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Review Article

Peanut Protein: Rich Source as Vegan Protein

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Abstract

Protein is a building block and contributor for growth and development and different activities in human body system. Various animal and plant based food are rich source of protein and essential amino acids. Egg protein, milk protein, soy protein, peanut protein and many proteins contain essential amino acids having various health benefits and functional properties. Peanut is an important oilseed and defatted peanut flour is a byproduct of peanut oil milling industry with a rich source of protein. This protein can be concentrated as Peanut Protein Concentrate (PPC) and Peanut Protein Isolate (PPI) with around 80-85% and more than 90% protein, respectively. Peanut protein can be extracted for bioactive peptides, hydrolysates, can also be converted into texturized protein such as meat analogue, packaging film. Favorable functional properties of peanut protein such as emulsifying activity, emulsifying stability, foaming capacity, excellent water retention and high solubility etc. made it versatile for various food system. Various extraction methods such as isoelectric precipitation, aqueous precipitation, isoelectric precipitation, alcohol precipitation, Ultrafiltration (UF) and combination of thereof are used for preparation of PPC and PPI. The peanut protein can compete with another animal and plant proteins with all the required health benefits and functional properties necessary for the food system. There is a huge scope in exploring peanut protein as source of vegan protein.

Keywords: Functional properties; Peanut protein; Vegan protein

Introduction

Nature has classified food as source of energy in various ways according to the need of our body. Different food plays important role in the energy requisites of our body such as physical activity, metabolic process, growth and development and many important activities. Protein and the amino acids are the building blocks of life. They play a critical role as components of blood, muscle, enzymes, hormones and hormone receptors. In addition to this protein also imparts taste, texture and flavor to the food which are very important factors in selecting foods.

In nature, proteins exist as components of biological matrices with other compounds such as lipids, carbohydrates, minerals and other minor components. The vegetable sources of protein concentrate or isolate contain protein in the range of 30 to 50 % while the protein in concentrate and isolate comprise of 60-80 and >90% protein, respectively depending up on the process technology of extraction of protein adopted. For protein extraction, different techniques have been developed among them micellization, ultrafiltration, acidic and alkaline aqueous extraction followed by isoelectric precipitation. On the other hand, protein sources have been added in food elaboration/production due to its physicochemical properties like water and oil absorption capacities, gelification and foaming and emulsifying properties, which affects food protein behavior and influence in quality and organoleptic characteristics from food system. Protein concentrates and isolates from the flour of different foods have been obtained, which decrease the non-protein components in order to obtain a final product with high protein content.

Peanut, an important oil and food crop is currently grown on approximately 42 million acres worldwide. India, China and the United States have been the leading producers for over 25 years and grow about 70% of the world crop. With annual all-season coverage of about 70 lakh hectares, globally India ranks first in groundnut acreage and with an output of approx. 80-85 lakh MT (in shell groundnuts), second in production. Although in various states of India groundnut is cultivated in one or more (kharif, rabi and summer) seasons, nearly 80% of acreage and production comes from kharif crop (June-October). Among the many commercial uses of peanuts, extraction of oil from peanut yields Defatted Peanut Flour (DPF). DPF is an underutilized by-product of peanut processing that has been used for extending comminuted meat products, production of beverages, fermented products, composite flours and protein supplementation of bakery products and weaning foods. Despite the fact that DPF has an excellent potential in food formulations because of the high protein content, its uses remain limited.

In recent years, the need for less expensive proteins and the growing demand for alternatives to meat have increased interest in the potential of peanut by-products as a source of edible vegetable protein such as DPF. As like high protein soya flour, the DPF can be processed to yield meat-like products that can be used to formulate cholesterol-free vegetarian alternatives to many of the traditional meat-based food products. One way of producing meat-like products from DPF is extrusion cooking to texturize peanut proteins into fibrous meat substitutes. Despite the increased use of extrusion processing, extrusion is still a complex process that has to be optimized for specific applications based on the nature of raw materials and desired final product.

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Even within a given extrusion process, small variations in processing conditions affect process variables as well as product quality. Product quality can vary considerably depending on process variables such as the extruder type, screw configuration, feed moisture and temperature profile in the barrel, screw-speed and feed rate and die profile [1].

The peanut proteins had good emulsifying activity, emulsifying stability, foaming capacity, excellent water retention and high solubility and would also provide a new high protein food ingredient for product formulation and protein fortification in food industry [2]. Therefore, the peanut proteins can be regarded as one of the most attractive and promising vegetable proteins. Adequate modification on proteins may improve their functional properties, so detailed investigation of peanut proteins is necessary to elucidate the functional properties of peanut proteins. Similar process was also found to enhance the solubility and other functional properties of peanut proteins. Yu et al. [3], reported that the peanut flour by fermented treatment and Peanut Protein Concentrate (PPC) could enhance the functional properties of peanut proteins and peanut flour. Functional properties of many other plant protein concentrates/isolates produced from peas and beans were also studied by a number of investigators [4]. Functional properties of peanut protein have been the subject of limited studies [2,3]. Among plant proteins, the nutritional value of peanut proteins is lower than soy proteins, but the anti-nutritional factor content of peanut proteins is less than that of soy proteins. So it is important to study the functional properties of protein concentrates/isolates.

