A KINETIC STUDY OF HHP ON COLOR AND RHEOLOGICAL PROPERTIES OF LIQUID WHOLE EGG

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Abstract

High Hydrostatic Pressure (HHP) is one of the most promising minimal processing technologies in food preservation. HHP decreases microbiological spoilage of products and extend shelf life, while freshly-like properties are retained. For controlling microbiological safety of liquid whole egg (LWE) several preservation methods are viable in industry, but most of these apply heat or preservatives. On the one hand high temperatures are effective, but techno-functional properties could be declined, on the other hand the use of preservatives is rejected by consumers.

In our study LWE is treated between 150 and 600 MPa, for 5 min. After treatments color and rheological properties of samples were investigated.

Our results show, that up to 400 MPa detectable differences were observed in color of samples. Under 350 MPa Croma values of samples increased but above 350 MPa Croma values decreased of LWE.

In evaluation of rheological results, Herschel-Bulkley model was fitted. Relevant changes is values of Herschel-Bulky models were observed above 450 MPa. LWE after HHP treatment had a stronger pseudoplastic behavior.

Summarizing our data, using a higher pressure for preservation of LWE may have bad influence to techno-functional properties. But the border pressure for adequate techno-functional properties may differ depending on final use of LWE.

Keywords: Liquid whole egg, LWE, high hydrostatic pressure, color, viscosity attributes

Introduction

HHP has gained popularity as an alternative for conventional thermal treatment. It has advantages over thermal processing, including lower temperature and reduced extreme aggregation [13]. HHP is a powerful post-package treatment for controlling growth of microorganisms in different food products. Innovative processes have been reported by several researchers for improving the microbiological safety of eggs and egg products [17], [10], [14]. Different food products require different pressure levels providing microbiological safe products. E. g. meat products are mainly pasteurized, which is generally done in the range of 300–600 MPa, inactivating vegetative cells [6], [4]. High hydrostatic pressure (HHP) treatment could induce the egg white proteins denaturation and aggregation, depending on pressure range, protein concentration, time, pH, and temperature [11]. HHP process has shown a great potential to modify the protein conformational structure (secondary, tertiary and quaternary), which is stabilized by electrostatic interactions, hydrogen bonds and hydrophilic interactions, provoking protein unfolding, while preserving the protein's primary structure stabilized by covalent bonds [15], [3]. Previous works, pointed out the extent of protein modification is strongly affected by the nature of protein as well as by the processing conditions applied, namely pressure level, treatment temperature and holding time [12], [3], [7], [8].

Pressure processing of egg products has been used experimentally as an alternative to heat pasteurization and to eliminate *Salmonella* in several liquid egg products [1], [16]. The investigations pointed out that higher pressure ranges (above 450 – 500 MPa) minimalize microbiological spoilage of egg products [9], but it may cause a destruction of original structure [16] as well destroy techno-functional properties [5], [2].

In our study the effects of HHP between 150 - 600 MPa on rheological properties and color of LWE were investigated. The goal was to find out which pressure level does not change significant the properties of LWE.

Material and Methods

Sample preparing

Freshly laid, M size, traditional cage eggs were used for our measurements. Eggs were taken from a Hungarian layer farm, laid by farming Broilers. Homogenized, raw liquid whole egg (LWE) was taken from the production of Capriovus Ltd (Szigetcsép, Hungary). Samples refrigerated at 4 °C were transported to Szent István University, Budapest. For color and rheological measurements three times 100-100 mL of samples were packaged in polyethylene bags, for every treatment. 3-3 packages were prepared.

HHP treatment

HHP processing was carried out in a RESATO FPU100 – 1200 HHP equipment at room temperature. Pressure levels were chosen between 150 and 600, holding time was 5 min. Pressure's build up speed was 100 MPa/min, and the pressure decreasing was instantaneous. Before and after HHP treatments samples were stored at 4 °C.

