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Legume: composition, protein extraction and functional properties. A review

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Because of the high protein content and beneficial nutritional value, legumes (lupin, peas, beans, and soybeans) play an important role in human diet. Legumes provide energy, dietary fibre, protein, minerals and vitamins required for human health and endue well-balanced essential amino acid profiles when consumed with cereals and other foods rich in sulphur-containing amino acids and tryptophan. Some antinutritional compounds, found in legumes, can be toxic, unpalatable or indigestible, but their elimination can be achieved by selection of plant genotypes or through post-harvest processing. The production of legume protein concentrates or isolates is of growing interest to food industry because of their functional properties and ability to improve the nutritional quality of food products. For that, various techniques are used to extract protein concentrates / isolates with different features. Legume proteins have gained increasing importance because of desired functional properties, including gelling and emulsifying properties, and could be proposed as a potential supplement in a great number of food applications.

This review provides an overview of the chemical composition of legumes (lupin, peas, beans, and soybeans), their antinutritional compounds, current and emerging techniques for producing their protein concentrates / isolates, and major functional properties.

Key words: chemical composition, antinutritional compounds, protein isolate, functional properties

Introduction

About 20 leguminous species are used as dry grains for human nutrition. It's not only cheap and popular food for many people, but it is important source of food proteins. Due to animal protein sources often containing large amounts of saturated fat and cholesterol, most health organizations recommend the frequent consumption of vegetable protein, since it is known that it may reduce serum cholesterol levels, the risk of coronary heart diseases and diabetes [1]. Also protein malnutrition is one of the major nutritional problems in the developing world, so the potential for blending pulses with other locally grown grains to meet some of the protein malnutrition problem worldwide is, therefore, of tremendous interest. Soybeans are widely used in the food industry because of its high protein and oil contents [2]. Soybeans can be classified into oil bean and food bean according to its end uses. Another legume, lupin, has a high protein content and is therefore an interesting raw material for plant-based, high-protein products while beans and peas are amongst the most widely cultivated and consumed legumes of the world. Legumes have many good qualities and can be considered most suitable for the preparation of protein isolates because of their high protein content, low cost and wide acceptability. The proteins of legumes are mainly storage proteins belonging to the groups of albumins, globulins and glutelins, with the salt-soluble globulins constituting the main proteins found in the seeds. There are also a number of proteins, other than the water-soluble storage proteins, mainly enzymes, enzyme inhibitors and lectins which constitute part of the defensive mechanism of the seed but are considered as antinutritional factors for the human diet [3]. The techniques employed for legume exploitation in preparing rich-in-protein materials, such as concentrates or isolates with a protein content of about 70 and 90 %, respectively, are air classification and the so-called wet protein extraction methods [4]. These methods have their own advantages and disadvantages in preparing protein isolates / concentrates. Apart from their nutritional properties, legumes proteins also possess functional properties, including gelling and emulsifying properties, that play an important role in food formulation and processing. Intrinsic factors (amino acid composition), extrinsic (pH, temperature, solvent, salt) or environmental factors, and processing treatments (heating, drying, concentrating) or other intentional modifications (chemical or enzymatic modification) can all contribute to influence the functional properties of these proteins. Legumes are widely used in food industry as source of protein for baked goods, glazes, frosting, pastes, meat and extruded products, bean curd or baby food. For example, lupin flours, protein concentrates, and isolates can be applied in different food systems such as bakery products, salad dressings, lupin pasta, ice cream, and sausages [5]. Also there is a growing interest for legume biomass for renewable energy, fuels and chemicals.

The paper will focus on the chemical composition of lupin, peas, beans and soybeans, antinutritional compounds, protein extraction techniques and functional properties of protein isolates.

1. Chemical composition of legume

Lupin belong to the Genisteae family, Fabaceae or Leguminosae [6] and more than 400 species are known, from which only four are of agronomic interest [7]: *Lupinus albus* (white lupin), *Lupinus angustifolius* (narrow leaf or blue lupin), *Lupinus luteus* (yellow lupin) and *Lupinus mutabilis* (Andean lupin). Lupin generally contains about twice the amount of proteins found in those legumes that are commonly consumed by humans. There are variations in the protein content between species and cultivars as a result of the characteristics of the growing conditions and soil types [1] from 28 % to 62 % [5].