Other than contribution from proteins, peanut meals likely possess few other compounds in significant quantities that will impact functionality of peanut proteins, such as polysaccharides. Polysaccharides in manufactured products can improve structure and stability, but it will reduce in vivo and vitro protein digestibility and nutrient absorption. The decrease of protein digestibility by polysaccharides is often explained by the interactions between these two macromolecules that prevent the protein hydrolysis [5]. But little information is available on peanut polysaccharides that actually contribute to total functional properties. The methods of conventional industrial processing peanut oil involve crushing and solvent extraction. Thus, very little attention is given to the protein residue. Due to the denaturizing of protein or residual solvent, the protein residue is mainly used in the manufacture of compound feed stuffs or fertilizer. Although it has been recognized that the peanut protein resource is one of important plant proteins, it cannot be utilized reasonably. Recently, many researchers focus on exploring new technologies to separate peanut proteins and oil.

Traditionally, the separation of peanut proteins had been done by isoelectric precipitation, alcohol precipitation, isoelectric precipitation with alcohol precipitation, hot water extraction and alkali solution with isoelectric precipitation [3]. However, the methods have some fatal defects. For example, a great deal of wastewater produced causes serious environmental pollution and it is also limited capacity of raw material treatment and high consumption of acid and alkali. Moreover, it is easy to cause protein denaturation. Therefore, it is necessary to explore an alternative extraction approach of peanut proteins.

Peanut protein concentration and isolates

Most peanuts grown in the US are used for oil production, peanut butter, confections and snack products. Vegetable oil extraction from peanut yields partially Defatted Peanut Flour (DPF). DPF is a protein-rich, inexpensive and underutilized by-product of the peanut industry that offers the same health and dietary benefits of peanut with less fat. DPF contains 47-55% high quality protein with high essential amino acid content [6] and lends itself being used in many food applications. The development of a Peanut Protein Concentrate (PPC) from defatted peanut flour would also provide the food industry with a new high protein food ingredient for product formulation and protein fortification. The latter is critically needed in many developing countries where protein deficiencies remain a major health problem, especially among children (Table 1).

Preparing Sample	Method	Features	References
Peanut protein concentrates	Isoelectric precipitation	Better functional properties, worse color and flavor, lower extraction efficiency, severe contamination for environment	Liu et al. [7] Yu et al. [3] Wu et al. [2]
	Aqueous precipitation	Poor functional properties, protein denaturation, lower extraction efficiency	Yu et al. [3] Wu et al. [2]
	Alcohol precipitation	Better color and flavor, poor functional properties, lower nitrogen solubility index	Yu et al. [3] Wu et al. [2]
	Isoelectric precipitation and alcohol precipitation	Better color and flavor, poor functional properties, lower nitrogen solubility index	Yu et al. [3] Wu et al. [2]
	Hexane and aqueous alcohol precipitation	Better functional properties, higher nitrogen solubility index, lower coefficient of solvents recovery	Yu et al. [3]
	Ultrafiltration (UF)	no need for any chemicals, higher yield and superior functional properties of the UF protein product non-thermal and non-chemical nature of the UF process, membrane easily contaminated and be difficult to clean	Krishna Kumar et al. [8]
Peanut protein isolates	Alkali solution and isoelectric precipitation	Better functional properties, higher extraction efficiency, severe contamination for environment	Dumay et al. [9]; Yu et al. [3]; Wu et al. [2]
	Ultrafiltration (UF)	No need for any chemicals, higher yield and superior functional properties of the UF protein product non-thermal and non-chemical nature of the UF process, membrane easily contaminated and be difficult to clean	Krishna Kumar et al. [8]

Table 1: Different methods for obtaining the peanut protein concentrate and isolates.

Importance of different functional properties of PPC and PPI

Functional properties of food proteins are important in food processing and food product formulation. Some of these properties are water/oil binding, emulsification, foam affected by the intrinsic factors of protein such as molecular structure and size and many environmental factors including the method of protein separation/production, pH, ionic strength and the presence of other components in the food system. The importance of these properties varies with the type of food products in which the protein concentrate is used. For example, proteins with high oil and water binding are desirable for use in meats, sausages, breads and cakes, while proteins with high emulsifying and foaming capacity are good for salad dressing, sausages, bologna, soups, confectionery, frozen desserts and cakes [10]. Functional properties of protein are influenced by many factors. For end users, pH, temperature and ionic strength of the food system are important factors to consider. For producers, methods and conditions of protein extraction, as well as downstream processing of extracted proteins such as purification and drying are the factors need to be addressed. Methods used to develop plant protein isolate/ concentrate include isoelectric precipitation, alcohol precipitation and hot water extraction.