Color measurements

The color attributes L*, a* and b* were investigated using a Konica Minolta CR 200 colorimeter. The color was recorded through the special glass using the CIELab uniform color space at room temperature. Colour determined by CIE (Commission Internationale l'Eclairage) color is separated into three dimensions; L*, brightness, a*, red to green color and b*, yellow to blue colour. Each liquid egg sample was measured six times, averages and standard deviance were calculated. From results color difference (ΔE_{ab*}, CIE formula 1976)), hue difference (ΔH^{*}) and Croma (C_{ab}^{*}) were calculated.

Inspection of rheological properties

Rheological properties were measured with an Anton Paar MCR 92 rheometer applying a concentric cylinder system (d= 27 mm). Shear stress was measured between 10 and 1000 1/s shear rate. For every sample the speed up and speed down tracks 31 – 31 points were taken for flow curve.

For analysis apparent viscosity, Herschel- Bulkley model was fitted on yield curve of every treated sample.

Results

Color

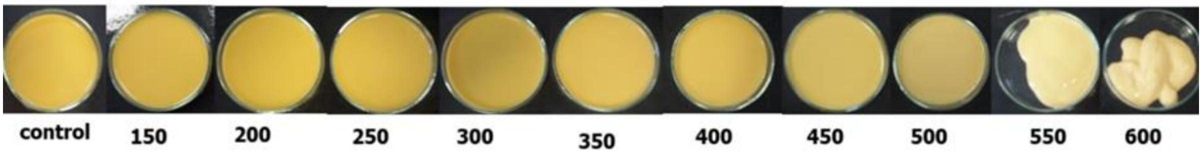

Figure 1.: The changes in color and texture of LWE affected by HHP between 150 and 600 MPa, 5 min

Figure 1. shows LWE samples after HHP treatments at different pressures. On the one hand color is infused b different pressure levels, on the other hand, texture hanged ftr HHP. The highest changes were found in L* values. L* increased affected by pressure. Calculated data from L*, a* and b* are summarized in Table 1.

Table 1. Color difference (ΔE_{ab}^{*}) and hue difference (ΔH_{ab}^{*}) of HHP treated LWE samples calculated for control and Croma (C_{ab}^{*}) of LWE

HHP, MPa	$\mathbf{\Delta E_{ab}^{*}}$	$\mathbf{\Delta H_{ab}^{*}}$	$\mathbf{C_{ab}^{*}}$
0	0	0	35,05
150	2,22	0,46	37,22
200	2,47	0,50	37,06
250	2,67	0,62	35,44
300	4,46	0,72	37,03
350	5,36	0,55	34,27
400	8,71	1,33	33,24
450	9,24	1,59	34,07
500	12,10	1,64	33,10
550	9,11	2,17	31,52
600	10,71	2,52	30,12

Color difference (ΔE_{ab}^{*}) increased with increasing pressure. Pressures above 35 MPa caused well visible difference in color of LWE compared to untreated control. Like color difference, hue difference (ΔH_{ab}^{*}) was increased by HHP's pressure level. In comparing trust, Croma C_{ab}^{*} was increased by lower pressure levels, but decreased by higher pressure levels. Comparing to control LWE pressure above 350 MPa had a negative effect on color.

Inspection of rheological properties

HHP caused a striking change in color and texture, which can be observed at different pressures for each LWE sample.

