Contents lists available at ScienceDirect

Food and Bioproducts Processing

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

Effects of ultrasound and microwave pretreatments on the ultrafiltration desalination of salted duck egg white protein

Bing Zhou[a], Min Zhang[a,*], Zhong-xiang Fang[b], Yaping Liu[c]

[a] State Key Laboratory of Food Science and Technology, Jiangnan University, 214122 Wuxi, Jiangsu, China
[b] School of Public Health, International Institute of Agri-Food Security, Curtin University, GPO Box U1987, Perth, WA 6845, Australia
[c] Guangdong Galore Food Co. Ltd, Zhongshan 528447, China

ARTICLE INFO

Article history:
Received 25 January 2015
Received in revised form 19 June 2015
Accepted 15 September 2015
Available online 25 September 2015

Keywords:
Duck egg white protein
Ultrasound
Microwave
Ultrafiltration desalination
Functional property
Pretreatment

ABSTRACT

The effects of application of ultrasound and microwave treatments before the ultrafiltration desalination of salted duck egg white protein were investigated in this work. The desalination rate, color, microstructure, foaming capacity, emulsifying index and gelling property were determined. The results showed that ultrasound and microwave pretreatments increased about 10% and 3% desalination rate, respectively, compared to that without any pretreatment sample, beside the product quality was also improved. The effect of ultrasound pretreatment was better than that of microwave in terms of foaming capacity and emulsifying index of the product.

1. Introduction

China is the biggest duck egg producer in the world, with an annual production of 4.2 million tons in 2008 (Agriculture, 2008). Salted duck egg is one of the most traditional and popular egg products in China. The most valuable product of salted duck egg is the egg yolk which is widely used in traditional Chinese foods such as the filling of the moon cakes that offers attractive orange color, unique flavor and desired texture (Kaewmanee et al., 2009). The salted duck egg white protein (SDEWP) is a by-product of the salted egg yolk processing which has, so far, not been fully utilized due to its high salinity (7–12% w/w) (Wang et al., 2009). Currently, SDEWP is used directly as a food ingredient in manufacturing of other foods or bioactive compounds. For example, SDEWP was used in producing high protein noodles (Liu and Zhang, 1994) and Frankfurt sausage (Lin, 1996). Zhang (2001) extracted bioactive peptides from enzymatically hydrolyzed SDEWP. In addition, Zheng et al. (2004) optimized the processing parameters in producing high quality SDEWP, and Huang et al. (1996) compared four different drying methods (freeze drying, spray drying, roller drying and hot air drying) on the SDEWP powder quality. However, no report is available on desalination of the SDEWP and the desalinated SDEWP may have wider applications with the low salt content. Therefore, desalination of SDEWP might be beneficial to the duck egg industry by providing a new type of high protein resource, and reduce the environmental impact by reducing the by-product waste.

In practice, some common and traditional protein desalination methods are ion-exchange column chromatography

* Corresponding author at: School of Food Science and Technology, Jiangnan University, 214122 Wuxi, Jiangsu Province, China. Tel.: +8651085917089; fax: +86 5108 5807976.
E-mail address: min@jiangnan.edu.cn (M. Zhang).
http://dx.doi.org/10.1016/j.fbp.2015.09.004
0960-3085/

(Greiter et al., 2002), electrodialysis (Xu and Huang, 2008), and ultrafiltration (Wang et al., 2013). The ion-exchange column chromatography is time consuming and inefficient, which requires frequent regeneration of the column that is a tough task and labor intensive (Bartlett, 1959). Comparatively, the electrodialysis is more efficient and could achieve a higher desalination rate, but the desalted solution should be concentrated to a suitable concentration before further processes, and therefore is a relatively cumbersome procedure (Dong et al., 2013). The more widely used and efficient method for protein desalination might be ultrafiltration (Aider et al., 2008). To further improve the efficiency, a number of new technologies have been reported for ultrafiltration desalination of proteins, such as ultrasound-assist-ultrafiltration desalination (UAUD) and microwave-assist-ultrafiltration desalination (MAUD) which includes the application of ultrasound and microwave pretreatments before the desalination process (Wang et al., 2013). The ultrasound can enhance the mass transfer through acoustic-induced cavitation and has been successively used in extraction of a variety of bioactives to increase the efficiency (Chemat and Khan, 2011). The assistance of microwave can highly localize temperature and pressure which cause selective migration of target compounds from the material to the surroundings at a more rapid rate (Spigno and Faveri., 2009), and therefore may also increase the processing efficiency. The purpose of this work was to apply UAUD and MAUD to increase the desalination rate of SDEWP and investigate their effects on the physicochemical properties of the desalted duck egg white proteins.