Globulins (α-conglutin or 11S-like protein, β-conglutin or 7S-like protein, and γ-conglutin) are the main storage proteins (80–90 %) in lupins [8] while prolamines and glutelins are detected in small amounts similar to those reported in most legume seeds [9]. Lupin is source of sulphur-containing amino acids and arginine, and has a good balance of essential amino acids with a high degree of digestibility.

The oil content of lupin may range from 1 to 17 %, with a high variation in fatty acid composition. The dominating fatty acids are oleic and linoleic acid. The seeds contain low amounts of starch (0 to 5 %), and structural polysaccharides such as hemicellulose. The primary cell walls of cotyledons are composed of arabinogalactans, arabinans, rhamnogalacturosan, galactoxyloglucans and galactans. Mature seeds of yellow lupin accumulate stachyose, verbascose and raffinose, amounting 11 % of dry mass, and sucrose (1.5 %) [10]. Lupin seeds contain about 1.5 to 3.5 % of sucrose, a relatively high amount of stachyose (6.0 to 7.5%). The raffinose and verbascose content are about 0.5 to 0.9 %, and 0.3 to 0.8 % respectively [10].

Lupin seeds, like other legumes are good sources of vitamins and phenolic compounds. Carotenoids and tocopherols are present, with the former being mainly responsible for the color of the oil fraction [11].

Peas are a genus of the family Fabaceae. It contains one to five species, depending on taxonomic interpretation. *Pisum sativum* (the field or garden pea), is domesticated and is a major human food crop. Like other legume seeds, pea is rich in protein (18–30 %) and also contain vitamins, minerals and dietary fiber [12]. Pea seed storage proteins are composed mainly of legumin (11S), vicillin (7S) and albumins (2S) and the majority of pea protein isolates contain globular 11S and 7S [12]. The ratio of legumin to vicilin in pea ranges from 0.2 to 1.5 [12].

Beans are one of most consumed legume worldwide**.** Beans are reported to contain 17.96–23.62 % proteins, 1.27–3.62 % fat, 2.86–5.00 % ash and 56.53– 61.56 % carbohydrates [13]. They have a balanced amino acid composition while they are low in sulfur-containing amino acids (methionine and tryptophan) as is the case with other pulses [14]. They contain vitamins, as well as antinutritional factors, such as proteolytic enzyme inhibitors, phytic acid and lectins and their consumption is negatively affected by the reduced protein digestibility [14]. The storage proteins of beans are vicilin and legumin. Vicilin is a 7S globulin and is often referred to as phaseolin. It is comprised of 3–5 subunits and represents 50 % of the total protein content. Legumin is an 11–12S, globulin, comprised of acid and basic subunits, and usually sediments with vicilin as a single [14].

Soybeans are widely used in the food industry because of its high protein and oil contents. Soybeans can be classified into oil bean and food bean according to its end uses [2]. Oil soybean, i. e. commodity bean, is the primary source of vegetable oil and soy protein products, such as defatted soy flour and soy protein concentrate; food bean, i.e. specialty bean, is either consumed directly or processed into various soy products. The composition of soybeans may vary somewhat according to variety and growing conditions. Through plant breeding it has been possible to obtain protein levels between 40 % and 45 %, and lipid levels between 18 and 20 % [15]. Usually, an increase of 1 % in protein content is accompanied by a decrease of 0.5 % in oil.

The four major fractions of soybeans protein are known as 2S, 7S, 11S and 15S [15]. The 11S and 7S fractions constitute about 70 % of the total protein in soybeans. The ratio 11S/7S is a varietal characteristic and may vary from 0.5 to 3. The 2S fraction consists of low molecular weight polypeptides (in the range of 8000 to 20000 daltons) and comprises the soybean trypsin inhibitors. The 7S fraction is highly heterogeneous. Its principal component is beta-conglycinin, a sugar containing globulin with a molecular weight in the order of 150000. The fraction also comprises enzymes (beta-amylase and lipoxygenase) and hemagglutinins. The 11S fraction consists of glycinin, the principal protein of soybeans. Glycinin has a molecular weight of 320000–350000 and is built of 12 subunits, associated through hydrogen bonding and disulfide bonds. The ability of soy proteins to undergo association-dissociation reactions under known conditions, is related to their functional properties and particularly to their texturization. The 15S protein is probably a dimer of glycinin. Conglycinin and glycinin are storage proteins and they are found in the protein bodies within the cells of the cotyledons.

