Flow Properties of Processed Liquid Egg White Products

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ABSTRACT

The aim of present study was to investigate flow properties of liquid egg white produced by recently accepted industrial technologies (pasteurized; long term heated at 53°C; powdered and rehydrated) in comparison with carefully heat treated products (at 53, 57, 63°C temperature for 5, 10, 15 minutes) using raw liquid egg white as control. Results indicate that structural viscosity of raw liquid egg white was destroyed by all of the industrial pretreatments used. In case of carefully heat treated products at above 53°C and at longer duration than 5 minutes higher viscosity compared with control was observed, indicating that due to heat stress egg proteins are denaturated, aggregated producing high viscosity. Based on rotational measurements the optimal heat treatment for liquid egg white products could be predicted, providing objective method for qualifying egg products for industrial purposes.

INTRODUCTION

Nova days food manufacturing plants (e.g. pastry and cookie factories, cold kitchens) prefer „ready-for-use" egg products (liquid egg, egg powder) to whole eggs. These are easier to use since one should not deal with breaking and storing the egg shell contaminated by faeces.

For the production of egg products heat treatment of the raw liquid egg is required i.e. spoilage or pathogenic micro-organisms (*Escherichia coli, Salmonella spp., Staphylococcus aureus*) may contaminate the egg and proliferate during breaking the shell[1,2] For heat treatment of liquid eggs the temperature and duration of treatment should be selected to reduce the number of living contaminating micro-organisms sufficiently while avoiding impairment of the egg content (proteins, vitamins)[3,4]. In the pasteurization procedures widely used in practice the egg white passes through intermittent or continuous heat exchanger where it is exposed to temperatures of 57-60 °C for 5 to 10 minutes[5].

Furthermore, there is the opportunity for spray-drying of liquid egg products resulting in powdered egg products (egg white powder, egg yolk powder, whole egg powder) with longer shelf-life even at room temperature (1-1.5 year) but with poorer functional and organoleptic characteristics compared to liquid egg products[6]. Egg powder is mostly used as liquid egg after re-hydration (reconstituted).

Results from international microbiological monitoring measurements have shown that pasteurization of eggs is not a sufficiently procedure to reduce the germ count; survival micro-organisms, sometimes pathogens can be found in the liquid egg product after pasteurization[7]. The direction of development is to find a more efficient germ reducing technology. A solution may include the treatment of liquid egg at relatively lower temperature (53-55 °C) for long time (6-24 hours) i.e. thermostation during which the live germ count of specific bacteria can be reduced significantly or completely destroyed without damaging egg proteins demonstrated by our experiments with *Serratia marcescens*, *Escherichia coli* and various *Salmonella enteritidis* strains.

For egg product manufacturing plants it is very important that rheological properties of liquid egg products should not be different from that of the original egg since any possible changes lead to technological disadvantages (more difficult pumping) as well as reduced organoleptic and functional (foaming) values[8]. Regarding liquid egg products testing of liquid egg white is particularly important since heat sensitive proteins (conalbunin, lysozyme) can be found in this fraction.

Rheological properties of liquid egg white and other liquid egg products were determined at 4°C (refrigerated temperature), 25°C (room temperature) and 60°C by using concentric cylinder viscometer within the shear rate range of 8-53,7 s^{-1}, mildly pseudoplastic behaviour of liquid egg white was observed and the experimental data successfully fitted Herschel-Bulkley model[9]. The results for liquid whole egg were similar. Rheological behaviour of liquid egg yolk can be described by power law model[10].

The research has shown that rheological properties of some liquid egg products may also be changed during refrigerated storage[11].

Aim of present study was investigate if long term heat treatment at around 50 °C affect rheological, functional properties of liquid egg white products. In addition of new thermostation technology on flow properties of liquid egg white was investigated in comparison with rheological behavior of conventional ready-for-use liquid egg products.

MATERIALS AND METHODS

Materials

The liquid egg white samples (egg white powder, pasteurized liquid egg white) preserved by different methods were obtained from a Hungarian egg processing plant a day before manufacturing. Like the raw liquid egg white was used as control.

The incubated liquid egg white samples manufactured with the new technology produced in laboratory environment. The raw liquid egg white was filled into 100 ml glass flasks and then treated in thermostat with airspace at 53°C for 24 hours.

In studying the different treatment durations (5, 10, 15 minutes) and treatment temperatures (53, 57, 63°C) raw liquid eggs were treated in water bath.

