

Effects of ultra-high hydrostatic pressure on foaming and physical-chemistry properties of egg white

Rui-Xiang Yang, Wen-Zhao Li, Chun-Qiu Zhu, Qiang Zhang

Key Laboratory of Food Nutrition and Safety, Tianjin University of Science & Technology, Tianjin, China.
Email: yrxsky@126.com

Received 11 July 2009; revised 1 September 2009; accepted 2 September 2009.

ABSTRACT

The influences of ultra-high hydrostatic pressure treatment on foaming and physical properties (solubility, hydrophobicity and sulfhydryl content) of egg white were investigated. A pressure range of 0-500 MPa, time range of 0-20 min and pH range of 7.5-8.5 were selected. The foaming property of egg white is improved by 350Mpa and 10min. The treatment resulted in increase of sulfhydryl content of egg white, while solubility and hydrophobicity were significantly decreased.

Keywords: Ultra-High Hydrostatic Pressure; Egg White; Foaming Property

1. INTRODUCTION

Egg white is well known for their high nutritional quality, foaming, gelling and emulsifying characteristics, which can give the foods unique color, flavor, and texture characteristics. Therefore, as an important ingredient, egg white has been widely applied in the food industry, such as cakes, biscuits, breads, ice cream, and other protein products [1]. At present, for convenience and safety, liquid egg white products are widely used by home and producer. However, decrease of the foaming property after pasteurization is found in practice, which seriously affects the application and development of the egg white products.

Ultra-high static pressure technology is a new sterilization technology, which can be used to resolve the problems brought by pasteurization. Ultra-high pressure can improve the function of biological macromolecules by modifying their structure [2]. The high pressure does not affect the primary structure of protein molecules, but can cause agglutination of protein by changing the hydrogen bonds, disulfide bonds and hydrophobic groups among the protein molecules. In addition, ultra-high hydrostatic pressure can cause viscosity and surface tension of egg white increased [3]. The relationship between foaming property and solubility, hydrophobicity, sulfhydryl content under ultra-high hydrostatic pressure

is also investigated in this paper, and only the irreversible changes in the properties are taken into account.

2. MATERIALS AND METHODS

2.1. Materials and Equipments

Fresh eggs were obtained from supermarket. Eggshell was washed by clean water and exposed to ultraviolet light for 30 min to disinfect. The egg white was separated from egg yolk and the chalazae were removed. The albumin was gently mixed and stored at 4 °C until use. The protein content of the egg white was determined to be 11.23 ± 0.56 % (w/v).

2.2. Ultra-High Hydrostatic Pressure Treatment

A volume of 200 mL of egg white was packed in polyethylene plastic packs (170×120mm) and sealed. The ultra-high hydrostatic pressure treatment was performed in high pressure equipment (Hpp-M1, Senmiao, China) and a pressure range of 0-600 MPa, time range of 0-20 min were selected in the experiment. All samples were analyzed at room temperature after 24-hour storage at 4 °C.

2.3. Determination of Foaming Property

A volume of 35 mL (18~25 °C) egg white was placed in a graduated cylinder of 250 mL (diameter = 398 mm) and whipped for 5 min (which is an optimal time for whipping egg white in this measurement system in previous study) with a rotating anchor (275 mm diameter, rotor from the bottom of the graduated cylinder 15 mm) at 2100 rpm, using a laboratory stirrer with controlled constant speed (OJ-100, Onuo, China). The volume of foam (V_0) was recorded immediately after the whipping stopped. The foaming capacity (FC) [4] was defined by

$$FC(\%) = \frac{V_0}{35} \times 100\% \quad (1)$$

The volume of drainage of liquid (V_d) was recorded at 10 min, The foam stability was defined by

$$\text{Drainage}(\%) = \frac{V_d}{V_0} \times 100\% \quad (2)$$

Samples were determined in triplicate.

2.4. Determination of Solubility

Samples were centrifuged during 10 min at 10,000 r/min and 18°C. Protein content of the supernatant was determined.

2.5. Determination of Sulfhydryl Content

The concentration on sulfhydryl (SH) groups of the egg white solutions was determined using Ellman's reagent (5', 5-dithiobis (2-nitrobenzoic acid), DTN-B). 1mL of sample add to 4mL of 0.05mL 0.01M DTNB in phosphate buffer (0.1M, pH 8.0), after 20min of mixing, the reaction mixture was centrifuged during 15 min at 10,000 r/min to remove precipitated protein. Finally, the absorbance of the supernatant was measured at 412 nm against a reagent blank. A blank sample in which DTNB was substituted by phosphate-buffer was carried through in parallel. The sulfhydryl content is expressed as a mole thiol/globulin grams = n mol / mg protein [5].

2.6. Determination of Surface Hydrophobicity

The determination of the protein hydrophobic domains through Takagi [4] approach, using 8-aniline-based-1-Chennai acid (referred to as ANS). Each sample was diluted with the 0.1M phosphate buffer (pH6.8), until the protein concentration of 0.05%, 4.5mL of the diluted sample and 0.5mL 1.25×10⁻³m ANS mixed phosphate buffer. Placing at room temperature for two hours, the fluorescence intensity was measured (excitation wavelength 375nm, Kaloula 1.0nm, emission wavelength of 420-600nm (475nm), Kaloula 1.0nm, medium-speed scanning speed). Globulin in the hydrophobic region is expressed as fluorescence intensity and protein concentration of 0.05%.