The limiting amino acids are the ones containing sulphur (methionine and cystine) [15]. Soybean protein is exceptionally rich in lysine and can serve as a valuable supplement to cereal foods where lysine is a limiting factor.

2. Antinutritional compounds

Antinutritional factors (ANFs) in legumes can be divided into several groups based on their chemical and physical properties such as non protein amino acids, quinolizidine alkaloids, cyanogenic glycosides, pyrimidine glycosides, isoflavones, tannins, oligosaccharides, saponins, phytates, lectins or protease inhibitors [16]. Since many of the ANFs are toxic, unpalatable or indigestible, their elimination can be achieved by selection of plant genotypes or through post-harvest processing (germination, boiling, leaching, fermentation, extraction).

The main antinutritional substances found in lupin seeds are various alkaloids of the quinolizidine group [17–19], but the levels of others undesirable constituents, such as phytic acid, oligosaccharides, trypsin inhibitors, and lectins and saponins are lower in comparison with other legumes [5]. Faba beans and peas are devoid of alkaloids [20].

Alkaloids are organic substances, colourless, crystal or amorphous, sometimes liquid, which have toxic and pharmacological features [21]. There are known a few thousand alkaloids which are classified into protoalkoids, pseudo-alkaloids and natural alkaloids [22]. Alkaloids content in lupin depend on lupin type – sweet or bitter. The main alkaloids found in lupines are lupinine, lupanine, sparteine, lupinidine, hydroxylupanine, anagirine, monolupine, termophsine, puziline and angustifoline (Fig. 1) [22], giving a bitter taste and causing respiration problems and liver damage.

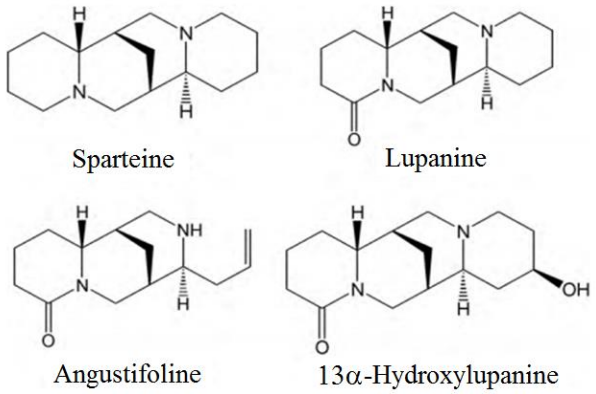

Fig. 1. Chemical structures of the some quinolizidine alkaloids

Various authors determined the alkaloid composition in different lupin species [20]. The major alkaloids of *L. albus* are lupanine (700 mg/g total alkaloids), albine (150 mg/g total alkaloids) and 13α-hydroxylupanine (80 mg/g total alkaloids). In *L. angustifolius*, various authors found mainly lupanine (70 mg/g total alkaloids), 13α-hydroxylupanine (120 mg/g total alkaloids), and angustifoline (100 mg/g total alkaloids), while predominant alkaloids of *L. luteus* were identified as lupanine (600 mg/g total alkaloids) and sparteine (300 mg/g total alkaloids). The toxicity of alkaloids is different and depends on concentration. The most toxic is lupanine, less toxic are sparteine and lupinine. The presence of alkaloids proves to be non-toxic at low concentrations. Since most alkaloids of lupin are water-soluble, the alkaloid level of lupin (0.5–4 %) can be decreased to 0.04 % by soaking in running water, brine or scalding. Also it has been possible to grow sweet genetic varieties with low alkaloid contents ranging from 0.008 % to 0.012 % [23].

Lupin contains flatulence-causing factors, known as α-galactosides or the raffinose family of oligosaccharides (RFOs), that range from 7 % to 15 % of raw seeds [24, 25]. Comparing white and yellow lupin, stachyose was always the main α-galactoside present in lupin seeds, followed by verbascose [1]. Finally, raffinose content was the lowest (compared with stachyose and verbascose levels). *L. luteus* showed a remarkably high content of total α-galactosides (~12 %) which was about 1.5 times higher than white lupin cultivars. In raw seeds, trypsin inhibitor activity was found in yellow lupin where differences between cultivars were found and *L. luteus* cv. 4492 showed the lowest content [1]. Levels of protease inhibitors found in lupin analysed are very low in comparison with other legume seeds, particularly soybean [1]. Phytic acid was present in white and yellow lupin seeds [1].

