Canola proteins for human consumption: Extraction, profile, and functional properties

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Canola protein isolate has been suggested as an alternative to other proteins for human food use due to a balanced amino acid profile and potential functional properties such as emulsifying, foaming, and gelling abilities.

This is a review of the studies on the utilisation of canola protein in human food, comprising the extraction processes for protein isolates and fractions, the molecular character of the extracted proteins, as well as their food functional properties. The majority of studies were based on proteins extracted from the meal using an alkaline solution, presumably due to its high nitrogen yield, followed by those utilising salt extraction combined with ultrafiltration.

Characteristics of canola (and its predecessor, rapeseed) protein fractions such as nitrogen yield, molecular weight profile, isoelectric point, solubility, and thermal properties have been reported and were found to be largely related to the extraction methods. However, very little research has been carried out on the hydrophobicity and structure profiles of the protein extracts that are highly relevant to a proper understanding of the functional properties of food.

Alkaline extracts were generally not very suitable as functional ingredients and contradictory results regarding many of the measured properties of canola proteins, especially their emulsification tendencies, have also been documented. Further research into improved extraction methods is recommended, as is a more systematic approach to the measurement of desired food functional properties for valid comparison between studies.

Factors affecting canola meal

Antinutritional factors in oil-free canola meal are the major obstacle for its use in human food manufacture. Canola meal contains glucosinolates, phenolics, phytates, and a high amount of fibre that makes it problematic for food use (Wu and Muir, 2008; Yoshie-Stark *et al.*, 2008). The impact of these components leads to unacceptable properties of canola meal that include relatively inferior physicochemical properties, poor digestibility, objectionable colour, and bad taste (Wu and Muir, 2008).

Removal of antinutritional factors

Many studies have been carried out to remove or reduce antinutritional factors in rapeseed and canola. Naczk *et al.* (1985) reported a two-phase solvent extraction system to produce canola meal with glucosinolate content decreased to trace levels.

A protein extraction method, which is based on the formation of protein micellar mass (PMM), has proven to be efficient in removing glucosinolates with minimal loss of proteins (Tzeng *et al.*, 1990a), with the reduction in glucosinolate level being associated with the ultrafiltration step as the toxic compounds have significantly lower molecular weights than rapeseed proteins (Ser *et al.*, 2008).

Preparation of seed meals

Canola seeds are typically crushed or ground to aid the separation and defatting process, usually in a Soxhlet apparatus. Removal of fat from the crushed canola seed is normally carried out using hexane as solvent (Tzeng *et al.*, 1988a; Wu and Muir, 2008). The defatted meal is usually dried at room temperature in a fume hood (Aluko and McIntosh, 2001; Ghodsvali *et al.*, 2005) or under vacuum in an oven at 40°C (Tzeng *et al.*, 1990a).

The dried and defatted meal may then be ground to pass through a 40 mesh (Aluko and McIntosh, 2001) or 60 mesh (Wu and Muir, 2008) screen in order to assure thorough interaction of the meal with chemicals during the protein extraction process.

Extraction by alkaline solution

Alkaline extraction with sodium hydroxide (NaOH) solution followed by precipitation with dilute acid is the most typical procedure used in the preparation of canola protein isolates (CPIs) (Klockeman *et al.*, 1997; Aluko and McIntosh, 2001). The reported extraction procedures, however, had slight differences in pH of extraction, concentrations of NaOH used, centrifugation and filtration settings, type of acid, and pH for protein precipitation.

Generally, the alkaline solution was first added to the defatted canola meal and stirred or shaken for a given period to solubilise the proteins. The mixture was then centrifuged, and the pH of the supernatant was adjusted by dilute acid to precipitate the proteins. Precipitated protein was then separated by centrifugation and the precipitate was freeze-dried.

Extraction by PMM method

The PMM method is made up of four main steps that consist of extraction, ultrafiltration, dilution, and precipitation. The defatted meal was first extracted by sodium chloride (NaCl) solution, followed by an ultrafiltration process to concentrate and purify the proteins. This ultrafiltration step has proven to be efficient in removing glucosinolates with minimal loss of proteins (Tzeng *et al.*, 1990b).

The retentate was then diluted with cold water to reduce the ionic strength of the concentrated protein and promote precipitation. Burgess (1991) suggested a dilution factor of one to six to precipitate the purified salt extracted canola protein

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effectively through the formation of protein micelles. The protein micelles were then separated from the water through centrifugation. Precipitates were collected and freeze-dried.

Food functional properties

Functional properties of proteins have been largely classified into three groups, including those related to hydration mechanisms such as water-holding capacity and solubility, those related to structure and rheology such as thickening, viscosity, and gelation, and those related to protein surface such as foaming and emulsification (Damodaran, 1997). In this review, however, based on the relative amount of information available about canola or rapeseed meals and proteins, their functional properties will be classified largely into three groups: emulsifying, foaming, and gelling.

Emulsifying properties

Proteins are an important group of emulsifying agents used in food. Proteins reduce the oil-water interfacial tension and thus facilitate the formation of emulsions as well as stabilise the oil droplets against coalescence (Kinsella, 1982).

During the process of emulsification, proteins with satisfactory emulsifying properties can adsorb rapidly at the newly created oil-water interfaces, followed by structural change and rearrangement at the oil-water interface, and subsequently the formation of a cohesive film with viscoelastic properties due to intermolecular interactions (Damodaran, 1989). Many physicochemical factors are involved in this formation, stability, and textural properties of emulsions (Khattab and Arntfield, 2009).

Foaming properties

Foams are two-phase systems composed of air bubbles surrounded by a continuous liquid lamellar phase (Sanchez-Vioque *et al.*, 2001). Foams can be formed and stabilised by either proteins or surfactants.

Literature shows that canola proteins as foaming agents have been studied mainly in terms of foaming capacity (FC) and foam stability (FS). FC is related to the readiness of proteins to bind to the air-water interface to form foam particles, whereas FS is related to the protein-protein interactions that form strong interfacial membranes that stabilise the foam particles (Kinsella, 1981).

Gelling properties

The gelling properties of canola proteins have been studied mostly in terms of least gelling concentration (LGC) (Gill and Tung, 1978; Khattab and Arntfield, 2009). Test tubes with various gelling concentrations were prepared by heating respective solutions or suspensions, and LGC was determined as the concentration in which the gel in the inverted test tubes did not slip.

Properties of gels produced from canola proteins can also be improved by the addition of polysaccharides. The inclusion of low levels of polysaccharides has been shown to improve gel properties in comparison to canola protein alone (Cai and Arntfield, 1997).

Conclusion

The potential for the utilisation of canola meal proteins in food processing is supported by the fact that canola proteins are balanced in all essential amino acids, having a better amino acid profile than soya bean protein isolates and comparing favourably with the amino acid requirements for both adults and children.

Although antinutritional factors, colour and the taste of canola proteins are major obstacles for their use in human consumption, targeted extraction procedures should be able to overcome these problems. Various methods for preparing CPIs have been reviewed, with the majority of these studies being based on alkaline extraction. However, proteins extracted by alkali were not very suitable as food ingredients, probably due to irreversible denaturation during the isolation process.

As solubility is often considered to be a prerequisite for the performance of proteins in food applications, it is significant that protein isolates from alkaline extraction of canola meal have poor solubility at a neutral pH and poor technological functionalities. Meanwhile, there is evidence of significant amounts of water- and salt-soluble proteins in *Brassica* species.

Thus, a more comprehensive study is warranted that would be based on the utilisation of these soluble fractions in order to provide a better understanding of the characteristics and functionality of canola proteins in food application.

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