Peanut protein can be considered from multiple quality perspectives, including seed physiology, seed agronomic performance, human and animal nutrition, flavor development during thermal processing, and peanut allergy, among others. In the case of nutrition, protein is a basic and critical input for human (food) and animal (feed) growth and vitality and the world's protein supplies are under extreme pressure considering our planet's exponentially increasing population. Plant proteins are inherently more efficient to produce than animal protein, and increased future emphasis is expected to be placed on producing more plant protein more efficiently, i.e., with less land, water and inputs, for food and feed. Among regularly consumed nuts (tree nuts and peanuts) worldwide, peanuts have the greatest protein content [11], which is commonly reported near 25.8%. Peanut protein, as a primary component of defatted solids, has shown cardiovascular health-promoting effects in model studies [12].

Amino acid composition

Amino acids are the primary subunits of all proteins and the typical amino acid composition (relative %) of peanut protein derived from either blanched peanut seed or removed peanut testae (skins) is provided in table 2 [13]. Amino acid data for blanched seed is ultimately most relevant to peanut nutrition as the skin only accounts for approximately 3% of the total seed weight after shelling and skins are relatively low in total protein compared with the blanched seed, i.e., approximately 15% versus 25%. For blanched seed, asparagine/aspartic acid and glutamine/glutamic acid residues predominate, accounting for approximately 35% of the amino acids, in good agreement with data from other sources [11,14]. Comparisons across common tree nuts and peanuts show that all are naturally high in these acidic amino acids, in addition to also being naturally high in hydrophobic amino acids, including leucine, glycine and valine, among others [11]. Peanut has a high percentage of arginine (12.5%), which when coupled with its overall high protein content, makes peanut an important dietary source of this amino acid whose consumption has been directly linked to various cardiovascular health promoting activities.

Amino Acid	Defatted Peanut Meal	Peanut Protein Concentrate	Peanut Protein Isolate
Lysine	3.0	3.0	3.0
Histidine	2.3	2.4	2.4
Arginine	11.3	12.6	12.8
Aspartic acid	14.1	12.5	12.3
Threonine	2.5	2.5	2.5
Serine	4.9	5.2	5.1
Glutamic acid	19.9	20.7	21.4
Proline	4.4	4.6	4.8
Glycine	5.6	4.2	4.1
Alanine	4.2	4.0	3.9
Cystine	1.3	1.4	1.4
Valine	4.5	4.5	4.4
Methionine	0.9	1.0	1.0
Isoleucine	4.1	4.3	3.6
Leucine	6.7	6.7	6.6
Tyrosine	4.1	4.4	4.3
Phenylalanine	5.2	5.2	5.6
Tryptophan	1.0	1.1	1.0

Table 2: Amino acid compositions of peanut protein concentrate and Isolate (g AA/16gN_2).

Several measurements of protein nutritional quality based on amino acid composition are found in the scientific literature and these measures are typically a function of the target organism and its amino acid requirements, i.e., human or specific animal, amino acid composition of a given protein source, its digestibility and its subsequent bioavailability [14]. Considering human nutrition, there are 20 common amino acids, nine of which are essential, meaning the human body cannot synthesize these amino acids on its own given adequate calories. Peanut protein, like most vegetable proteins, is incomplete, meaning it is lacking adequate levels of at least one of the essential amino acids necessary for human nutrition. Based on controlled rat feeding studies, peanut is limiting in methionine, lysine and threonine [15]. Considering the recommended intakes of amino acid requirements of 2- to 5-year-old children, the first limiting amino acid in peanut is threonine [11]. While peanut is nutritionally deficient in certain essential amino acids, like most vegetable-based sources of protein, it is recognized that even in developing countries, protein sources are rarely isolated to one particular food and adequate essential amino acid intake is readily achieved by consuming complementary protein sources.

The peanut protein can be used for different food and feed purposes, also to make peanut protein biopeptides, hydrolysates, protein films etc. The peanut protein hydrolysates can be prepared by protein hydrolysis, acid hydrolysis, alkaline hydrolysis, enzymatic hydrolysis and microbial hydrolysis methods are used [16], while peanut protein films can be prepared by formation of peanut-protein-lipid films on the surface of heated peanut milk or by casting of PPC or PPI solutions. The film formation and different properties are greatly affected by pH, drying temperature, plasticizer [17,18].

There is still wide scope of exploitation of knowledge as per requirement of industries. The protein isolates from peanuts have versatile applications as food ingredients and meat analogues and

according to the industrial requirements; PPI can be modified and used for variety of applications.

Summary

Peanut protein has been so far considered as deficient source of amino acids while looking the compositions and importance, it is therefore necessary to enlighten the views and researches to make up peanut protein as a vegan diet source. Similar to other protein concentrates and isolates, protein from peanut has variety of applications in food and other industries as briefed in this article. Peanut protein is also a rich source of Arginine. Arginine or L-arginine is an amino acid that is needed to keep the liver, skin, joints and muscles healthy and is a precursor to nitric oxide that helps to keep the arteries relaxed, improving blood flow and healing time in tissues in the body. Commercialization of peanut protein as a vegan source is therefore having a demanding future, if worked out well.

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