |
| Tyr | 3.98 | 3.76 | 3.77 | 2.79 | 3.18 | 2.87 | 3.18 |
| Lys | 18.34 | 19.69 | 17.03 | 6.93 | 6.55 | 6.39 | 6.63 |
| Thr | 3.04 | 4.22 | 6.92 | 3.45 | 3.64 | 3.34 | 3.53 |
| Trp | 0.02 | 0.02 | 0.02 | n.a. | n.a. | n.a. | n.a. |

**Table 2.**
*Amino acid profile of different pea cultivars [20, 25].*

The muscle development and growth in human body is dependent on postprandial essential amino acid availability particularly leucine [30]. AA composition, essential AA content and anti-nutritional factors regulate the availability of essential AA [31]. Thus, variation in AA composition particularly in essential AA are desirable for improving AA profile of pea proteins. Natural variation among varieties for AA profile is present as depicted in **Table 2**. Wide crosses and mutants can be searched for more desirable AA profile of pea proteins. Furthermore, introgression approach can be deployed for improvement of existing germplasm using a natural variation.

## 4. Seed storage proteins

Apart from protein comprising a major part of the seed, the other constituents include 1.5–2% fat, minerals, vitamins, polyphenols, oxalates, saponins and phytic acid [32–34]. Starch and dietary fibre account for 60 percent of carbohydrate content and rest include non-starch part of carbohydrates comprising sucrose, cellulose, and oligosaccharides (**Figure 1**) [34, 35]. Protein and the starch fraction of seed show high variations, whereas the other components remain comparatively constant [15]. Pea proteins are classified based on Osborne fractionation [36] into two different categories, i.e., globulins soluble in salt and albumins soluble in water which collectively account for 80% of the pea seed protein. Young embryos after germination of seed obtain nitrogen from globulins and some of

the albumins which are also known as storage proteins. Globulins are further divided into two categories based on coefficients of sedimentation, i.e., legumin (11S fraction), vicilin and convicilin (7S fraction) as shown in **Figure 2**. The two classes differ from each other in structure and molecular weight. Legumin has a molecular mass ranging from 300 to 400 kDa and hexameric protein form. There are three polypeptide families of legumin, and sequence similarities differentiate them into various groups. The LegA polypeptide comprises of legA, legB, legA2, legC, and legE, LegJ polypeptide comprises leg J, legK, legL and legM whereas LegS is single member of family [37, 38]. The LegA and LegJ families comprise an apparent subdivision with the molecular mass of 65 kDa, and on the other hand, the apparent subdivision of LegS has *) kDa molecular mass. Only a single peptide of legumin is imported to the endoplasmic reticulum and removed during translation. Ultimately, trimers of legumin peptide are formed and moved to the