Samples were tested at the storage temperature, 4°C in each case.

Methods

Rheological measurements were performed using MCR 51 (Anton-Paar, GmBH, Germany) rheometer, controlled by Rheoplus software. A concentric cylinder measurement system (CC 27, 27 mm in diameter, 18 ml measuring cell) was used. Rotational measurements were carried out in controlled shear rate mode at 4°C, increasing the shear rate logarithmic from 500 to 1000s^{-1}, using five replicates per sample.

RESULTS AND DISCUSSION

Of the liquid egg white products preserved with various methods the viscogram of raw liquid egg white differs the most from the others (Fig. 1) as in this case the viscosity decreased in the first phase of measurement (up to 700 s^{-1}) depending on the share rate. Hurschel-Bulkley model ($\tau = \tau_0 + K \cdot \gamma^n$; τ_0 yield stress in Pa, K consistency coeficient in Pa·s) fitted well to viscograms as indicated by high correlation coefficient (Table 1). It can also be seen in Table 1 that after re-mixing the viscogram changes i.e. the liquid egg samples looses their structural viscosity.

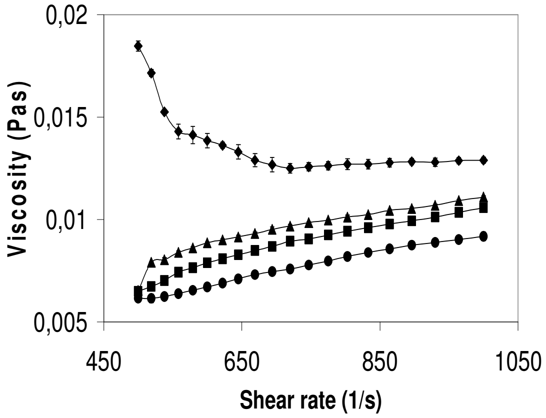

Figure 1. Flow curves of liquid egg products treated with different methods:
♦ raw liquid egg white, ▲ pasteurized liquid egg white, ■ incubated liquid egg white, ● rehydrated egg white powder.

Table 1. Parameters of Hurschel-Bulkley model in modelling flow curves of liquid egg white samples preserved with various technologies.

	τ_0	K	n	r^2
RAW	8.74	0.0000	5.0500	0.9507
PAS**	0	0.0274	0.9180	0.9991
INC**	0	0.0145	0.9990	0.9994
POW	0.19	0.0001	1.6948	0.9996
RAW*	1.3843	0.0008	1.3757	0.9997
PAS*	0	0.0018	1.2841	0.9988
INC*	0	0.0210	0.9487	0.9994
POW*	0	0.0010	1.3347	0.9996

RAW- raw liquid egg white
PAS- pasteurized liquid egg white
HŐN- incubated liquid egg white
POR- rehydrated egg white powder
** samples remixed in the viscosimeter*
*** newtonian liquid (index n close to1)*

In testing of liquid egg white samples treated at a certain temperature for different times a slight increase in viscosity was observed at 53°C (Figure 2). This increase in viscosity was the most predominant at low share rate. At 57°C (Figure 3) was observed a change similar to the results obtained at 53°C. At this point it can be observed that the slight increase in viscosity seen at low shear rate decreases after 10 minutes. Unlike the results measured at 53 and 57°C, at 63°C the entire viscogram shifted upward because proteins obviously started to denaturize (Figure 4).

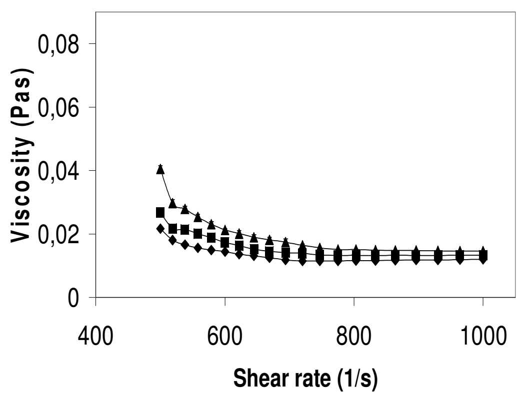

Figure 2. Viscosity curve of liquid egg white treated at 53°C
♦ after heat treatment for 5 minutes, ■ after heat treatment for 10 minutes, ▲ after heat treatment for 15 minutes.