Generally, legume seeds contain considerable amounts of various categories of protease inhibitors [20]. Traditionally, protease inhibitors belong to two major classes, the Kunitz trypsin inhibitor which is mainly present in soybeans, and the family of Bowman-Birk trypsin/chymotrypsin inhibitors, which widely occurs in other legumes [20]. Generally, trypsin inhibitor activity (TIA) is used as measure to determine protease inhibitor. According to Jezierny et al. [26], TIA values of faba beans, peas and lupin are lower than soybean meal.

Vicine and convicine (Fig. 2) are generally present in faba beans and belong to the group of pyrimidine glycosides, which are composed of one molecule glucose linked to one pyrimidine nucleoside [20]. In contrast, other grain legumes (e. g. *Pisum sativum*) contain only negligible amounts as compared to faba beans [20]. Vicine and convicine act by reducing glutathione and glucose-6-phosphate dehydrogenase activity, which may result in haemolyticanaemia due to biochemical abnormalities of blood cells [20].

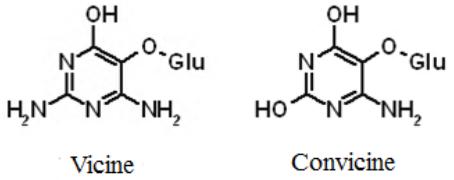

Fig. 2. Pyrimidine glycosides

Lectins, also referred to as phytohaemagglutinins, are glycoprotein compounds which have been shown to agglutinate red blood cells *in vitro* [20]. Lectins are found in a wide range of grain legumes including faba beans, peas, soybeans and lupins [20]. Peas generally have higher lectin activities than faba beans, but both show considerably lower amounts in comparison to raw defatted soybeans or other grain legumes (e. g. beans), while lupins contain only negligible levels of lectins [20]. Furthermore, there is some evidence that low-alkaloid lupins may be completely devoid of lectins [20].

3. Legume protein isolation

The major proteins found in legumes are globulins and albumins [27]. Albumins are water soluble and comprise enzymatic proteins, protease inhibitors, amylase inhibitors and lectins and have molecular masses (MM) ranging between 5000 and 80,000 Da. Globulins represent roughly 70 % of legume seed proteins and consist primarily of the 7S, 11S and 15S proteins. Molecular weights of these proteins range from 8000 to

600 000 Da [27]. These proteins generally have a minimum solubility at pH values between four and five (isoelectric point). By manipulating the solubility of the proteins and using filtration techniques that take advantage of their hydrodynamic properties, protein concentrates and isolates with varying purity and functionality can be obtained.

*Protein extraction.*The protein extraction processes generally used are (1) pin-milling plus air-classification which when applied to starch-rich legume seeds (peas, beans), results in concentrates (defined as having protein contents of 60–75 %), and (2) wet processes (e. g. alkaline extraction/isoelectric precipitation, acid extraction) which produce isolates (defined as having protein contents of 90 % to 95 %) [28]. By air-classification, concentrates having 68 % and 65 % protein can be obtained, respectively, from bean (31 % protein) and pea (21 % protein). Isolates, prepared by extraction of the flour proteins with alkaline solution followed by acid precipitation, have a protein content generally between 90 % and 96 % and a protein recovery yield varying between 60 % and 65 % [28].

Air classification and pin milling are generally used to fractionate legumes into a light or fine fraction (protein concentrate) and a heavy or coarse fraction (starch concentrate) [29]. Using this method, whole or dehulled seeds of legumes are pin – milled and then yielded flours are fractionated into “protein” and “starch” concentrates using air classifier (Fig. 3). The purity of the protein fraction obtained using this process is, however, low (38–65 %) and further processing is often required.

Alkaline extraction and acidic (isoelectric) precipitation (Fig. 4) is one of the commonly applied methods for protein isolates [30]. The basis of such method lies on the application of different solubility and precipitation profiles of proteins [30]. Higher solubility is observed at the alkaline and acid pH range whereas lowest solubility occurs at the isoelectric point (around pH 4–5). This phenomenon provides the basis for many protein isolation techniques as acid, alkaline extraction and isoelectric precipitation.