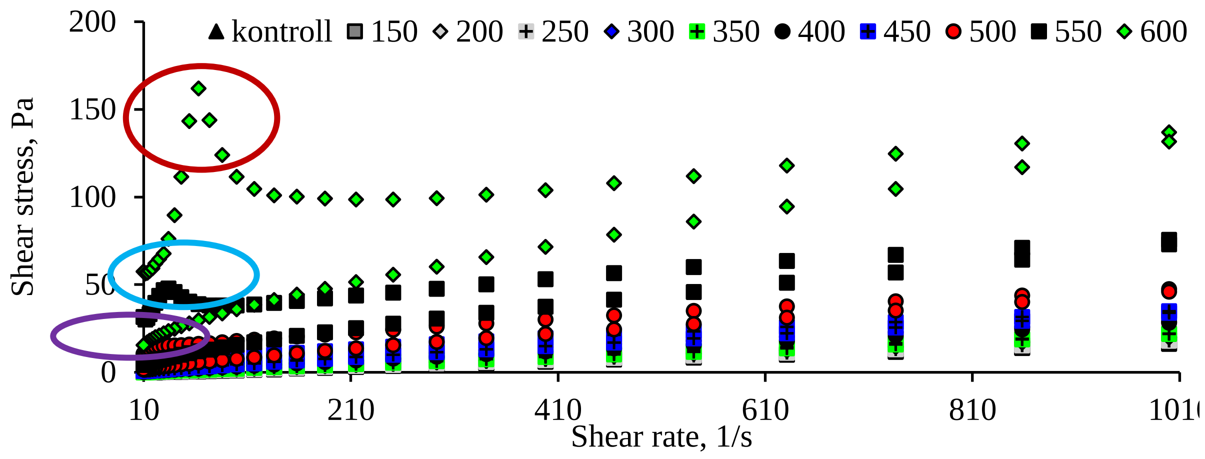

Figure 2.: The changes in yield curves of LWE affected by HHP between 150 and 600 MPa, 5 min

The texture of liquid whole egg samples proved to be the most resistant to pressure level of HHP because, as shown in Figure 1, only the changes at 550 and 600 MPa caused a visible change. Flow curves of the samples are shown in Figure 2. The control shear curve gives the lowest shear stress values. The higher the pressure applied, the higher the shear stress values shear stress as a function of the shear rate. The measured points of the accelerating and decelerating sections do not overlap, the measuring points of the decelerating section show smaller values of shear stress. The reason for this may be that the whole egg's texture is destroyed by the rotation of the probe. This thixotropic behavior is likely to have been a disruption of the spatial structure of protein agglomerates and lipid compounds at higher pressures. Similar thixotropic behavior is observed e.g. also in fat-scaled, fat-yoghurts [18].

For samples treated at 500, 550 and 600 MPa, one can observe a protruding part of the flow curves during the accelerated measuring section (purple ellipse: 500 MPa, blue: 550 and red: 600 MPa), then the curves have a run similarly for the samples treated at lower pressures. This protrusion occurred at different shear rates for the three samples. The higher the applied pressure value was, the higher the peak value and the higher the shear rate were.

Table 2. Calculated constants of Herschel–Bulkley for LWE samples treated for 5 minutes between 150 and 600 MPa

MPa	τ_0 (Pa)	K	n	R^2
0	0,00±0,01	0,01±0,01	1,10±0,01	0,99
150	0,03±0,01	0,01±0,02	1,02±0,01	0,99
200	0,00±0,01	0,02±0,01	0,99±0,01	0,99
250	0,03±0,01	0,01±0,01	1,02±0,01	0,99
300	0,03±0,01	0,02±0,02	1,01±0,01	0,99
350	0,03±0,01	0,03±0,01	0,99±0,01	0,99
400	1,21±0,05	0,05±0,01	0,95±0,01	0,99
450	1,26±0,01	0,22±0,02	0,89±0,01	0,98
500	1,84±0,15	0,34±0,01	0,85±0,01	0,99
550	2,46±0,01	0,45±0,01	0,76±0,01	0,98
600	12,96±0,35	0,80±0,05	0,72±0,01	0,97

Table 2. summarizes the calculated values τ_0 of the Herschel – Bulkley model fitted to the measurement points of LWE samples. We can see that the values τ_0 of the yield point, τ_0, increased with the increase of the pressure level, as the consistency index, K values τ_0 show a slight increase. In contrast, the power-law index, n, shows a slight decrease. The deviation from the properties of Newtonian fluids is characterized by n: If we are talking about a Newtonian fluid approaching 1, if we take values τ_0 between 0 and 1, we are dealing with a pseudoplastic fluid. According to my results, liquid whole egg samples from near Newtonian fluid becomes pseudoplastic, which correlates with increasing the pressure levels. Their correlation coefficient is -0.93.

Conclusion

Summarizing our data, color is highly influenced by HHP's pressure level. Texture and viscosity attributes are influenced by HHP as well. I n overall, application of HHP with a pressure above 350 MPa have negative effects of LWE’s sensorial and techno-functional attributes.

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