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Fractioning of the sunflower flour components: Physical, chemical and nutritional evaluation of the fractions

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Hexane (PubChem CID: 8058)
Sodium hydroxide (PubChem CID: 14798)
Hydrochloric acid (PubChem CID: 313)
Ethanol (Pub Chem CID: 702)
Sodium bisulfite (Pub Chem CID: 23665763)
Chlorogenic acid (Pub Chem CID: 1794427)
Sodium bicarbonate (Pub Chem CID: 51689)

ABSTRACT

Reduced phenolic content products were obtained from defatted sunflower flour using a process designed to make an integral use of the components. In order to eliminate the phenolic compounds, the flour was extracted at pH 5 with extractor solutions: 70 mL/100 mL ethanol, 0.1 g/100 mL sodium bisulfite and a 70:30 mixture of the two. The raw material, protein isolate and fibrous concentrate were chemically characterized. The protein isolates were evaluated for protein extraction yield, protein solubility, heat stability and nutritional properties (chemical score, digestibility, PDCAAS). The fibrous concentrates from the extraction with bisulfite presented 60.84 g/100 g fiber and 35.67 g/100 g protein. The protein isolates result in protein contents above 92.00 g/100 g and phenolic compounds content below 0.45 g/100 g. All showed elevated protein solubility (>84.22%) and *in vitro* digestibility (>90.00%). The residual phenolic compounds content interfered with the digestibility and coloration of the isolates. The feasibility of the process for the prior extraction of the phenolic compounds to obtain high protein and nutritional value products was demonstrated. The mixture of bisulfite and ethanol was the most promising to obtain the isolate, and bisulfite solution was the best for the co-production of the fibrous concentrate.

1. Introduction

The sunflower (*Helianthus annuus* L.) is one of the four major predominant oleaginous cultures in the world, widely cultivated on the five continents (USDA, 2016). The growth of this culture in the world is to a great extent linked to the adopstion of systems that make complete use of the seed, since this results in environmental gains as well as promoting the amplification and sustainability of the culture. Thus, the total and effective use of the byproducts results in the economic valorization of the whole productive chain (Pedroche, 2015). The potential of the oil extraction residue includes: an elevated protein content (40–50 g/100 g), the fact that it is not genetically modified organism (GMO) and is rarely allergenic. All these factors indicate sunflower bran as a raw material for human consumption (Gassmann, 1983; González-Pérez & Vereijken, 2007; Wildermuth, Young, & Were, 2016). However, the obstacle for its use consists of the elevated phenolic compounds content (1–4 g/100 g), being predominantly chlorogenic acid. The phenolic compounds confer a dark green color on the bran and also bind to the proteins, causing an alteration in their functional properties and undesirable organoleptic characteristics. Currently, the bran resulting from the oil extraction, it is exclusively destined to animal feeding (González-Pérez et al., 2002; Pedrosa et al., 2000; Sodini & Canella, 1977; Weisz, Kammerer, & Carle, 2009).

Therefore, there is a constant search for technologies to extract the phenolic compounds from sunflower byproducts, which are technically and economically feasible for industry, since to date there is no consensus concerning the best process to be employed (Wildermuth et al., 2016). It is desirable that the extraction of the phenolic compounds occurs concomitantly with an elevated protein yield, and that the technological properties that make its

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application in foods feasible be maintained (González-Pérez & Vereijken, 2007). The strategies explored to obtain protein isolates propose the use of mixtures of organic solvents, saline solutions and/or reducing agents, before the alkaline extraction of the proteins (González-Pérez et al., 2002; Pickardt et al., 2009; Salgado, Ortiz, Petruccelli, & Mauri, 2011). Other methodologies use a combination of a slightly acid protein extraction with the adsorption of the phenolic compounds in resin (Pickardt, Hager, Eisner, Carle, & Kammerer, 2011; Weisz, Schneider, Schweiggert, Kammerer, & Carle, 2010).

The aim of the present work consists of the complete use of the byproducts resulting from the extraction of sunflower oil, by fractioning the major components of the flour, producing the following fractions: protein isolate, fibrous concentrate and an extract rich in phenolic compounds. Hence the procedures were selected aiming an elevated yield of protein extraction and a reduced phenolic content, presenting color characteristics, technological and nutritional properties appropriate to be used in human diet.

2. Materials and methods

2.1. Materials

Sunflower dehulled grain (*Helianthus annuus* L.) were provided by the company Giroil Agroindústria Ltda (Santo Ângelo, Rio Grande do Sul, Brazil). The oil was extracted in two steps: 1) cold extraction in a mechanical press (Carver Press, USA), and 2) hexane to extract the residual oil. The material was subsequently ground and homogenized (Retsch ZM 200, Germany) to obtain the sunflower flour used in the following procedures.

