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Functional properties and food processing applications of plant proteins

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Abstract

The plant sources with high protein content with good functional properties are suitable for food applications. There are two methods to extract the protein from plant sources such as dry processing method and wet processing method. In this paper, protein extractions using wet processing methods such as alkaline extraction, functional properties and applications in food processing industries were reviewed.

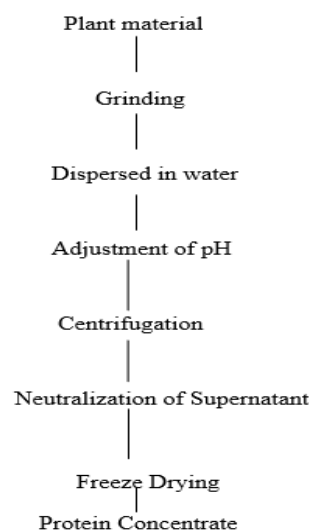
Keywords: Pulse proteins, protein concentrates, wet processing technology, alkaline extraction

Introduction

Protein concentrates and isolates are often used as a valuable ingredient in food products development, primarily to improve the nutritional, physicochemical, textural and sensory properties of food products. Proteins supplies in food processing industries are obtained from different sources; they include animal proteins such as gelatine, vegetable proteins such as soybean protein, and animal-derivatives protein such as milk. Most vegetable proteins need to be processed to make them valuable food ingredients of acceptable functional properties (Ibrahim *et al.*, 2021)^[6]. Plant proteins, especially from legumes, cereals, fruits and vegetables and tubers have been used by food industries as ingredients in food products for many years because of their amino acid profile.

Protein Extraction

Generally alkaline extraction can be used to isolate the proteins from plant sources. There are two methods to isolate the proteins such as dry method and wet method. Wet processing methods such as alkaline extraction, water extraction, acid extraction and salt extraction can be used to purify the proteins from plant sources.

Extraction of Proteins

Functional Properties

Differences in structure and composition of protein can lead to differences in protein functionalities that can be used in food processing applications (Kim *et al.*, 2020)^[7].

Protein solubility

Protein solubility can be determined at different pH ranges from 2 to 12 by dispersing the protein samples in distilled water and then stirring followed by centrifugation. The supernatant is collected and subjected for protein content analysis. Protein solubility can be determined by percent ratio of the protein content in supernatant and total protein content in initial sample. Protein Solubility is used as a useful indicator to determine the utilization at different food processing operations. Maximum proteins are solubilised at alkaline conditions and acidic conditions, because major portion of proteins are soluble in alkaline and acidic conditions only (Ibrahim *et al.*, 2021)^[6].

Water holding capacity

Briefly, 20 mg of protein sample and 1.5 mL of distilled water or soybean oil were mixed in a vortex in a 2 mL centrifuge tube for 20 s. After incubation at 30 °C for 30 min, the tubes were centrifuged at 15,000×g for 20 min at room temperature. The free water or oil was removed using a pipette and the sample was re-weighed. The WAC and OAC were expressed as grams of water or oil absorbed per gram of protein sample.

Foaming capacity and stability

The foaming capacity (FC) and foaming stability (FS) were determined using a modified method of (Rodsamran & Sothornvit, 2018)^[8] from coconut milk cake and oil cake were analyzed using SDS-PAGE (Fig. 1). The protein Twenty milliliters (V) of protein solution (10 mg/mL) was prepared in distilled water and its pH was adjusted to 11. The solution profiles from milk cake (lanes 2–4) showed more intense bands than was stirred at 30 °C for 30 min and then homogenized at 13,500 rpm for from oil cake (lanes 5–7) corresponding to the concentration of each extracted protein found in Table 1. The higher protein molecular 1 min in a high speed homogenizer (Polytron® PT-MR 3100D, Kine-weight (> 250 kDa) retained at the top of the separating gel occurred in maticca AG, Luzern, Switzerland). The whipped protein solution was transferred into a 50 mL graduated cylinder and the volume was recorded at 0 min (V0) and 60 min (V1).

Emulsification Properties

The emulsifying activity index (EAI) and the emulsifying stability index (ESI) were determined according to the standard method. The protein solution (10 mg/mL, WE) was adjusted to pH 11 and stirred at 30 °C for 30 min. Then, 18 mL of protein solution was mixed with 2 mL of soybean oil and then homogenized at 13,500 rpm for 1 min. The emulsion (50 µL) sample was pipetted at 0 and 10 min from the bottom of the tube and diluted with 5 mL of 0.1%.

Food processing applications

Various research studies have suggested that regular dietary intake of plant proteins may reduce the risk of developing chronic diseases such as obesity, diabetes, heart disease and cancer. Furthermore, regular consumption of pulses may assist with weight management by increasing the feeling of satiety and also controlling blood sugar and appetite due to their low glycemic index. In addition to their health and

nutritional benefits, the functional properties of pulse ingredients could play an important role in food systems. Techno-functional properties of interest in food formulations include solubility, water binding, fat binding, emulsification, foaming, gelation, thickening and flavour binding capacity. These physico-chemical properties play an important role during food processing, storage, preparation and consumption. Amino acid composition, structure and conformation and interactions between proteins and other food components (e.g., salts, fats, carbohydrates and phenolics) as well as pH, temperature (Zare *et al.*, 2015)^[12].