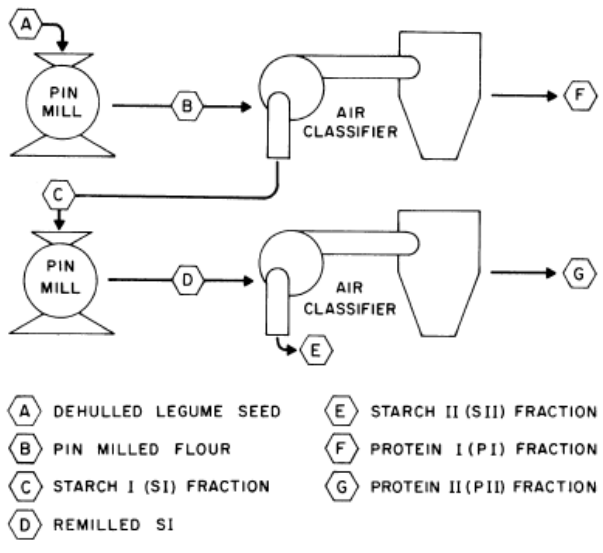

Fig. 3. The pin-milling and air-classification process [31]

During the process of alkaline extraction and acidic precipitation of protein, the raw material is usually subjected to an alkaline pH level between pH 8 and 11 where the protein is found to be the most soluble [30]. The pH of the soluble protein fraction is then adjusted between pH 4 and 5, where the isoelectric points of most of the vegetable proteins lie [30].

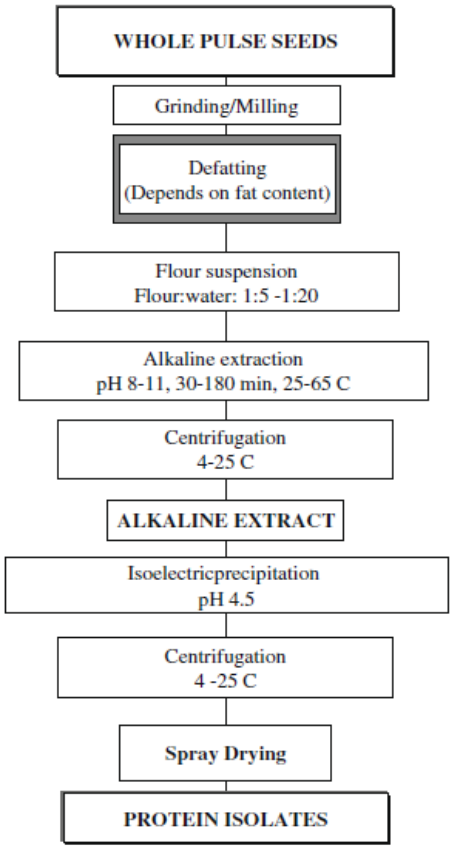

Fig. 4. Flow diagram for the preparation of protein isolates [27]

Legume proteins can be produced using acid extraction or may also be directly extracted with water without the subsequent acid precipitation step [27]. The principle of acid extraction is similar to that of alkaline extraction except that the initial protein extraction is conducted under acidic conditions.

Solubility of pulse proteins is also high under very acidic conditions (i. e., pH < 4). Authors studying the direct acidification (pH 4.4–4.6) of the supernatant from starch extraction of pin-milled faba beans and peas obtained protein contents of 91.2 % and 91.9 % for faba bean and pea, respectively [27].

The salt extraction process, sometimes also referred to as micellization is based on the salting-in and salting-out phenomenon of food proteins [27]. In this process, after extraction of protein using an appropriate salt solution at desired ionic strength, the solution is diluted, inducing protein precipitation that can then be recovered by centrifugation or filtration, followed by drying.

More recent research findings have shown that techniques such as membrane separation can yield protein isolates with improved functionality [29]. This latter

technique can also be effectively used to remove some anti-nutritional components [29].

