Food Chemistry 240 (2018) 784–798

Contents lists available at ScienceDirect

Food Chemistry

journal homepage: www.elsevier.com/locate/foodchem

Preparation, characterization, nanostructures and bio functional analysis of sonicated protein co-precipitates from brewers' spent grain and soybean flour

Muhammad H. Alu'datt[a,*], Sana Gammoh[a], Taha Rababah[a], Mohammed Almomani[b], Mohammad N. Alhamad[c], Khalil Ereifej[a], Ali Almajwal[d], Asma Tahat[a], Neveen M. Hussein[a], Sura Abou Nasser[a]

[a] Department of Nutrition and Food Technology, Faculty of Agriculture, Jordan University of Science and Technology, Irbid, Jordan
[b] Industrial Engineering Department, Faculty of Engineering, Jordan University of Science and Technology, Irbid, Jordan
[c] Department of Natural Resources and Environment, Faculty of Agriculture, Jordan University of Science and Technology, Irbid, Jordan
[d] Department of Community Health Sciences, College of Applied Medical Sciences, King Saud University, Riyadh, Saudi Arabia

ARTICLE INFO

Keywords:
Sonication
Nano technology
Free phenolics
Bound phenolics
Correlations
Biological properties
Co-precipitates

ABSTRACT

This investigation was performed to assess the effects of sonication on the structure of protein, extractability of phenolics, and biological properties of isolated proteins and protein co-precipitates prepared from brewers' spent grain and soybean flour. Scanning electron micrographs revealed that the sonicated protein isolates and co-precipitates had different microstructures with fewer aggregates and smaller particles down to the nanometer scale compared to non-sonicated samples. However, the levels of free and bound phenolics extracted from non-sonicated protein isolates and protein co-precipitates increased compared to sonicated samples. The bound phenolics extracted after acid hydrolysis of sonicated protein co-precipitates showed improved ACE inhibitory activity and diminished antioxidant potency compared to non-sonicated samples. However, the free phenolics extracted from sonicated protein co-precipitates showed decreased ACE inhibitory activity and increased antioxidant activities compared to non-sonicated samples. The free and bound phenolics extracted from sonicated protein co-precipitates showed increased alpha-amylase inhibitory activity compared to non-sonicated samples.

1. Introduction

Over the past ten years, interest from consumers in healthy, prepared, cheap, and readily available food has increased. Food science researchers have used nanotechnology to modify food materials and solve different problems. Nanotechnology is a tool that can be used to update food systems and agriculture at the nanometer scale (10^{-9} m) (Huang, Yu, & Ru, 2010). The modification of food constituents at the nanometer scale can change their molecular, chemical, physical, sensory, functional, and biological properties (Moraru et al., 2003; Huang et al., 2010). Interest in nanometer-scale modifications has quickly increased in the food industry. Moraru et al. (2003) reported the first application of nanotechnology to food material. Several nanotechnology applications for food material have been reported, including in food safety, creating functional foods, and analyzing and altering the physical and bioactive properties of foods (Baeumner, 2004; Chen, Weiss, & Shahidi, 2006; Lee, Wang, Ruengruglikit, Gezgin, & Huang, 2007; McClements, Decker, Park, & Weiss, 2009; Weiss, Takhistov, & McClements, 2006).

One objective of nanotechnology in food and nutrition is to increase the solubility of bioactive phenolics and peptides due to their poor solubility and digestibility. Another objective of nanotechnology is to enhance the bioavailability of minerals and vitamins in food (Shibamoto, Kanazawa, Shahidi, & Ho, 2008). Recently, it has been shown that altering food properties through food technology and processing is accompanied by reductions in the bioavailability and quantities of bioactive compounds, such as phenolics, ω-fatty acids, and peptides. Efforts to increase the bioavailability of these nutraceutical compounds have been extensive due to their low solubility and bioavailability in normal conditions. Many studies have reported the increased bioavailability of nutraceutical compounds accomplished through either encapsulation or nano-emulsion food technologies (Pegg & Shahidi, 2007), which can enhance the nutritional qualities and stability of bio-functional constituents in modified food products.

* Corresponding author.
E-mail addresses: Muhammad.aludatt@mail.mcgill.ca, malodat@just.edu.jo (M.H. Alu'datt).

http://dx.doi.org/10.1016/j.foodchem.2017.08.015
Received 26 March 2017; Received in revised form 1 August 2017; Accepted 2 August 2017
Available online 04 August 2017
0308-8146/