3. RESULTS AND DISCUSSIONS

3.1. Effect of High Hydrostatic Pressure on Foaming C Property of Egg White

Foaming property is one of the most important surface characteristic of protein molecule. Albumin proteins are typical amphiphilic molecules, which are easy to extend on the water-air interface and adsorb gas in the whipping process. It has been verified that globulin and albumin of egg white play a major role in forming bubble; Ovomucin and egg lysozyme are favorable for foaming stability [1]. Iesel Plancken has shown that the foaming property of egg white is mainly relative to the content of sulfhydryl and the flexibility of protein molecule. The interaction between protein and protein can improve the foaming stability of egg white [2].

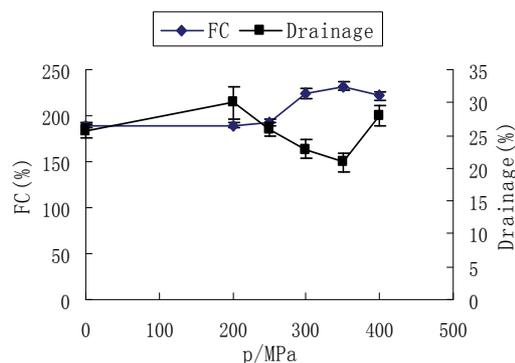


Figure 1. Effect of pressure on foaming property of egg white pH =8.1, t = 10 min, 18°C.

There are not significant changes for FC between 0-200MPa, as can be seen in **Figure 1**. But the drainage is increasing and reaches the maximum at 200MPa, which means the worst foam stability. With the pressure increasing, the FC is still rising until 350 MPa, but the drainage has been decreasing and reaches the minimum at 350 MPa. According to the relevant literature, the phenomenon above was analyzed as follows. It is known that practical aggregation of proteins can raise the protein foaming capability and stability [4]. In this process, aggregation affection can enhance the reaction among proteins and make them become precipitate or gel. While the protein gel appears, the foaming capability and stability will decline sharply.

3.2. Effect of Time on Foaming Property of Egg White

As can see from **Figure 2**, with the extension of processing time, the foaming capability increases and reaches the maximum at 10 min. While the drainage drops to the lowest, there is the best foaming stability. It indicates that in the aggregation of protein process, 10 min is suitable for foaming characteristic of egg white. According to the relevant report, the β -sheet structures of

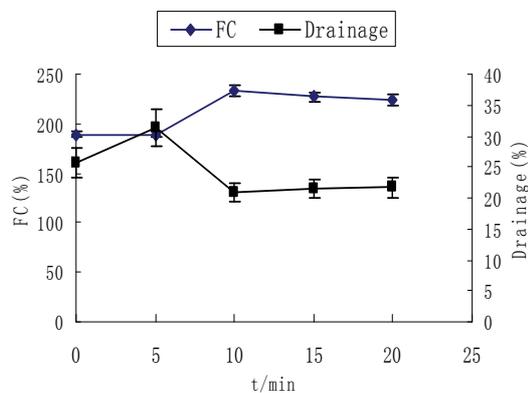


Figure 2. Effect of time on foaming property of egg white p = 350 MPa, pH = 8.2, 18°C.

protein treated with the pressure are unfolded, which can improve the ability of maintaining gas for egg white and make it easy to form bubble [4]. And also, it has enhanced the interaction among proteins, which is favorable for foaming stability. After 10min, the protein precipitate starts to appear, and the foaming capability is decreasing. The previous studies have shown that when egg white is treated by 350Mpa for 10min, the surface tension and viscosity is increasing [3]. From the phenomenon and the relevant conclusion above, we can draw a conclusion as follows: ultra-high pressure treatment can change the structure of protein molecules and cause aggregation of proteins, which can improve the foaming property of egg white.

Next, 10min was selected for different ultra-high pressure treatment to investigate the relationships between foaming property and other characteristic of egg white.

3.3 Effect of High Hydrostatic Pressure on Solubility of Egg White

Protein solubility is an important property of hydration. The protein and water molecules are connected through the interaction of the peptide bond or amino acid side chain (ionization, polar or non-polar group) [1]. As can be seen from **Figure 3**, the solubility of protein decreases with the pressure increasing. The tertiary and quaternary structures of protein treated by the ultra-high pressure were destroyed for that molecules of protein have been unfolded [4]. The reactions of aggregation among protein molecules have been enhanced, therefore, the solubility of egg white becomes decreasing. Comparing to **Figures 1,3**, there are not significant linear correlation between the foaming properties and solubility of egg white treated by ultra-high pressure. When the percent of soluble protein is 71%, the foaming property of egg white is better.