2.2. Obtaining of the fibrous concentrate (C-FC) and conventional protein isolate (C-I)

The conditions used were based on the methodology of Salgado, Molina Ortiz, Petruccelli, and Mauri. (2011) modified, as shown in Fig. 1. Preliminary studies pointed to the efficiency of the mixture in the proportion adopted in this work. The flour was dispersed in water (1:10 w/v), the pH adjusted to 9 (1 mol/L NaOH) and the mixture agitated for 1 h with monitoring of the pH value. It was then centrifuged at 11000×*g* for 20 min at 20 °C (Sorvall RC-26 Plus, USA), the supernatant reserved and the concentrate re-extracted. The supernatants were mixed and submitted to isoelectric precipitation (pH 4.5/1 mol/L HCL) of the proteins, leaving to rest for 1 h before centrifugation (11000×*g* for 20 min at 4 °C). The pH values of the final fibrous concentrate (C-FC) and final protein isolate (C-I) were adjusted to 7 (1 mol/L NaOH) and freeze dried. The processes was carried out in duplicate for validation of the yield results.

2.2.1. Treatment to reduce the phenolic contents and obtain the fractionated components

The efficiencies of the following 3 extraction systems were evaluated in order to obtain protein isolates with low phenolic contents: 1) 70 mL/100 mL ethanol (E), 2) 0.1 g/100 mL sodium bisulfite in water (B), and 3) a mixture of 70 mL/100 mL ethanol with 0.1 g/100 mL sodium bisulfite (70:30) (M). The fibrous concentrates and protein isolates generated were denominated: E-FC and E-I = sunflower fibrous concentrate and protein isolate extracted with 70 mL/100 mL ethanol; B-FC and B-I = sunflower fibrous concentrate and protein isolate extracted with 0.1 g/100 mL sodium bisulfite; M-FC and M-I = sunflower fibrous concentrate and protein isolate extracted with 70 mL/100 mL ethanol and 0.1 g/100 mL sodium bisulfite (70:30). For each extractor system, the defatted sunflower flour was submitted to 2 sequential extractions (1:10 w/v) at pH 5, and agitated for 1 h with monitoring of the pH value. After the extractions, the residue from each system was submitted to an alkaline protein extraction process (1:10 w/v) obtaining 3 products: 1) fibrous concentrate, 2) phenolic compounds rich extract, and 3) protein isolate, by the same procedure described to obtain the C-I. The processes were carried out in

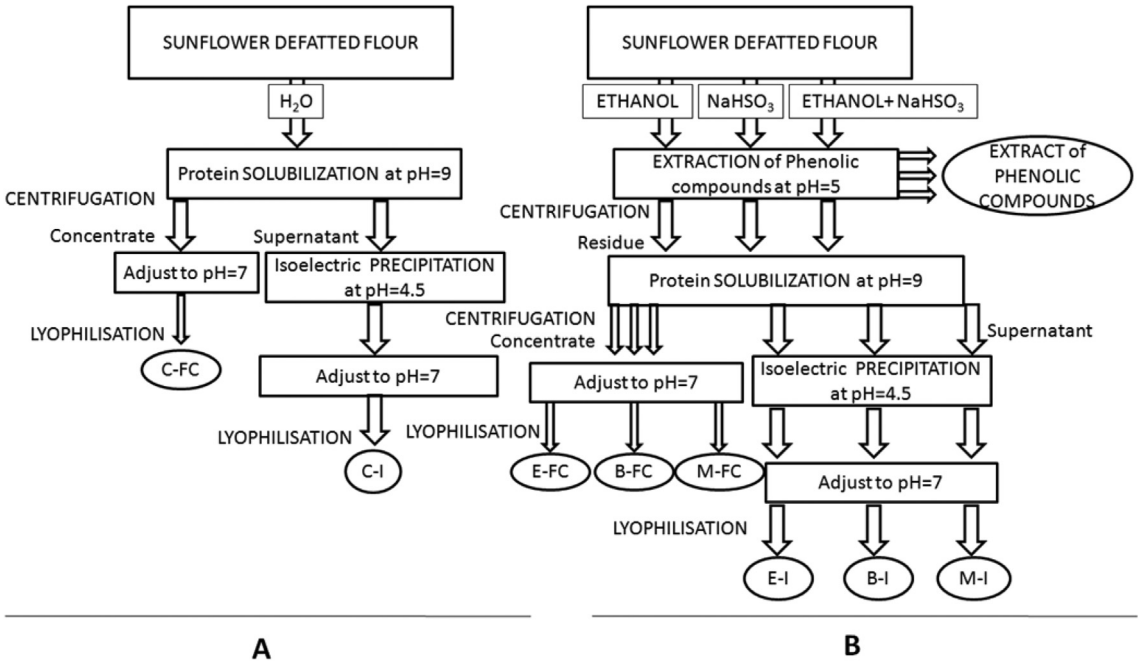

Fig. 1. Flowcharts for obtaining the sunflower products without (**A**) and with (**B**) extraction of phenolic compounds. C-FC and C-I = sunflower fibrous concentrate and conventional protein isolate; E-FC and E-I = sunflower fibrous concentrate and protein isolate extracted with 70 mL/100 mL ethanol; B-FC and B-I = sunflower fibrous concentrate and protein isolate extracted with 0.1 g/100 mL sodium bisulfite; M-FC and M-I = sunflower fibrous concentrate and protein isolate extracted with 70 mL/100 mL ethanol and 0.1 g/100 mL sodium bisulfite (70:30).