Modification on Pea Protein to Enhance Its Applications in Food Products

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Abstract. Pea is an important nutrient source, as it contains high volumes of protein, starch and fibre. Pea protein is expected as growing alternative protein in current food factory, owing to its global convenience, cost effective high nutrient and wholesome. As several food companies already use pea protein as alternative meat protein to make burger patties. Pea protein is a potential food ingredient because of its solubility, ability to hold both water and oil, ability to form emulsions, and viscosity. Therefore, in this review, pea protein fractions, functional characters and modifications to enhance its applications have been studied. In terms of modifications, pea protein can be modified through physical, chemical and biological approaches. These modifications can potentially improve its solubility, emulsifying ability, digestibility and reduce unpleasant beany flavor. Via these modification techniques, pea protein can be added to meat products and meat analogues to provide nutrients, making it competitive in various processed foods.

Keywords: Pea, Pea Protein, Modification, Pea Protein Applications, Pea Protein Products.

1. Introduction

Proteins make a difference in many food systems on account of their crucial functional traits. These important macromolecules are crucial for maintaining human health [1]. The majority of the proteins utilised by the food industry today come from milk (or whey), soybeans, eggs, etc. [2]. Given that they include all nine necessary amino acids, animal proteins are regarded as complete proteins. The lack of indispensable amino acids including lysine and threonine and sulfur-bearing amino acids like cysteine and methionine, which are required for normal growth and development, is what makes plant proteins, on the other hand, appear to be insufficient [3]. Finding consumer-friendly plant-based protein components to substitute which stem from anaphylactic and animal sources is becoming a growth trend in food business.

The pea (Pisum sativum L.) is one of the most commonly grown and eaten legumes around the world. The main nutrients included in peas are protein (20–25%), fat (1–2%), starch–based carbs (24–49%), and total content of dietary fibre (60–65%), which includes 10-15% insolvable fibre and 2-9% dissoluble fibre. They also conduce to the formation of non-starchy carbohydrates associate with sucrose, oligosaccharides and cellulose [2]. Despite being a more modern kind of plant protein, pea protein is an increasingly popular in the food industry because of its widespread accessibility, cost effective, high content, as well as several therapeutic gains [1]. Regular consumption of foods high in pea protein lowers the risk of developing diabetes and cardiovascular disease. It might be preventive against a variety of cancer diseases [2]. In general, pea proteins contain lots of bioactive small peptides, which are hypoallergenic and have health advantages including being antioxidant, anti-hypertensive, anti-inflammatory, controlling the activities of industrial bacteria, and decreasing cholesterol [1].

The development and production of dairy analogue drinks, fermented goods, and curd are aided by the functional features of pea protein and the capacity of its fractions forming a soft gel. In this review, the author will study the pea protein’s functional characters, such as protein fractions and physiochemical characters. Modifications on pea proteins to enhance its food product applications.

2. Pea protein and its fraction

Field peas are a major source of nutrients and may be fractionated into different types of ingredients and food that are richer in nutrients such as protein, starch, fibre, etc. [2]. Pea protein as a comparatively novel plant protein is steadily getting popular in the worldwide food industry owing to its accessibility, affordability, nutrient content as well as healthy advantages [4]. Neary 70-80% of the protein in pea protein is made up of globulins, with albumins making up 10-20% (Table 1), the rest portion is made of glutelin and prolamin.

Globulin could release nutrients for plant growth during seed germination by broken down. It is also soluble in salt solutions [1]. 18-25% of the gross protein in pea germ is the water-soluble albumin (2S), which is present in pea germ. It is thought to be a supersession and zymoprotein protein that functions in the cytosol and contains elements that are beneficial for seed germination [5]. Prolamin is a type of storage proteins found in plants, and pea seeds contain a little quantity of it. Due to its high concentrations of glutamine and proline, it is typically only soluble in concentrated alcohol solution (70–80%), low-concentration acidic and alkaline solutions [6]. Some grass family seeds contain in their endosperm the insoluble protein glutelin, a subclass of gliadin-like proteins, in their endosperm. It is also slightly present in pea seeds and plays a significant role in the protein composite known as gluten [4].