2. Materials and methods

Salted duck eggs (7.8 ± 0.08% salt content) were purchased from Shendan Healthy Food Co., Hubei Province, China. The eggs were cleaned and separated into egg yolk and egg white protein using an egg separator and then the egg white protein was kept at 4 °C and 95% relative humidity in a refrigerator until further use. The protein content in the egg white protein was determined as 8.8 ± 0.11%. Sodium dodecyl sulfate (SDS), and sodium hydroxide were purchased from Sinopharm Chemical Reagent Co. Ltd. (Shanghai, China). All chemical reagents used in this study were of analytical grade.

2.1. *Methods*

The SDEWP was divided into three batches in this study. The first batch was subjected to ultrasound treatment, the second one to microwave treatment, and the third one without any pretreatment was used as the control.

2.1.1. *Ultrasound treatment of SDEWP*

Ultrasound treatment was carried out using two laboratory scale ultrasound treatment apparatus, namely an ultrasound probe (model JY98-IIDN, NingBo Scientz Biotechnology Co. Ltd., Ningbo, Zhejiang, China) and an ultrasound bath (model SB-800D, NingBo Scientz Biotechnology Co. Ltd., Ningbo, Zhejiang, China). About 200 mL of SDEWP was added with 800 mL distilled water, placed in the sample container and treated under 3 different ultrasound conditions: (1) in the ultrasound probe system of 20 kHz and 1000 W for 20 min (U1); (2) in the ultrasound bath system of 40 kHz and 200 W for 20 min (U2); (3) in the ultrasound probe system of 20 kHz and 1000 W for 10 min and ultrasound bath system of 40 kHz and 200 W for 10 min (U3). All the treatments were conducted at 20 °C temperature and the ultrasound was operated as pulse on and pulse off 5 s each. After ultrasound treatments, the samples were poured into a 1000 mL beaker and then kept at 4 °C and 95% relative humidity for subsequent tests and processes.

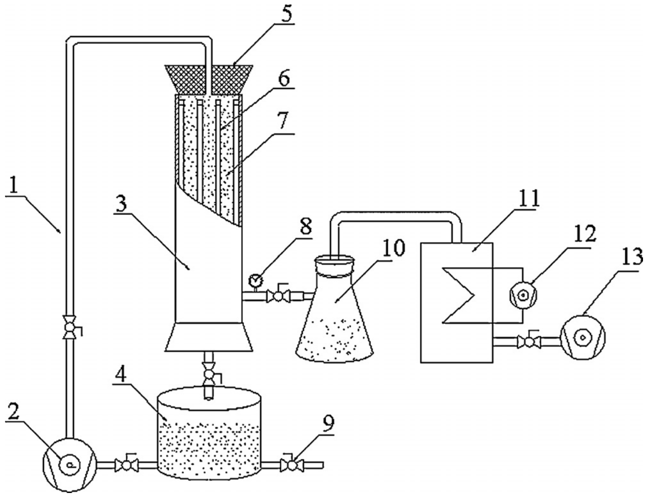

Fig. 1 – Schematic diagram of vacuum ultra-filtration desalination equipment system for salted duck egg white.

2.1.2. *Microwave treatment of SDEWP*

Microwave experiment was carried out using a commercial microwave oven (2450 MHz, Gospell Electric Technology Co., Ltd., Shenzhen, China) and was modified in our laboratory, whose power can be adjusted from 100 W to 800 W with a microwave power controller (Gospell Electric Technology Co., Ltd., Shenzhen, China). About 200 mL of SDEWP was added with 800 mL distilled water and placed in the microwave turntable plate for treatment of 3 min at the microwave power of 500 W. After this, the sample was poured into a 1000 mL beaker and then kept at 4 °C and 95% relative humidity for subsequent tests and processes.

2.1.3. *Vacuum ultra-filtration*

The SDEWP with and without ultrasound and microwave pretreatments were desalted using a laboratory scale vacuum ultra-filtration unit (FZ-8, Wuxi Ultra-filtration Equipment Company, Jiangsu Province, China) which was custom designed for our laboratory (Fig. 1). This system consists of the following four basic components: (1) seven ultrafiltration membrane tubes (PVDF, 1.2 cm outer diameter and 80 cm length) with a cut-off molecular weight of 10 kDa; (2) a gas–water separator system; (3) a vacuum system equipped with a water-cooler and a water-ring vacuum pump; and (4) a pulse circulating system equipped with a set of water pumps (flow rate of 10 L/min) and a sample container wrapped with a jacket through which heating/cooling water is circulated.

About 1000 mL SDEWP solution, with or without ultrasound and microwave pretreatments, was transferred to the sample container of the vacuum ultra-filtration unit respectively. The operation parameters were set based on preliminary trials, which were: (a) pressure in the ultra-filtration tube = 5 kPa; (b) temperature in the sample container = 20 °C; (c) time of ultra-filtration = 2 h. After ultra-filtration, the desalted duck egg white protein (DDEWP) solutions were taken out from the sample container and poured in a 500 mL beaker and then kept at 4 °C and 95% relative humidity for the following drying process.