NON-ALLERGENIC PLANT PROTEIN SOURCES

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Abstract
An increase in the incidence of allergic reactions to the proteins in food products has led to the search for more suitable protein sources that do not trigger an adverse reaction in individuals. Moreover, a major fraction of the population is adopting a vegetarian or vegan lifestyle, causing them to explore high-quality plant-based protein sources that can fulfil their dietary requirements. Being economical and sustainable, plant proteins have the potential for solving the problem of Protein Energy Malnutrition (PEM) in the under-developed and the developing countries. An interesting method of extracting proteins is by converting them to protein isolates and concentrates so that they can offer high protein products, and encourage their utilization in a broad range of food products, and thereby supplementing the diet. Some of the non-allergenic plant protein sources are reviewed in this article to highlight their potential in the food industry, and their functional properties like solubility, gel-forming capacity, foaming ability, rheological property, water-holding capacity, oil-holding capacity, and emulsifying capacity, so that more research can be done to improve them using better isolation techniques and other treatments. This will encourage their application in more diverse varieties of food products besides protecting the protein in oilseeds leading to their utilization instead of wastage.

Keywords: plant protein, vegan, vegetarian, non-allergenic food, functional properties, protein isolate, protein concentrate, food applications

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1. INTRODUCTION

Food allergies occur when the susceptible individuals become sensitized to specific food proteins, leading to the production of specific IgE against the food protein. The IgE recognizes the allergens on subsequent exposure leading to health effects ranging from mild reactions to potentially fatal reactions like systemic anaphylaxis. Due to the steady increase and prevalence of food allergy it is important to find suitable non-allergenic proteins.

Plant protein presents a lot of opportunity as it's cheap and abundant. The increase in global population, increased protein consumption which resulted from rising income, the limited availability of animal protein and the growing health concerns related to the benefits and safety of animal-based protein raises the demand for proteins from vegetarian sources.

To utilize plant proteins in the food industry, it is also important to characterize them in terms of their functional properties. Some of the functional properties of proteins are solubility, gel forming capacity, foaming ability, rheological property, water- and oil-holding capacities, and emulsifying capacity, and these properties are influenced by the amino acid composition, structure, molecular size and charge distribution in the plant protein.

2. NEED FOR PLANT PROTEIN:

According to the Food and Agriculture Organization of the United Nations (FAO), there would be an increase in population up to 9 billion in the year 2050. The consumption of animal proteins has been continuously increasing which affects gas emission from cattle breeding which represents an ecological issue. Moreover, the population in under-developed and developing countries face protein-energy malnutrition (PEM), commonly seen among children and the elderly causing the popularity of high protein foods and of the so-called "protein diets" (Hadnađev et al., 2017).

There has always been an active search for other protein sources to satisfy the human nutritional

requirements due to the high cost of animal protein (Ambriz et al., 2005).
The consumer confidence in animal proteins has decreased due to food safety issues related to the use of animal hormones and diseases like bovine spongiform encephalopathy. When converting vegetable protein into animal protein, a loss in energy, protein and water is observed. Moreover, the consumption of energy per kilogram animal protein under industrial conditions is 8-10 times more than for vegetable protein. The rising cost for energy and raw materials force the market towards production of low-cost high quality protein foods (González-Pérez & Arellano, 2009).
In developing countries where the average protein intake is less than the requirement, plant protein plays an important role, also vegetable proteins are economical and considered to be resourceful alternatives to animal proteins for use in formulations (González-Pérez & Arellano, 2009).
Plant sources of proteins that are already widely consumed are the ones obtained from soy, wheat, peas and potatoes and oilseed meals, by-products obtained after oil extraction, legume seeds and green plants, which represent exceptional alternative protein sources. In the hopes to use protein sources with high sustainability, low carbon footprint and low cost, isolation of proteins from plant sources like flax, hemp seed meal, canola, rice bran, faba beans, sugar beet leaves, lemna, chickpea, etc. was investigated (Hadnađev et al., 2017).
Special attention has been given to the concentration and isolation of proteins from oil seeds in the last 10 years because these concentrates and isolates offer an opportunity for supplementation and incorporation in a broader variety of foods, and may fit into the needs of infants who require high protein content in their limited food intake.

Protein Isolates

Protein isolates are the most refined form of protein products containing the greatest concentration of protein (up to 90% in legume protein isolates), and no dietary fiber unlike flour and protein concentrates. They are easily digestible and incorporated into different food products, especially in formulated foods because of their high protein concentration with the advantage of colour, flavor and functional properties, making protein isolate an ideal product that can be used in infant foods, children's milk products, beverages, textured protein products and other specialty foods (Garba & Kaur, 2014).
Isolates are derived from plant sources like peanut, soy, wheat, almond, canola, navy beans, etc. and animal sources like gelatin (Garba & Kaur, 2014). The functional properties of protein isolates are influenced by isolation methods and conditions, intrinsic factors (protein conformation and composition) and extrinsic factors (food and model system composition), and their successful use depends on the versatility of their functional properties.