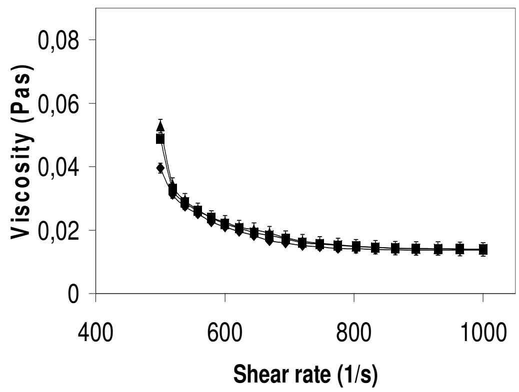

Figure 3. Viscosity curve of liquid egg white treated at 57 °C
♦ after heat treatment for 5 minutes, ■ after heat treatment for 10 minutes, ▲ after heat treatment for 15 minutes.

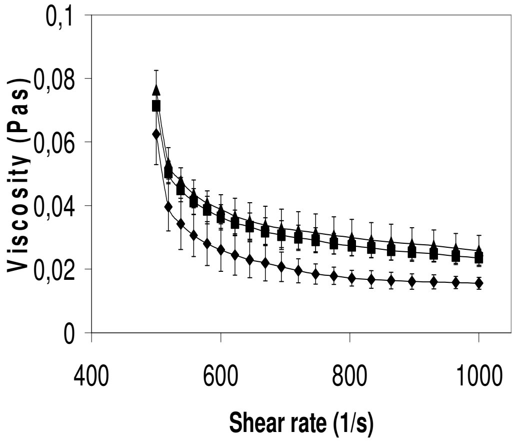

Figure 4. Viscosity curve of liquid egg white treated at 63 °C
♦ after heat treatment for 5 minutes, ■ after heat treatment for 10 minutes, ▲ after heat treatment for 15 minutes.

The viscograms of the liquid egg white samples measured first are described best by Blau I model /y=a [(coth(x/b)]^2, y is share rate in s^{-1}, x is share stress in Pa/ (Table 2) where r^2 value always exceeded 0.96 (in case of Hurschel-Bulkley model r^2 was always below 0.61). Viscograms of re-mixed samples could only be described appropriately a secondary polynomial model ($y = a + b \cdot x + c \cdot x^2$; x is share rate in s^{-1}, y is viscosity in Pa·s) as all other models tested (Herschel-Bulkley, Bingham, Casson, Blau I., etc.) described the viscogram very poorly for each sample (Table 2).

CONCLUSION

Results indicate that structural viscosity of raw liquid egg white was destroyed by all of the industrial pretreatments used. In case of carefully heat treated products at above 53°C and at longer duration than 5 minutes higher viscosity compared with control was observed, indicating that due to heat stress egg proteins are denaturated, aggregated producing high viscosity.

Based on rotational measurements the optimal heat treatment for liquid egg white products could be predicted, providing objective method for qualifying egg products for industrial purposes.

Table 2. Parameters of Blau I model in modelling of flow curves of liquid egg white samples treated fro various periods and at different temperatures.

	a	b	c	r^2
53 °C				
5 min	0.0116	225.9	27.5	0.9723
10 min	0.0124	270.9	16.3	0.9651
15 min	0.0141	292.5	15.8	0.9964
57 °C				
5 min	0.0136	247.2	31.4	0.9970
10 min	0.0138	258.4	30.3	0.9988
15 min	0.0140	259.0	29.6	0.9923
63 °C				
5 min	0.0170	358.8	11.0	0.9868
10 min	0.0243	225.7	46.7	0.9972
15 min	0.0249	239.3	31.5	0.9806

Table 3. Parameters of the secondary polynomial model in modelling of flow curves of liquid egg white samples treated for various periods and at different temperatures.

	a	b	c	r^2
53 °C				
5 min	32.167	-0.0654	0	0.9389
10 min	-1.2245	0.0152	0	0.9990
15 min	3.4211	0.0042	0	0.9978
57 °C				
5 min	2.3597	0.0063	0	0.9996
10 min	0.6964	0.0116	0	0.9969
15 min	3.3547	0.0049	0	0.9979
63 °C				
5 min	4.067	0.0041	0	0.9983
10 min	-14.247	0.0768	0	0.9923
15 min	15.778	-0.0088	0	0.9901

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