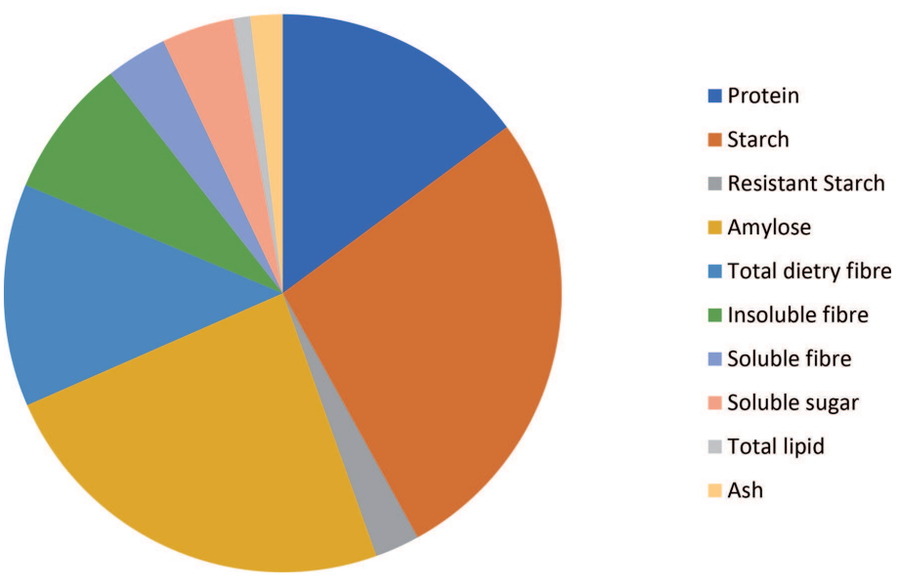


**Figure 1.**
*The average composition of pea seeds [56].*

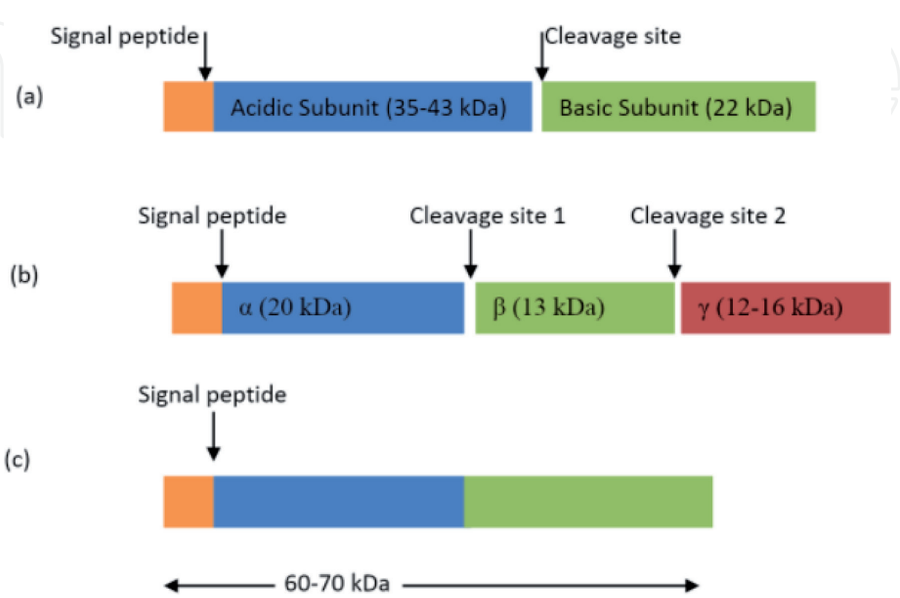


**Figure 2.**
*Size of subunits of pea proteins, including the cleavage site of (a) Legumin (b) Vicilin (c) Convicilin [57].*

pre-vacuolar compartment [39]. Furthermore, the peptides are processed into basic and acidic polypeptides of 20 and 40 kDa with the help of vacuole processing enzyme and the two peptides are linked by disulphide bridge. A complete protein structure is assembled from trimers to hexamers. The molecular weight of vicilin is 47–50 kDa and it forms trimers of 150 kDa molecular mass [40]. Only some vicilins undergo cleavage at post translational level [41]. Vicilin contains two cleavage regions which are separately processed. Three fragments of 13 kDa (â), 20 kDa (R) and 16 kDa (γ) are obtained by cleavage in both regions. Two fragments of 25 kDa (â + γ) and 20 kDa (R) are obtained, if site A is cleaved and two fragments of 16 kDa (γ) and 36 kDa (R + â) are obtained if site B is cleaved [41, 42]. Noncovalent bonds held processed peptides [38, 42]. Glycosylation takes place near to C terminus of γ subunit of vicilin polypepetides as they are glycosylated [43]. Trimers of 210 kDa molecular mass are formed by convicilin protein having a molecular mass of 70 kDa. Heteromeric trimers comprising convicilin and vicilin polypeptides also occur [2, 44]. Elimination of single peptide is only reported post translational modification in the case of convicilin and glycosylation is absent [45]. Convicilin and vicilin show sequence similarity of amino acids at C terminus whereas N terminal being highly charged have different sequences between two polpeptides [46, 47]. Based on isoform, sequence similarity occurs between 122 and 166 amino acid residues. Physiochemical properties of globulins are different, owing to variations in molecular weight and structure.