Protein isolate could be produced using alkaline extraction and a novel ultrafiltration/diafiltration (UF/DF) process. Membrane separation is a frequently used alternative to isoelectric precipitation. In this process, the supernatant obtained either after alkaline or acid extraction is subjected to ultrafiltration or ultrafitration/diafiltration to concentrate the proteins. Ultrafiltration (UF) is a pressure-driven membrane process and is one of the most widely used forms of Membrane-based Tangential Flow Filtration (TFF) for proteins separation. Depending on the protein to be retained, membrane nominal molecular weight limits in the range of 1 kD to 1000 kD are used. Diafiltration (DF) is a TFF process that can be performed in combination with ultrafiltration to enhance either product yield or purity. Boye et al. [27] research showed that UF/DF process yielded protein concentrates of pulses (pea, chickpea and lentil) with slightly higher protein contents compared with the isoelectric precipitation (IEP) process. Studies conducted by Fuhrmeister and Meuser [32] also found that wrinkled pea concentrates prepared by ultrafiltration had higher protein content (70–80 %) and lower fat content (2.3 %) than concentrates obtained by isoelectric precipitation (68 % and 3.8 %, respectively). Hojilla-Evangelista et al. [33] evaluated UF/DF method for the production of protein products from undefatted lupin (*Lupinus albus*). UF/DF produced only protein concentrates (73 % crude protein, dry basis), while acid-precipitation (AP) produced protein isolates (about 90 % crude protein). The surface hydrophobicity and emulsion activity indices of lupin proteins were significantly improved by using UF/DF.

As a rule, isolates resulting from ultrafiltered extracts have a higher protein content. Extraction of α-galactosides significantly increased protein content up to 45 % in *L. Albus, L. angustifolius* and *L. luteus* species [1, 34]. Significant increase of lupin protein extraction was an effect of fermentation with participation of the lactic acid bacterium [35]. From the nutritional evaluation of these two types of products, concentrates and isolates, it appears that wet processes are more efficient for eliminating antinutritional factors. α-galactosides and glycosides are present in isolates only in traces. As for trypsin inhibitors and haemagglutinins, only one third of the activities in the flour remained in the isolates (in dry processes, the residual levels of these antinutritional factors were higher).

4. Chemistry and functional properties of legume protein isolates

The functional properties of a protein are: "Those physical and chemical properties, which affect the behavior of proteins in food systems during storage, processing, preparation and consumption" [36]. The functional properties of proteins have been classified according to the mechanism of action on three main groups: (i) properties related with hydration (water and oil absorption, solubility) (ii) properties related with the protein structure and rheological characteristics (viscosity, elasticity, gelification), and (iii) properties related with the protein surface characteristics (emulsifying, foaming) [37]. Properties of most interest in food processing include solubility, water binding, fat binding, emulsification, foaming, gelation, thickening and flavor binding. The factors that affect functional behavior of proteins in foods are their size, shape, amino acid composition and sequence, net charge, hydrophobic acid structure, molecular rigidity in response to external environment (humidity, temperature, salt concentration) or interaction with other food constituents [36].

The solubility of a protein is the most important functional property since the protein needs to be soluble in order to be applicable in food systems. Other functional properties like emulsification, foaming, and gelation are dependent on the solubility of proteins [38]. Solubility can be described as when equilibrium exists between hydrophilic and hydrophobic interactions. Protein solubility depends on the hydrophilicity/hydrophobicity balance of the protein molecule but mainly on the composition of molecular surface in terms of polar/non-polar amino acids that in turn affects the thermodynamics of protein–protein and protein–solvent interactions. Legume globulins, are relatively hydrophobic in nature and tend to exhibit reduced solubility at pH environments close to the protein isoelectric point, where electrostatic repulsion and ionic hydration of molecules reach a minimum. In general, the solubility of a number of pulse protein materials is very low at a pH range between 4 and 6 but exhibits a sharp rise when the pH is moved either to more acidic or to neutral and alkaline environments. The solubility is influenced by pH, temperature and ionic strength, freezing, heating and drying [39].

Protein isolate because of its hydrophilicity or hydrophobic balance, depending on surface activity agents, can form and stabilize the amino acid composition, particularly at the protein emulsion by creating electrostatic repulsion on oil surface [37]. Protein isolates are widely used as emulsifiers in various food products.