Protein Concentrates

Protein concentrate is a dietary supplement for man or animals. It has a high protein content and may be prepared or extracted from animal or vegetable sources. Protein concentrates are obtained when non-protein components (carbohydrates, soluble minerals, antinutritional factors and some low molecular weight nitrogenous compounds) are eliminated from the source, and removed using aqueous-alcoholic solutions (examples include ethanol, 1-butanol, isopropyl alcohol, etc.), acidic or basic solutions.
Protein concentrates contain small amounts of carbohydrates and the concentration of protein is lesser in protein concentrates than protein isolate (concentrates contain 80% protein, isolates contain 90% protein). Common examples of protein concentrates are leaf protein concentrate (LPC), fish protein concentrate (FPC) and whey protein concentrate.

3. NON ALLERGENIC PROTEIN SOURCES

a. Coconut protein:

The incidences of coconut causing an allergic reaction is extremely rare, leading to its use in infant formulae and foods like chocolates, sweets and cakes (ASCIA, 2019). Although there exists a case report of atopic dermatitis in an infant due to the preparation of infant formula with coconut oil, there are no reports of immediate hypersensitivity to coconut. Due to this lack of evidence on coconut hypersensitivity, patients with nut allergies are not counselled to avoid coconut, thus making it a suitable choice for non-allergenic protein source (Teuber & Peterson, 1999).

Glutelin is the predominant protein fraction in coconut meal. The leftover coconut oil cake also contains 20% high quality proteins with better foaming capacity and emulsion stability index (in comparison with coconut milk cake). On the other hand, coconut milk cake protein showed comparatively higher water and oil absorption capacity (Rodsamran & Sothornvit, 2017). For safe recovery of proteins from coconut oil cake, ultrafiltration is used. In comparison with other protein isolates and concentrates, the emulsion stability of coconut protein concentrate was higher, proving its scope in emulsified food products (Kwon et al., 1996).

b. Buckwheat protein:

The bran milling fraction of buckwheat has a high concentration of proteins, and in the embryo, it reached 55.9%. But the amount of protein in the hull is only about 4%. The main protein fractions in this pseudo-cereal are water soluble albumins and salt-soluble globulins (Christa & Soral-Śmietana, 2008).

The functional properties of buckwheat proteins showed that it has a higher solubility than soy protein, higher fat absorption capacity than casein and soy protein, and relatively high emulsion stability at pH 2-3. These properties make it suitable for use in meat products, sausages and mayonnaise (Tomotake et al., 2002).

The amino acid profile of buckwheat is similar to soy and casein, and being well-balanced, it can be used in infant food (Tomotake et al., 2002). These proteins also have high biological value. The various health benefits of buckwheat proteins are suppression of colon and mammary carcinogenesis (reduces cell proliferation & serum estradiol respectively), suppresses gallstone formation, better hypocholesterolemic activity than soy protein, thereby treating obesity, hypertension, hypercholesterolemia, alcoholism and constipation. It can also be used as prophylactics of GI tract diseases, mainly celiac disease (Christa & Soral-Śmietana, 2008).

c. Pumpkin seed protein:

Pumpkin seeds are usually used for culinary purposes and oil extraction (Vinayashree & Vasu, 2021). Protein isolation from pumpkin seeds helps reduce waste pollution (Mansour et al., 1993). The defatted pumpkin seed meal has a protein content of 60-65%, making it a good plant protein source (Vinayashree & Vasu, 2021). The major protein fraction of pumpkin seeds is globulin (60%) (Mansour et al., 1993). The amino acid profile of pumpkin seed protein was similar to soy protein (Vinayashree & Vasu, 2021).

The functional characteristics of pumpkin seed protein is that it is a high-quality protein (Protein Energy Ratio of 2.70), high emulsifying properties, oil holding capacity and solubility comparable to soy protein). It's high oil holding capacity makes it valuable in sausages, ground meat formulation, meat extenders and substitutes, baked products, soups, mayonnaise and salad dressings. Moreover, it has higher solubility in acidic conditions between pH 2-3, making it a promising ingredient in acidic fruit juice and beverage formulation (Vinayashree & Vasu, 2021). In addition, pumpkin seed proteins have pharmacological benefits like anticancer, antioxidant, antidiabetic, and hepatoprotective activity (Mansour et al., 1993).

d. Oat protein:

The 7th most abundant cereal in the world, oats, has a high protein content (15-20%) compared to other cereals (Mäkinen, 2017; Spaen & Silva, 2021). The endosperm has nearly 12% protein while the bran has 18-26% proteins and the germ has 29-38% protein. Oat allergies are rare and mostly limited to infancy, and the absence of gluten makes it suitable for people with celiac disease (Mäkinen, 2017).