The water-soluble albumin proteins have 5–80 kDa molecular mass and consist of enzymes and anti-nutritional factors such as amylase inhibitors, lectins and protease inhibitors [32]. Further two classes are obtained in albumins, i.e., albumin protein with two polypeptides having 25 kDa molecular weight and another with 6 kDa molecular weight [44]. Minor portions include prolamins which are soluble in diluted alcohol and glutenins, which are soluble in diluted acid [32]. The protein structure can be altered by external factors such as temperature, pH and salts during the extraction process resulting in different surface features and conformations.

The globulin protein classes, i.e., vicilin and legumin in different concentrations, can make good gels, whereas convicilin is known to hinder gel formation [48]. The food industry needs raw material with desirable composition of globulin in peas like high levels of vicilin and legumin or low levels of convicilin [38]. Further, gel making property not only depends on the composition of globulins but also matter of isoforms of isolate [49, 50]. The genetic variation in the composition of globulins and decreased levels of anti-nutrients in albumin fraction of pea proteins are desirable material for development of new varieties using breeding techniques. Natural variation is reported in case of the protein content of pea and its composition, which can be used in breeding programs [51–53]. The r locus in the pea genome is known to control the starch synthesis, which shows pleiotropism with protein content and its composition [54, 55]. With the advancement of techniques for elucidating in planta processing of proteins, there will be more clues for the controlled composition of proteins using genome editing techniques.

## 5. Seed crude protein determination in pea

### 5.1 Protein isolate extraction methods

Alkaline extraction/isoelectric precipitation (AE/IEP) – This method utilizes the high solubility of pea proteins in alkaline conditions and their minimal solubility at isoelectric point (pI) at pH between 4 to 5 [32]. This method is the most common for legume protein extraction, and it takes advantage of similar solubility characters

for legumin and vicilin [33, 58]. The de-fatted flour of legume (with or without seed coat) is dispersed in water and pH is adjusted to an alkaline range using NaOH, KOH or $Ca(OH)_2$, and further left for 30–180 mins for maximizing protein solubility [32, 33]. Without de-fatting process, the protein-lipid interaction limits the solubility of protein leading to decrease in the isolated yield, and the temperature can be increased to 50–60°C to aid solubilization [59, 60]. The protein denaturation can be limited by avoiding the higher temperatures. The mixture is further centrifuged, and supernatant is collected, and isoelectric pH is adjusted using HCl or $H_2SO_4$. The precipitated protein is collected after centrifugation and washed, neutralized, and dried by drum or freeze drying [32, 33]. The isolate yield can be increased up to 80–94% by optimal processing conditions and the conditions used in a process can affect the purity, yield and functionality of the isolate [58]. Hoang [58] evaluated that the extraction pH and flour: water ratio were most critical factors. The flour: water ratios of 1:5 to 1:20 (w/v) was reported [32] but Hoang [58] stated that the increase in concentration gradient between the solid and liquid phase in low ratio slurry can increase solubility. Although high alkalinity increases the isolate solubility and yield of protein, but the pH 11 and above are basically associated with increase in swelling of starch, leading to contamination of starch in isolate product [58]. Alkaline Extraction is also responsible for the adverse chemical reactions like the conversion of serine and cysteine residues to lysinoalanine compounds (nephrotoxic), decreased proteins bioavailability, and racemization of amino acids [61, 62]. The processes employing high alkaline pH, high temperature is associated with high yield of isolate, but there is high susceptibility of denaturation of isolate [61, 63]. The particle size of flour and solubilizing agent used can also affect the yield of isolate. The optimum particle size for flour is 100–150 μm and it was reported that NaOH and KOH generate more yield in comparison to $Ca(OH)_2$ [64]. Also, there was protein loss of 6.2% from discarded supernatant from this extraction method [58] and in place of IEP, ultrafiltration (UF) or diafiltration membranes with specific molecular weight cutoffs can be utilized for isolating proteins of interest from the supernatant [32]. The efficiency of extraction can be improved by alteration in the molecular weight cutoffs, membrane type, concentration, and volume of the filtrate and addition of diafiltration to UF techniques [65]. The albumin proteins can be recovered by controlling these factors and further result in enhancing yield of isolate and alteration in isolate functionality leading to reduction in effluent losses. The use of UF can provide milder conditions for extracted proteins, so that their functionality can be enhanced and it gives higher yields in comparison to IEP [66].