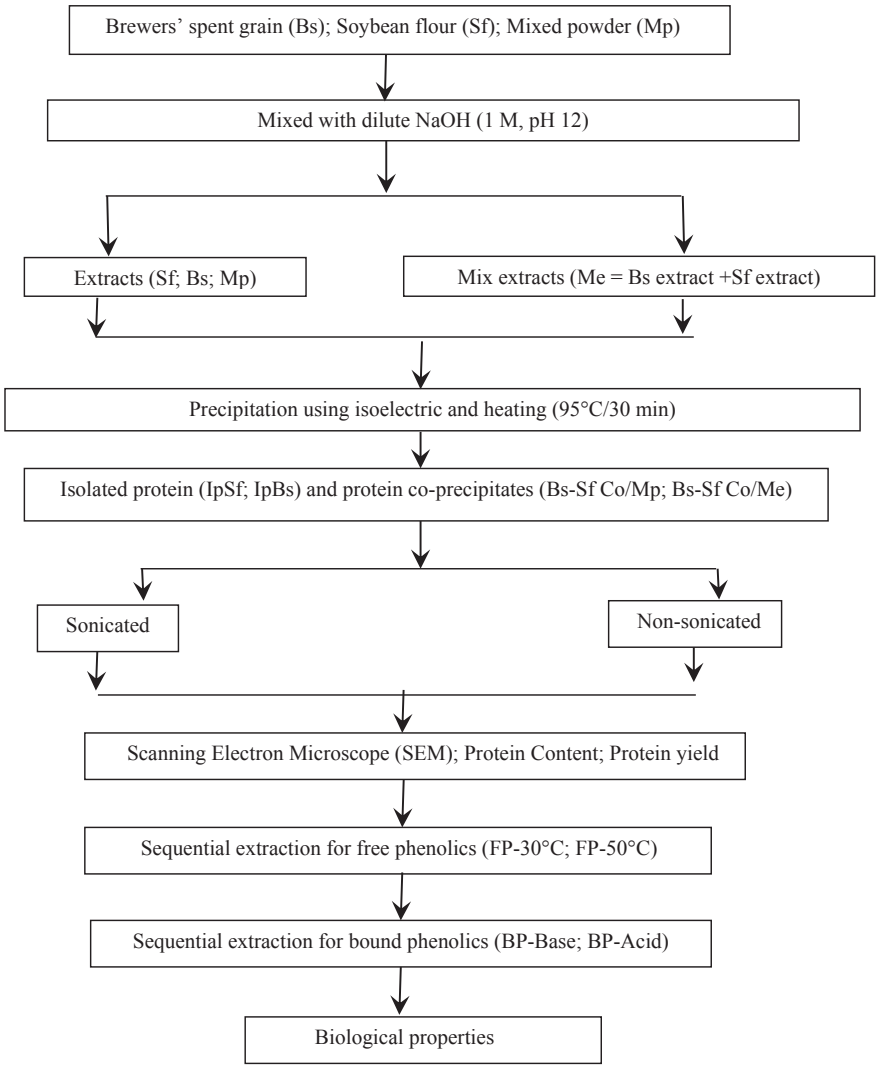

Fig. 1. Experimental diagram for preparation, sonication and bio functional analysis of isolated (Ip) and co-precipitated (Co) proteins from brewers' spent grain and soybean flour.

Emulsion systems are commonly used in the food, nutraceutical, and pharmaceutical industries; these systems increase the solubility and bio-functional activity of lipophilic components through encapsulation in water (Dickinson, 2011). The stability of emulsions is determined by many factors, including the type of emulsifier, number of charges, concentration of emulsifier, and surfactant conditions (Gharsallaoui et al., 2010). Proteins have been used extensively as emulsifying agents in the food industry (McClements, 2004).

The dried by-products of brewers' spent grain industry are rich with protein, fiber and phenolics (Waters, Jacob, Titze, Arendt, & Zannini, 2012). By-products of brewers' spent grain industry is mainly used as animal feed and fortified with bakery industry to enhance contents of fiber with unacceptable consumer products related to undesirable contents of insoluble large granules (Hassona, 1993; Miranda, Grossmann, Prudencioferreira, & Nabeshima, 1994; Ozturk, Ozboy, Cavidoglu, & Koksel, 2002). Utilization of high contents of proteins and bound phenolics from by-products of brewers' spent grain industry in food has limited applications and consumer attributes in literature. Utilization of high contents of proteins and bound phenolics from by-products of brewers' spent grain industry in food industry suggested by my group through the preparation of the protein co-precipitates with soybean flour to produce cheap, commercial food grade protein with a wide range of nutritional, physical and functional properties. Technology of ultrasound has been used in different food systems to improve extractability of oil, proteins and sugars (such as extraction of protein and sugar from defatted soy flake, heteroxylan and xylan from corn and oil from soybean) (Ebringerova, Hromadkova, Alfoldi, & Ibalova, 1998; Khanal, Montalbo, van Leeuwen, Srinivasan, & Grewell, 2007; Li, Pordesimo, & Weiss, 2004; Karki et al., 2010). Phenolics has affinity to conjugate with digestive enzymes in the intestinal tract and inhibit them. Phenolics compounds were extensively studied to inhibit digestive enzymes in vitro (like ACE, α-amylase, protease and amyloglucosidase) (Alu'datt et al., 2016; Bravo, 1998). The overall objective of this study was to investigate the effects of sonication on the structure, molecular size, and yield of protein and the bio-functionality of phenolics associated with isolated proteins or protein co-precipitates that were prepared from brewers' spent grain and soybean flour in mixed powder or mixed extract format.

2. Materials and methods

2.1. Material

Liquid by-product of Brewers' spent grain industry was obtained from General Investment Company LTD/Jordan Beer Factory (Alzarqa, Jordan). The drying of brewers' spent grain was accomplished with a spray dryer (Mobile Minor, Niro Atomizer Ltd, Copenhagen, Denmark) equipped with an air turbine and a vaned centrifuge to atomize particles. The radius of the drying chamber is 50 cm. The atomizer wheel of the vaned centrifuge is rotated at 30,000 rpm. The atomizer vaned centrifugal pressure was 3 bars, and the feed was at room temperature. The inlet air temperature was 75 °C with compressed air velocity of