OPTIMIZATION OF THE EXTRACTION OF ADHERENT EGG WHITE PROTEINS FROM EGGSHELL WASTE

Ivica Strelec*, Lora Stojanac, Marta Ostojčić, Sandra Budžaki

Josip Juraj Strossmayer University of Osijek, Faculty of Food Technology Osijek, Franje Kuhača 18, Osijek 31000, Croatia
**ivica.strelec@ptfos.hr*

Introduction

During the egg-breaking process in industrial plants, a small amount of egg white remains adhered to the inner part of the eggshells and is inevitably lost if the eggshell waste is discarded in landfills. This loss is significant because adherent egg white contains valuable proteins that can be used to produce fine biochemicals.

In this regard, we examined the possibility of extracting these proteins from eggshell waste using water as a solvent.

Materials & Methods

Eggshell waste (ESW) from industrial egg-breaking plant was generously supplied by Elcon-Nutritional Products Ltd. (Zlatar Bistrica, Croatia).

Extraction of adherent egg white proteins from ESW was performed at three different mass-to-volume ratios (1:5, 1:10, and 1:15) over three consecutive 20-minute cycles, with protein content determined every 5 minutes (**Figure 1**).

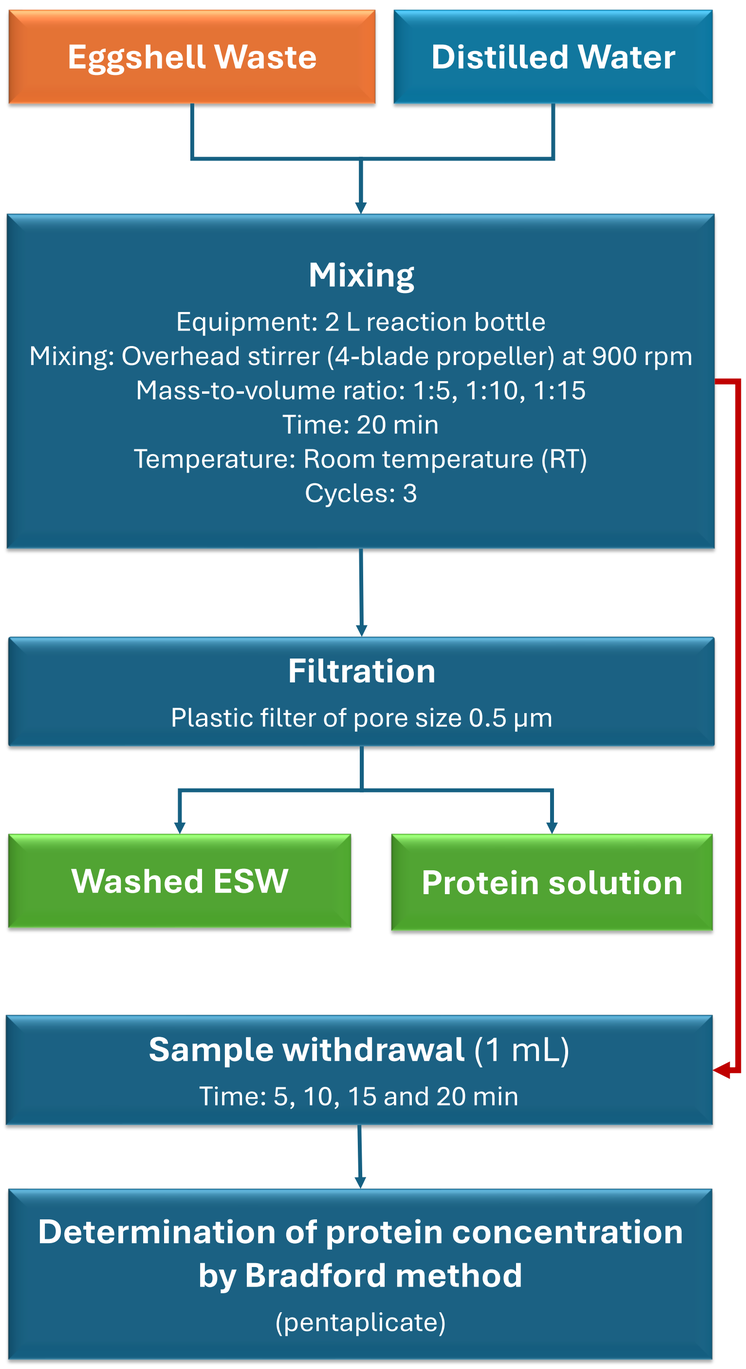

Figure 1 Optimization of adherent egg white protein extraction from eggshell waste: A schematic overview

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Results & Discussion

The results revealed that three consecutive cycles were necessary for the complete extraction of adherent proteins, regardless of the ratio used. However, increasing the mass-to-volume ratio affected both the time needed for complete extraction and the distribution of proteins across the cycles. For complete extraction at a 1:5 ratio, three 20-minute cycles were needed; at 1:10, three 10-minute cycles sufficed; while at 1:15, 3×5 minutes was sufficient (**Figure 2**). The proportion of proteins recovered in the first cycle increased with the ratio, while it decreased in the second and third cycles. Specifically, the distribution for the 1:5 ratio was 92.8%, 6.3%, and 0.7%; for 1:10, it was 93.9%, 5.2%, and 0.5%; and for 1:15, it reached 96.2%, 3.3%, and 0.1% (**Table 1**).