Table 1. The content and characteristic of pea protein fractions

Class	Content	Solubility	Protein	MW	Peptide
Globulin	70-80%	Salt solution	Legumin	320-410 kDa	40 kDa acidic 20 kDa basic
			Vicilin	150 kDa	N/A
			Convicilin	180-210 kDa	N/A
Albumin	10-20%	Water solution	Albumin	68.5 kDa	PA1a 53 aa 5.8 kDa PA1b 37 aa 4 kDa
Prolamin	4-5%	Alcohol solution	Prolamin	N/A	N/A
Glutelin	3-4%	Insoluble	Glutelin	N/A	N/A

Field peas have a balanced distribution and contain a lot of lysine [6]. In a range of functional products, pea protein is commonly applied to replace soy or animal proteins on account of its convenience, affordability, nutrient content, and health goodness [4].

3. Methodology

3.1. Physical transformation

3.1.1 High pressure therapy

Using high hydrostatical pressure (HHP) in the scope of 100 to 800 MPa for several minutes, is a non-thermal method that was adapted from isostatic pressing [6]. Because it can disclose sulfhydryl groups that are otherwise buried when proteins are unfolded, denaturated, subsequently aggregate and coagulate, and an improvement in functional characteristics, the HHP process aids in the improvement of protein hydrophobicity while decreasing solubility [7]. Increased surface hydrophobicity, sulfhydryl and secondary structural alterations are among these structural changes, can improve the protein's heat stability and emulsifying abilities [6]. When pea protein is treated with high pressure supercritical CO2, its solubility is not greatly affected, but its foaming stability and emulsifying ability are significantly increased [7].

3.1.2 Heat with projection

Projection is a process that combines mechanical shearing, pressure and heat. A high temperature (90–200 °C) and high pressure (1.5–30.0 MPa), large rotary screws generate high mechanical stress

[8]. Pea protein molecules are unfolded, denaturated, and realigned during extrusion, which enhances their functional characteristics and creates texture, since extrusion is a high-temperature short time technique [8]. Through the increment of availability of the amino acids, when proteins are extruded at elevated temperatures and pressures, they become more digestible, which also impacts the anti-nutrients [8].

3.1.3 Cold air plasma treatment

The use of cold plasma is the cornerstone of dealing with cold atmospheric plasma, is achieved over a wide temperatures and pressures range, combining thermal, mechanical, nuclear and electrical energy [9]. This method has the advantages of homogeneous heating without heat damage and the lack of dangerous chemicals. Enzymatic stability and microbiological product safety have been the key objectives of this treatment [9]. It is used to make plant-based proteins more functional and reduce the protein molecule sizes while suppressing aggregations [10]. The secondary structure of pea protein is altered by cold plasma, which leads to increased solubility, emulsifying power, and ability of holding water. Additionally, by enabling pea protein to gel at temperatures below 90 °C and by raising PPI solubility, it enhances the gelling capabilities of pea protein [9].

3.1.4 Ultrasonic treatment

Because non-covalent interactions are broken during ultrasonic treatment, protein conformation and structure can be changed using this non-thermal green technique [10]. As a result, it can completely denature the protein's secondary structure while only partially altering the tertiary and quaternary structures [9]. Pea protein solubility was markedly improved by US treatment, and it continued to improve with longer sonication periods. High-intensity US processing also successfully enhanced the foaming and emulsifying abilities of pea protein [10].

3.2. Chemical transformation

3.2.1 Glycation

Glycation is an exogenous chemical-free glycosylation procedure that modifies protein functions without enzymes or other external substances. Chemical glycation takes place using the covalent conjugation approach through carefully regulated heating while being exposed to water employing a range of techniques, such as molecular crowding, moist heating, and dry heating [11]. The production percentage, quality, and the use of glycosylated proteins can be increased through adjusting various factors such as duration, temperature, composition, acidity, moisture content, and reaction concentrations, all these factors should be under control [12]. The alterations in the glycated protein's aromatic profile suggest that the Millard reaction not only reduces the odour of beany but also enables the use of such substances in food formulations without negatively impacting their organoleptic qualities [13]. Furthermore, poor solubility as a primary drawback of pea protein can also be improved by glycation. For example, gum arabic glycation improves solubility approximately 5.5% [11].

