Development of Green Process for Extraction of Bioactive Compounds from Flaxseed

Abstract

In today's world, the interest of people is growing towards the consumption of healthy and nutritious food. Consumption of functional foods is growing day by day due to their health benefits; on account of this, the production of safer and bioactive compound-rich food is the need of the hour. This can be possible by developing green solvent-free extraction processes for bioactive compounds and knowing the chemistry of bioactive compounds in terms of their applicability in the proper food system. Researchers, scientists, and food manufacturers now have a greater obligation to provide consumers with naturally antioxidant-rich foods. Due to the constant expansion of the population and the need for adequate nutrition, the search for nutritious foods addresses malnutrition, vitamin and mineral deficiencies, and the treatment of chronic diseases. Functional nutrients and nutraceuticals have paved the way for resolving these problems. Nonetheless, new nutritional pressures, such as nutrition transition, are emerging.

Flax is an oilseed praised for high omega-3 oil, fibre and lignan content. Supercritical carbon dioxide (SCo2) can be used as a green solvent alternative to extract flax bioactive compounds from flaxseed. In this work, the green process is designed to develop different bioactive compounds from flaxseed, i.e., mucilage, oil and lignan. The process of enrichment of flaxseed oil is developed to increase the nutritive value of flaxseed oil. The flaxseed oil is extracted using four different extraction techniques like supercritical fluid extraction, solvent extraction, mechanical extraction and ultrasound-assisted extraction. All characteristics of extracted flaxseed oil are analysed using AOCS analytical methods. It was found that supercritical extracted flaxseed oil has high alpha-linolenic acid content as compared to other extracted oil.

All the physical properties, including length, width, thickness, weight, geometric diameter, bulk density, true density, porosity, and angle of repose, are studied with respect to moisture content. The effect of moisture content on the physical properties by adding different moisture in the range of 2-15% is studied in detail.

The flaxseed mucilage is the gel layer that is present in the flaxseed, and it can be extracted when the seed is soaked in water. The polysaccharide at the epidermal cell layer of the seed coat then becomes viscous in contact with water. The mucilage is extracted by using flax seeds (*Linum usitatissimum L.*) by using hot water in a 1: 10 (w/v) ratio. The effects of different drying methods (oven drying, vacuum drying, spray drying, and drying with ethanol precipitated) on the functional properties of flaxseed mucilage were evaluated. The chemical composition, yield percentage, physicochemical properties,

functional properties, and gel strength of mucilage were studied and compared with those of untreated samples. This study shows that the different drying method has significant effects on the properties of dry mucilage. It is found that spray-dried mucilage powder shows a better yield as compared to the mucilage powder obtained by other drying methods. The oven-dried sample showed the best foaming capacity and foam stability. These results provide guidelines for selecting the best drying method for flaxseed mucilage. The final product flaxseed mucilage powder (dry form) can be utilized as a stabilizer in the food and cosmetic industry.

Flaxseed is the principal source of the compound secoisolariciresinol diglucoside (SDG). Flaxseed is a significant source of functional food or nutraceutical components because of its advantageous fatty acid composition and high fibre content. In this work, pressurised liquid extraction of SDG lignan from flaxseed was studied to determine the most efficient extraction conditions. In the aim to do this, the effects of extraction factors, including temperature (150, 160, and 170 °C), extraction time (5, 15, and 30 minutes), and sample amount (5 and 10 g), were investigated. SDG lignan analysis has been carried out using HPLC. It was established that the SDG lignan concentration of water extracts was significantly influenced by temperature, extraction duration, and sample size. The maximum concentration (12.94 mg/g) and extraction yield (72.57%) were obtained using 5 g of flaxseed deoiled cake at 160 °C for 15 min. with 40% fresh water.

Due to its high concentration of omega-3 fatty acids, flaxseed oil is now utilised as a significant functional dietary component. Carotenoids, however, which could improve the oil's oxidative stability, are absent from flaxseed oil. In this part of study, cold-pressed flaxseed oil is enriched with carotenoids from Seabuckthorn pomace using ultrasound-assisted extraction technique. The carotenoid content of the flaxseed oil was increased by optimising the process parameters using the Box-Behnken design method. Due to its high concentration of -3 fatty acids (-linolenic acid), flaxseed oil is becoming a significant functional dietary component. But the oxidative stability-enhancing carotenoids are absent from natural flaxseed oil. The ultrasound-assisted extraction extracts carotenoids from Seabuckthorn pomace and enrich it directly in the cold-pressed flaxseed oil. A by-product of the Seabuckthorn business that is high in carotenoid concentration is Seabuckthorn pomace, is utilized for enrichment.

Through Box-Behnken design, the process parameters (time, feed ratio, and Amplitude%) were enhanced to maximise the amount of carotenoid in the enriched flaxseed oil. According to the statistical analysis's findings, a yield of 14.02 mg/L of carotene was obtained at parameters time-75.56 min, feed oil ratio-19.94, and amplitude-80.81%. The process optimised parameters showed that, when the same enrichment conditions were used for both the ultrasound-assisted extraction approach and traditional extraction (mixing), the yield from the ultrasound-assisted extraction technique was found to be increased by 46.96%. This shows that the ultrasound-assisted extraction approach greatly accelerates the extraction of carotenoid in a less amount of time as compared to tradition extraction method. The enhancement of flaxseed oil's nutritional content through the use of ultrasound technology is a quick and efficient process that does not require the use of solvents. UAE can take the place of the traditional method of oil enrichment. Using the metrics of peroxide value and rancimat, the quality and stability of oil were investigated. It is contrasted with their unenriched oils. Foods can be supplemented with enriched flaxseed oil, or it can be utilised in medications and nutraceuticals. For the purpose of comparing the quality and stability of flaxseed oil before and after enrichment, thorough physicochemical characterization was done.