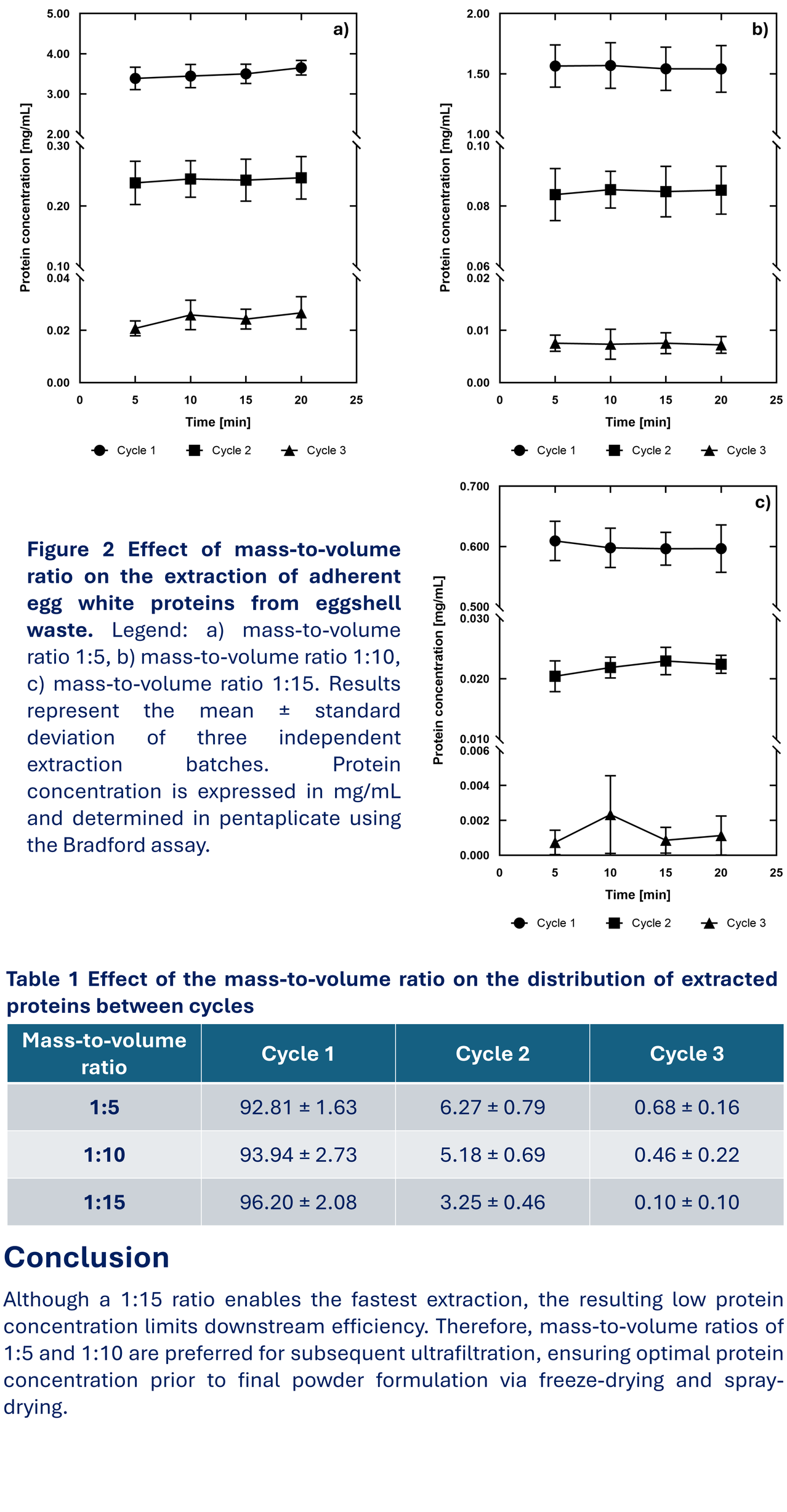

Figure 2 Effect of mass-to-volume ratio on the extraction of adherent egg white proteins from eggshell waste. Legend: a) mass-to-volume ratio 1:5, b) mass-to-volume ratio 1:10, c) mass-to-volume ratio 1:15. Results represent the mean ± standard deviation of three independent extraction batches. Protein concentration is expressed in mg/mL and determined in pentaplicate using the Bradford assay.

Table 1 Effect of the mass-to-volume ratio on the distribution of extracted proteins between cycles

Mass-to-volume ratio	Cycle 1	Cycle 2	Cycle 3
1:5	92.81 ± 1.63	6.27 ± 0.79	0.68 ± 0.16
1:10	93.94 ± 2.73	5.18 ± 0.69	0.46 ± 0.22
1:15	96.20 ± 2.08	3.25 ± 0.46	0.10 ± 0.10

Conclusion

Although a 1:15 ratio enables the fastest extraction, the resulting low protein concentration limits downstream efficiency. Therefore, mass-to-volume ratios of 1:5 and 1:10 are preferred for subsequent ultrafiltration, ensuring optimal protein concentration prior to final powder formulation via freeze-drying and spray-drying.