Boye et al. [65] also confirmed that there were slightly higher protein levels in UF than the IEP process. Membrane filtration is also effective in reduction of anti-nutritional compounds in isolate [65]. Taherian et al. [67] conducted a study for functional properties of commercial and membrane-processed yellow pea protein isolates. The use of UF results in reduction of phytic acid upto 28–68% and possess improved functionality (e.g., solubility, rheology, foaming and emulsification) for commercially available isolates. The solubility of the commercial protein isolates was reported as ~20% vs. ~80% by using UF/diafiltration at pH 2.0. Fuhrmeister and Meuser [68] found the enhanced solubility, emulsifying, foaming and fat-holding properties by UF recovery of proteins from wrinkled pea relative to heat, acid, and heat/acid precipitation.

### 5.2 Salt extraction (SE) and micellization

SE has advantage of the salting-in and out phenomenon of proteins which is followed by desalting for lowering the ionic strength of protein environment [32, 69]. In this process, the flour is stirred in salt solution of ionic strength (1:10

(w/v) ratio) for 10–60 mins and further followed by removal of insoluble matter by settling, screening, decanting, filtering or centrifugation. The supernatant is desalted and dried [32, 69, 70]. The choice or concentration of salts is selected according to salting-in and salting-out characteristics of the protein and any unwanted proteins, respectively because the proteins precipitate at an array of ionic strengths [71, 72]. The salting-in of proteins generally occurs at ionic strength (between 0.1 to 1 M) [60] and the other factors include interactions of salt and sample components and ensuring the use of food-grade salts [69, 73]. The major advantage for this technique is that extreme level of acidic or alkaline pH alongwith elevated temperature is not required. The extraction occurs at pH level of 5.5–6.5, but Crevieu et al. [74] reported slightly alkaline pH for increasing protein solubility [69]. The pH can be maintained by the addition of acid or base or a salt solution with buffering capacity can be used. The supernatant with extract of high-salt protein should have a protein concentration of 15 to 100 mg/mL [69] and many methods have been used for decreasing its ionic strength.

In the process of micellization, protein precipitation is induced by adding cold water at a ratio of 1:3 to 1:10 (v/v) of high-salt protein extract to water [69, 75]. The solubilized proteins can be adjusted to low ionic strength by the dilution of protein solution through different dissociation reactions which forms loosely associated and low molecular weight aggregates. After reaching a specific concentration of protein, the aggregates can re-associate into low molecular weight species, known as micelles [69]. The arrangement of micelles is as thermodynamical spheres with minimum interfacial energy by giving exposure to polar moieties in outer aqueous environment and hydrophobic moieties towards the center. The proteins possesing more surface hydrophobicity have more protein–protein interactions and are also more successful for creating large and uniform aggregates [69]. The diluted solution can be left to stand for certain time for increasing micelle formation. This is followed by centrifugation and further the pellet is dried, and the high salt aqueous solution is discarded [32, 69]. Mwasaru et al. [75] reported that after using 0.25 M NaCl solution at pH value of 6.5 and 6 hours of micellization standing time, the protein extractability for pigeon pea and cowpea was yielded a 40.2% and 36.7%, respectively and these values were further compared to alkaline-extracted samples at pH value of 10.5 and 8.5, respectively, where the yields increased with respect to alkalinity. Gueguen [35] evaluated that 95% yield can be attained using micellization method.