3.2.2 Acylation

Proteins can be acylated by adding acyl groups using acyl anhydrides and acyl halides. This procedure can be classified as either acetylation or succinylation depending on whether the acylating reagents are acetic acid or succinic anhydride, respectively [13]. A common reagent for acetylating proteins is acetic anhydride, which covalently attaches acetyl groups to the amino groups, which causes the protein to unfold. Hydrophilicity rises and improves solubility by exposing the hydrophilic groups. Plant-derived proteins' secondary structure is altered by acylation, as well as tertiary conformation, which increases their hydrophobicity and may enhance their functional characteristics without impairing their nutritional value [13]. The pea proteins’ waterholding capacity, emulsification stability, solubility, and foaming properties all enhanced by the effect of succinylation on secondary structure [13].

3.2.3 Deamidation

Deamidation is the approach of raising the protein's negative charge in order to produce carboxyl groups by the conversion of amide groups of glutamine and asparagine residues. While acylation requires chemicals, deamidation can be accomplished under benign condition without the addition of any more molecules. It is therefore regarded as a secure way of protein modification in food systems [14]. For the deamidation of proteins derived from plants, glutaminase is the enzyme most frequently utilised. A novel kind of protein-deamidating enzyme is protein-glutaminase. In addition, it facilitates the release of ammonia during the deamidation of glutamine residues in the underlying protein or peptide to glutamate [14]. Pea protein's solubility and technological functionality are enhanced by the glutaminase deamidation procedure, which also lessens the lumpiness, bitterness, and bad bean taste [14].

3.3. Biological transformation

3.3.1 Enzymatic transformation

Since the reactants and byproducts of enzymatic modification are non-toxic, it is one of the most widely applied approaches to change proteins, especially for their incorporation into food systems. Furthermore, this type of alteration can be carried out in low-stress environments with few byproducts. After the enzymatic transformation, the chemical content of the original protein will be kept as opposed to chemical modification [15]. The rapid response time and enzyme specificity of enzymatic modification over chemical methods are further benefits. This type of protein transformation can be divided into two categories: enzymatic crosslinking as well as enzymatic hydrolysis [15]. Enzymatic crosslingking is accomplished by catalysing an acyl transfer between the protein-bound glutamine and lysineγ-formamide groups (Figure 1), whereas enzymatic hydrolysis is acquired by enzymatic digestion to break peptide bonds [16].

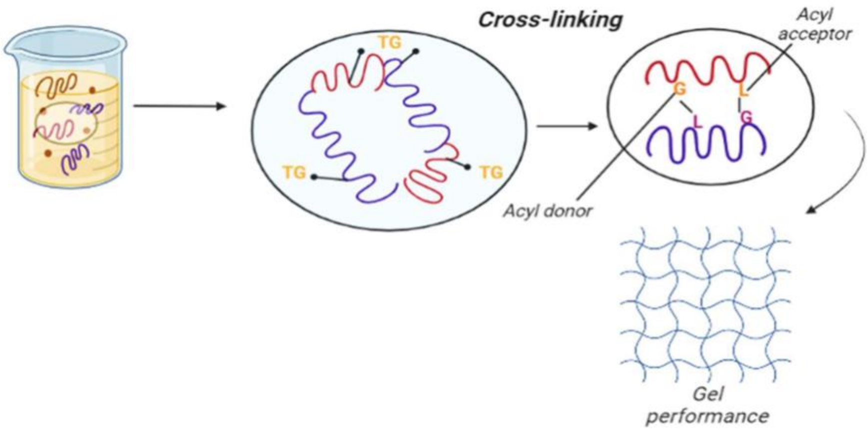

Figure 1. Enzymatic crosslinking modification of pea protein [16]

Transglutaminase and laccase are used to do this. Different enzymes can be used for crosslinking to modify proteins obtained from plants. The type of enzyme, the protein substrate, the volume ratio of enzyme to substrate, the processing conditions (acidity, temperature and pressure), and the presence of protease inhibitors are some of the variables that affect proteolytic digestion [16].