Interest in plant proteins as an alternative to animal protein has currently grown due to the increase in consumer demand originating from health concerns, religious restrictions and vegetarianism trends with a comparative low cost. Many plant residues from food industries are good candidates as low cost materials for plant proteins, especially from oil processing. Coconut milk press cake and peanut cake are such residues due to their large amounts of desirable protein recovery.

Coconut cake, a by-product from milk and oil extractions, contains a high amount of protein. Protein extraction from coconut milk cake and coconut oil cake was investigated. The supernatant and precipitate protein powders from both coconut milk and oil cakes were compared based on their physicochemical and functional properties. Glutelin was the predominant protein fraction in both coconut cakes. Protein powders from milk cake presented higher water and oil absorption capacities than those from oil cake. Both protein powders from oil cake exhibited better foaming capacity and a better emulsifying activity index than those from milk cake. Coconut proteins were mostly solubilized in strong acidic and alkaline solutions. Minimum solubility was observed at pH 4, confirming the isoelectric point of coconut protein. Therefore, the coconut residues after extractions might be a potential alternative renewable plant protein source to use as a food ingredient to enhance food nutrition and quality (Rodsamran & Sothornvit, 2018)^[8].

Functional properties of food ingredients in beverage applications are affected by a variety of factors including protein content, pH, ionic strength and temperature. This research illustrated differences in the functional properties of the different pulse ingredients studied. The physical analysis on the beverage systems showed that supplementation at all levels and in both orange and apple juice matrices increased pH and turbidity. Also, apple juice and orange juice supplementation with pulse ingredients decreased cloud stability, however higher level of supplementation resulted in a lower loss of cloud stability over storage time. Color of apple juice and orange juice was significantly affected by pulse supplementation and they were altered towards red and yellow hues respectively. In terms of sensory attributes (flavour, mouthfeel and overall acceptance), 1% or 2% of all pulse ingredients in apple juice and orange juice supplementation gave relatively acceptable products in comparison with the control samples. This result was highlighted for chickpea flour and pea fiber supplemented orange juice. Considering the growing interest in healthier food products and the importance of continued innovation in different product streams, including the development of healthier beverages, there is good potential to examine the use of pulse ingredients in the formulation of pulse supplemented beverages. Further research on the sensory properties, storage stability and marketability of such pulse supplemented beverages would be useful (Zare *et al.*, 2015)^[12].

The addition of plant protein additives to milk beverage affected the pH, titratable acidity %, syneresis, viscosity, dry matter, ash, color (L, b values), protein and amino acid contents ($p < 0.01$). During storage, the viscosity values showed an increase and protein additives increased amino acid levels in fermented milks beverage. The highest essential amino acid content was found in drinks containing SPI, with the most prevalent amino acids being lysine, leucine, isoleucine, methionine and threonine. The taste of fermented milks with PPI was preferred. In general, plant protein additives improved the sensory attributes. ($p < 0.01$). In conclusion, the use of plant protein additives in non-fat fermented milk drink formulations was shown to improve the physico-chemical and sensory properties and to increase the nutritional value of the formulations and therefore could be an alternative strategy for the development of new healthy dairy products (Akin & Ozcan, 2017)^[1].

These plant proteins can be used as a thickening agents, stabilizers, foaming agents, emulsifying agents, water binding agents, fat binding agents in different food processing applications such as beverage industries, bakery and confectionary, extrusion technology, Breakfast cereals, malt food preparations, weaning food preparations, different Pet foods, different functional foods.

Conclusion

It has been found that the plant protein additives that had different compositions and were obtained by different methods enhanced the physico-chemical and sensory characteristics of non-fat fermented milk beverages, enriched their amino acid content and can be used in developing functional milk products. The application of plant proteins with specific combinations of pro- and prebiotics in the production of fermented dairy products can improve the nutraceutical properties and nutritional value of these products. These plant protein concentrates can be used all food processing operations as a food additive.

High temperature-pressure cooking and extrusion treatments are inexpensive processes that combined with ultrafiltration could be used in the production of black bean protein concentrates, suitable for ready to eat formulations, preserving high-quality and high yield. Controlled high temperature-pressure cooking and extrusion processes could enhance some of the techno-functional properties of black bean protein concentrates. However, more experimentation is needed to support this conclusion. Black bean protein concentrates showed improved emulsifying properties at pH 5.0. They could be used as emulsifiers in food applications with pH around 5.0. Further research is needed to investigate the influence of different filtration membrane pore sizes in the obtention of black bean protein fractions. Black bean protein concentrates could be an alternative ingredient for the food industry with enhanced techno-functional properties.

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