Foams are formed through unfolding and absorption of the protein, at the air-water interface, as well as film formation around the air bubbles. Different proteins have different abilities to form and stabilize foams, and just as in the case of proteins and their different emulsifying properties, this is related to different physical properties of the proteins. For a protein to have superior foaming properties, it must possess high solubility in the liquid phase as well as the ability of quickly forming a film around the air bubbles in the food system [40]. The extrinsic factors that affect the foaming properties are e.g. pH, temperature and ionic strength. The protein should also have the ability to form strong bonds like hydrogen bonding and hydrophobic interactions.

According to Ikeda and Nishinari [41] protein gelation is one of the most important functional properties when it comes to modify the structure and texture of foods. Globular proteins, such as soybean protein, are able to form gels upon heating [40]. For a gel to form it is important that the functional groups (e. g.

hydrophobic groups) within the protein are exposed. This makes it easier for the groups to interact and form a three dimensional network. Gel formation is complicated, and affected by the concentration of protein, amount of water, ionic strength, time and temperature as well as pH and interaction with other components in the food system [39]. Proteins containing a high frequency of non-polar amino acid residues tend to form coagulum type gels [42], whereas proteins containing a high frequency of hydrophilic amino acids form transparent gels.

Modification of food proteins is being increasingly considered as a viable approach for the improvement of the physicochemical properties of proteins [43]. Physical, chemical, enzymatic or genetic methods are used for protein modification [43]. For example, functionalities of soy protein concentrates and isolates can be modified by adjustment of pH with sodium or calcium bases, application of mechanical stress, hydrolysis by proteolitic enzymes before drying [44]. Acylation of legume proteins, which involves chemical derivatization of groups such as ε-amino group of lysine in proteins with succinic anhydride, increases emulsifying capacity and foam capacity of the protein [45]. These modifications alter chemical, structural and physicochemical properties of proteins and create new interactions between structure and functions.

Conclusion

Legumes are food resources that offer various health benefits. Legumes have many good qualities and can be considered most suitable for the preparation of protein isolates because of their high protein content, low cost and wide acceptability. Various methods are used for protein extraction and every technique has its own advantages. The functionality of legume proteins is closely related to their physical and chemical properties, such as molecular weight, amino acid composition and sequence, structure, surface electrostatic charge, and effective hydrophobicity. Physical, chemical, enzymatic or genetic modifications of proteins can alter proteins functionality. Because of the functional properties of protein isolates, their application to food products is increasing.

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ANKŠTINIAI AUGALAI: SUDĖTIS, BALTYMŲ EKSTRAKCIJA IR FUNKCINĖS SAVYBĖS. APŽVALGA

S a n t r a u k a

Dėl didelio baltymų kiekio ir naudingos maistinės vertės ankštiniai augalai (lubinai, žirniai, pupos ir sojos pupelės) atlieka svarbų vaidmenį žmogaus mityboje. Vartojant kartu su grūdų produktais ar kitais maisto produktais, praturtintais sierą turinčiomis aminorūgštimis ir triptofanu, ankštiniai augalai suteikia energijos, yra sveikatai reikalingų baltymų, mineralinių medžiagų ir maistinių skaidulų šaltinis, turintis gerai subalansuotą aminorūgščių kompleksą. Kai kurie ankštinių augalų antimitybiniai junginiai gali būti toksiški, nemalonaus skonio ar sunkiai virškinami, tačiau jie pašalinami atrinkus tinkamus genotipus ar taikant technologinius procesus po derliaus nuėmimo. Maisto pramonėje vis labiau domimasi baltymų koncentratais ir izoliatais, nes jie turi svarbių funkcinių savybių ir gali pagerinti maisto produktų mitybinę vertę ir kokybę. Baltymų koncentratams ir izoliatams su savitomis funkcinėmis savybėmis gaminti taikomi įvairūs technologiniai sprendimai. Dėl tokių funkcinių savybių kaip emulsavimas ar želatinavimąsis ankštinių augalų batymai tampa vis svarbesniu pakaitalu gaminant daugelį maisto produktų.

Šiame apžvalginiame straipsnyje pateikiama ankštinių augalų (lubinų, žirnių, pupų ir sojos pupelių) cheminė sudėtis, antimitybiniai junginiai, esami ir nauji baltymų koncentratų ir izoliatų išskyrimo metodai ir pagrindinės funkcinės savybės.

Reikšminiai žodžiai: cheminė sudėtis, antimitybiniai junginiai, baltymų izoliatai, funkcinės savybės.