3.3.2 Fermentation

In order to biologically modify proteins derived from plants, fermentation is a time-honored and economical approach. For fermenting plant proteins, a variety of starter cultures are utilised, containing yeast, mould, bacillus strains, and lactic acid bacteria, while lactic acid bacteria are the most natural [17]. Soy protein solubility, water and oil retention capacity, and foaming qualities are all thought to be improved through fermentation [17]. Fermentation is also used to boost nutritional qualities, as well as the structure and functional features of food [16]. Owing to the production of organic acids by microbial metabolism, which subsequently interact with mineral molecules to make soluble complexes. Fermentation also increases the bioavailability of minerals by limiting the development of insoluble mineral-phytate complexes [17].

4. Pea protein food products

Pea proteins are regarded as useful nutrients to increase the diet's protein content, and also acted as emulsion and foam stabilisers, gelation and thickening agents, and fat-binding agents. They can be modified through different methods (Table 2). They also have biological characteristics like anti-oxidants or antibacterial activities. Pea protein could be found in dairy, meat, cereals and baked goods that are intended for human consumption [17]. Peas are added to a number of meat products and meat analogues, according to formulations, techniques, and regulations. Pea proteins are high in amylose content, carbohydrate retrogradation, and gelation assist it to bind moisture and fat and also provide it with a firm texture. Due to their usefulness, flavour, and texture characteristics, peas historically enhanced processed meat products with various substances. Pea proteins could alter the nutritional value of food, yet they make splendid processed meat products.

Meat patties that contain pea proteins must become more tender, oily, and less tough than standard. Pea proteins are capable of binding water and fat of processed steaks, which in that case, they function as gels. Adding pea protein isolate (8%) in cooked restructured steaks increases the protein content which makes them harder, chewier, gummier, and more cohesive [17]. Pea proteins have a high binding ability, which creates a stronger network in processed meat products, and lovers of cooking losses of them.

Table 2. Different Modification Treatment and Characteristics [13,16]

Physical Modification	**Characteristics**
High Pressure Treatment	Structural changes, foaming stability, and enhanced emulsifying property
Heat with Extrusion	Improve protein texture
Cold Atmospheric Plasma Treatment	Improve solubility, emulsifying ability, and water holding capacity
Ultrasonic Treatment	Improve gelling properties and enhance solubility
Chemical Modification	
Glycation	Reduce beany flavor
Acylation	Improve solubility, Emulsion stability, water holding capacity, and foaming properties.
Deamidation	Improve solubility&Reduce unpleasant beany flavor, bitterness, and lumpiness
Biological Modification	
Enzymatic Modification	Improves protein digestibility
Fermentation	Improves protein solubility, hydrophobicity, emulsifying and foaming properties

5. Conclusion

Pea proteins have numerous industrial uses, such as emulsifying, gelling, binding, and film-forming, they also have been increasingly used among worldwide food businesses during the past few years. Creators in the food manufacturing industry are looking for protein components to substitute existing plant-based or animal-based proteins in order to stay up with changing customer preferences. The availability, affordability, allergenicity, and high nutritional value of pea protein have all increased interest in it. Pea proteins are also non-genetically modified, gluten-free, and have outstanding functional characteristics. Pea proteins have some limits in terms of their functioning, flavour, and colour, just like other plant proteins do. Pea proteins may produce less pliable and brittle gels during food processing than soybean protein. These factors limit the usage of plant protein as a component in food systems. Hence, to partially or totally substitute animal protein, effective modification techniques of plant protein extraction require thorough study.

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