The amino acid profile of oat protein is more balanced than other cereals and the major protein fraction is globulin. The extraction can be done by wet method, followed by centrifugation and decantation to fractionate proteins and isoelectric precipitation or membrane filtration to isolate proteins. Higher protein extraction (90% efficiency) was seen when beta-glucan was extracted from defatted oats before alkaline fractionation (Spaen & Silva, 2021).

The functional properties of oat protein includes low foaming, low solubility, and low emulsification, making its application limited (Mäkinen, 2017). Better foaming ability was observed when supercritical CO_2 based defatted oat flour was used for protein isolation (Spaen & Silva, 2021). Similarly further research to modify the extraction process will improve the functionalities of oat protein. Application of oat protein isolates are seen in meat analogues, breakfast cereals, cereal bars, and bakery products (Mäkinen, 2017).

e. Quinoa protein:

The FAO, 2014, selected quinoa among the crops in the 21st century that has the potential to offer food security (Toapanta et al., 2016). This pseudo-cereal hardly causes allergies and, due to the absence of gluten, it is also suitable for people with celiac disease. Besides being a good protein source, it also contains all essential amino acids making it a complete protein (Bastidas et al., 2016).

The protein content in quinoa is less than legumes but higher than cereals. It has a high biological value (BV) of 73% (similar to beef - 74%) (Bastidas et al., 2016). Its digestibility was 75-84%, which is greater than the digestibility of wheat protein (Elsohaimy et al., 2015). The isolation of proteins can be done by protein solubilization at acidic pH for isoelectric precipitation (Toapanta et al., 2016).

The functional properties of quinoa protein isolate includes increased protein solubility with increasing pH, good water absorption capacity (similar to soy protein), comparable oil absorption capacity, high foaming capacity and stability but low emulsion ability and stability (Elsohaimy et al., 2015). Application of quinoa protein in baked products improves its mouthfeel and flavor retention. Other beneficial factors include lower levels of antinutritional factors, its bioactive components like betaine content which improves diabetes, and high protein levels (Bastidas et al., 2016).

f. Pea protein:

Pea protein isolates are high quality proteins containing all the essential amino acids. Besides the essential amino acids, this protein isolate is rich in leucine, arginine, and glutamine. They are highly digestible (98%). Besides its high protein content, it is also a good source of iron and supports anti-inflammatory gut bacteria. Pea protein isolates account for the largest share in the pea protein market in 2019. They are utilized in various food products like nutrition products, confectioneries, plant-based meat and plant-based dairy. Due to its grainy texture, it is used in smoothies (Collins, 2017).

g. Canola protein:

According to USDA 2010, canola protein is the second largest feed meal. It has a decent amino acid content, but its anti-nutritional aspects prevent it from being widely used in the food business. Alkaline extraction followed by isoelectric precipitation are the most common methods for isolating canola protein. Canola protein isolate was discovered to have poor solubility and digestibility, as well as functional qualities such as water holding capacity, oil binding capacity, gelling capacity, emulsification and foaming (Alashi et al., 2011).

h. Chickpea protein:

Chickpea is the third most widely grown pulse crop and an important source of vegetable protein. Many functional properties of chickpea protein isolate were investigated, but information on gelation properties of chickpea protein isolate was lacking. The rheological behaviour of chickpea protein isolate spread with sodium and calcium salts varies with ionic strength and pH. Increasing the ionic strength of the dispersion could improve the gelation properties of canola protein isolate under acidic conditions while decreasing its elastic parameters at pH 7.0 (Zhang et al., 2007).

i. Cashew nut protein:

The cashew nut has a number of commercially important components. It contains 40-57% fat and 21% protein. Alkaline extraction and methanol or isoelectric precipitation is used to isolate proteins from defatted cashew nut powder. Cashew nut protein was found to possess an emulsifying stability index of 447%, high water absorption capacity of 2.2 ml/g and high oil absorption capacity of 4.42 ml/g, foam stability and capacity of 55 and 45%. However, it has a low gelation capacity of 13.5% (Ogunwolu et al., 2009).

4. CONCLUSION

Due to the growing allergic responses to food products among the population, the need for finding other protein sources to satisfy the needs of the rising world population and increase in people adopting vegetarianism and veganism due to health reasons (like lactose intolerance) or ethical reasons (like animal welfare), the need for non-allergenic plant protein sources will rise in the near future. This leads to the need for further research in improving the functional aspects of the above-mentioned protein sources which could increase the possibility of their application in a broad range of food products. More research is also needed in better methods of protecting the protein in oilseeds so that they can be isolated and utilized wisely. Identification of other plant protein sources which have good quality amino acids and low allergenicity would also encourage their utilization in suitable products, and enhance the development of more creative methods of incorporation.

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