3.4. Effect of High Hydrostatic Pressure on Surface Sulfhydryl Content of Egg White

As can be seen from **Figure 4**, there are significant changes of surface sulfhydryl content with pressure

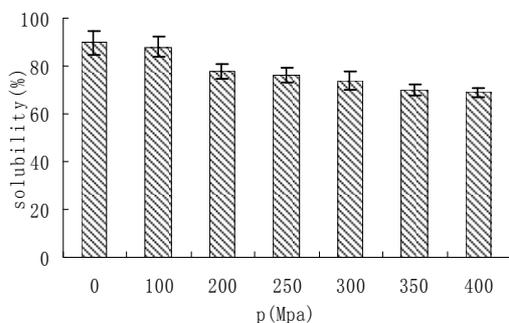


Figure 3. Effect of pressure on solubility of egg white pH =8.1, t = 10 min, 18°C.

reaching the maximum at 350MPa. When the egg white is treated by ultra-high hydrostatic pressure, the structure of the ovalbumin has been changed, which causes four internal sulfhydryl of c molecule being exposed and increases the surface sulfhydryl content on the bases of relevant literature. Comparing with **Figures 1,5**, there is the same trend between the foaming properties and the surface sulfhydryl content of egg white. The foaming capability, stability and surface sulfhydryl content all reach the maximum at 350 Mpa.

3.5. Effect of High Hydrostatic Pressure on Hydrophobicity of Egg White

As can be seen from **Figure 5**, the hydrophobic of egg white has the maximum at 100MPa. With the pressure increasing, hydrophobicity of egg white decreases. It is known that hydrophobic interaction is the main force to maintain protein tertiary structure. So we can deduce that the tertiary and quaternary structures of proteins of egg white treated by the ultra-high hydrostatic pressure are destroyed, and more hydrophobic regions are exposed. With the pressure increasing, hydrophobic amino acids are buried and the hydrophobic region is reduced. Therefore, hydro-phobic property of protein decreased.

4. CONCLUSIONS

The foaming capability and stability of egg white are im-

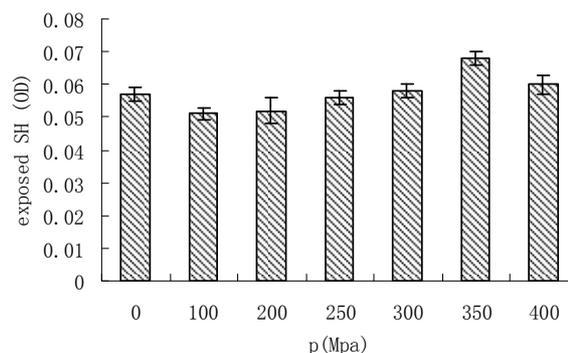


Figure 4. Effect of high hydrostatic pressure on sulfhydryl content of egg white pH =8.1, t = 10 min, 18°C.

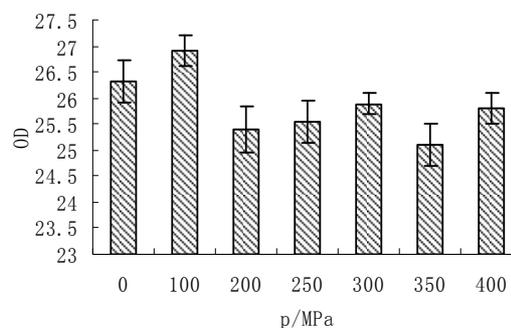


Figure 5. Effect of high hydrostatic pressure on hydrophobicity of egg white pH =8.1, t = 10 min, 18°C.

proved by the ultra-high hydrostatic pressure (100-400 MPa), and play the best performance by 350Mpa and 10min. The findings of the experiment of physical properties of egg white with ultra-high hydrostatic pressure show that with increasing pressure, the solubility of egg white will decrease. There is positive relation between the surface sulfhydryl content and the foaming properties of egg white. When the hydrophobicity of egg white is the lowest, the foaming capacity and foam stability of egg white will reach the best performance.

5. ACKNOWLEDGEMENTS

This research is support by the research fund of personnel of Tianjin University of Science & Technology.

REFERENCES

- [1] X. D. Li and L. W. Zhang. (2005) Egg Science and Technology. Chemical Industry Press.
- [2] E. V. Plancken, A. VanLoey, and M. E. Hendricks. (2007) Foaming properties of egg white affected by heat or high pressure treatment, *Journal of Food Engineering*, **78**, 1410–1426.
- [3] W. Wang and W. Z. Li. (2009) Effect of ultra-high hydrostatic pressure on foaming and physical properties of the egg white. *Journal of Tianjin University of Science and Technology*, **24**, 35–38.
- [4] H. Wang and Z. C. Tu. (2008) Egg white protein dynamic modification of ultrahigh-pressure micro jet and mechanism of, Nanchang University.
- [5] K. Lomakina. (2005) A study of the factors affecting the foaming properties of egg white-a review. *Food Science*, **24**, 110–118.
- [6] J. Liu and B. Jiang. (2007) Effects of ultra-high pressure on foaming property of chickpea protein isolated. *Anhui Agricultural Science*, **35**, 9012–9013.