### 5.3 Dialysis

The another commonly used method for desalting is dialysis. It is the process of membrane separation driven by a potential gradient for diffusing water and other solutes with low molecular weight like, salt and this process carried out using semipermeable membrane [72]. Gueguen et al. [70] and Crevieu et al. [74] used pea protein membranes with cutoffs of 8000 Da and 12,000–14,000 Da, respectively. The diffusion requires time for causing equilibrium on both sides and is complete when the potential gradient becomes negligible [72]. The changes in fresh, pre-cooled liquid against which the sample is dialyzed helps in ensuring that very low concentrations of solutes remain in the sample. Gueguen et al. [70] cited a process of 130 hours which requires five changes of water of 20 times the extract volume. Crevieu et al. [74] dialyzed solution of globulin against two changes of 10 times the extract volume of ammonium carbonate, that requires 70 hours and results in a yield of 66.8%. Dialysis can also be used for separation of gloulin and fractions. According to the protein classification of Osborne, the dialyzed sample is centrifugated and it results in dissolved albumin fractions in supernatant and precipitated fractions of globulin in the pellet [70]. The phenolic compounds present in pea can

be reduced by additional steps during processing, like the use of alcohol washes and charcoal filters. The cross linkage of proteins can be improved by antioxidant activity of phenolic compounds which can negatively affect protein digestibility and enzymatic activity, leading to undesirable color and flavor compounds within the food product.

## 6. Food applications of pea proteins

The application of bioactive ingredients (hydrophobic, hydrophilic compounds, minerals, and probiotics) is less due to their instability, less bioavailability, and unsuitable flavors in the food system. So, encapsulation can be a promising technique for solving these problems related to bioactive ingredients. Nowadays, there is an increase in research for pea protein as encapsulating materials, because of its health benefits, nil genetic modifications, and hypoallergenic issues [76]. As many researchers have recognized the importance of natural polymers for preparing biodegradable packaging and since pea protein acts as a biodegradable and biocompatible natural polymer, it can be used for producing biodegradable films. It can provide promising possibility for the application of pea proteins for making biodegradable films in industrial-scale food production.

There are extrusion techniques which include low-moisture extrusion (LME, 40%) and high-moisture extrusion (HME, >40%), these techniques are widely used in commercial food production. LME is generally used for preparation of snacks and HME is used basically for meat analogue preparation. The research of pea protein based extruded products is very common nowadays and many researchers reported that pea protein was used in different starches like rice starch [77–79] wheat starch [80] and corn grits [81] for preparing protein-fortified extruded snacks by LME, and the results concluded that pea protein-fortified extruded products exhibits high content of protein and possess balanced amino acid profile in comparison to pure extrudates of starch.

There are many studies which report that by the addition of pea protein in cereal products can improve the nutritional value of the product because pea protein provides the essential amino acids and improve the texture of cereal product [4, 82–85]. The plant protein can be used as substitute for animal protein for meeting nutritional need of lacto-vegetarians and thus can make the food healthier. Several researchers are working on partly or fully substitution of dairy proteins with pea protein and the impact on taste and structure of these products [86–90].

## 7. Conclusion and future prospects

Based on the literature reviewed in this chapter, we think that analogous research and advancement on pea proteins would be required if any significant boost in pea protein utilization is envisaged. While pea protein isolates have usually been discussed in the research literature as relatively mundane, you will find very few sensory analysis information to help the claim. The main limitation on the sales of pea protein meals components is the trouble in fighting with the well-established, versatile soy protein items which dominate the meals protein market. Soy proteins are already available for a very long time, and research by the main producing businesses has resulted in several tailored items for programs. Pea concentrates and flours are generally referred to as having a terrible taste (beany, bitter). The incorporation of pea concentrates and flours into meals products such as bread, is usually restricted by flavour problems. This truth is insignificant within the

foods ingredient industry because proteins in this particular marketplace are sold primarily by functional qualities and price. Although to be used in food aid plans for developing nations, this's of concern and demands that pea protein is together with a protein source that will offer a comprehensive source of sulfur amino acids. In pet feeding, the nutritional value of protein sources is likewise essential. Feeding studies show that pea protein requires supplementation with methionine to get it with the nutritional value of soy protein.



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