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EFFECTS OF MINIMAL PROCESSING AND VITAMIN C ENRICHMENT ON MICROBIOLOGICAL SAFETY AND VISCOSITY OF LIQUID EGG WHITE

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Abstract
Emerging technologies, like High Hydrostatic Pressure, heat treatments on low temperatures, and ultra-sonication, have an increasing tendency in industrial application. Vitamin enriched foods, like eggs, are considered as functional foods, but for high retention of biologically active compounds adequate minimal processing technologies are needed. In our study vitamin C enriched liquid egg white was examined to meet consumer expectations.
Several combinations of low temperature pasteurization (57 - 63°C, 5 – 7 min) and High Hydrostatic Pressure (350, 5 min) were used to provide microbiological stability of vitamin C enriched (1000 mg/L) liquid egg white. After enrichment and treatments, the samples were examined for mesophyll aerobe and Enterobacteriaceae cell counts and viscosity attributes.
Our results show that microbiological stability is not significantly influenced by vitamin C enrichment, but the different parameters of heat treatments and HHP have a strong effect.
Viscosity attributes (measured with Anton Paar MCR 92) analysed by Hershel-Bulkley models point out that higher pressure of HHP has a stronger influence on viscosity than the temperature of pasteurization. Our results show a great opportunity for industrial use of minimal processing technologies for liquid egg white.

1. INTODUCTION

Egg white is a key ingredient in many food products as it combines high nutritional quality (Seuss-Baum, Nau, and Guérin-Dubiard 2011) with excellent functional properties (de Souza and Fernández 2013). However, egg white is also one of the leading causes of IgE mediated food allergy in childhood (Moneret-Vautrin 2008; Lechevalier, Guérin-Dubiard, Anton, Beaumal, David Briand, Gillard, Le Gouar, Musikaphun, Pasco, et al. 2017). Hen egg isalso one of the leading causes of food allergy in childhood, affecting 1.6–3.2% of young children (Eggesbø et al. 2001). Studies are investigating the role of different allergic reactions in childhood in concection with egg consumption (Robinson and Lanser 2018). The high content of essential amino acids in egg white proteins and the high bioavailability of these proteins are of great benefit to human nutrition (Hester 2017; Lechevalier, Guérin-Dubiard, Anton, Beaumal, David Briand, Gillard, Le Gouar, Musikaphun, Pasco, et al. 2017). However, the effects of industrial processing such as dry heating on the nutritional quality of egg white proteins have been poorly documented. Some studies considered the effect of dry heating on the in vitro digestibility of proteins as it is a prerequisite to nutritional quality (Schmidt et al. 2007), but the effects of minimal processing technologies are not investigated in case of egg white. Studies viable about the digestibility assays confirmed previous findings that exposure of egg white to high temperatures increased digestibility markedly. However, it seems that the effects of pH and salt concentrations were found to be minimal (Lassé et al. 2015).

In the egg product industry, microbiological safety of liquid products is mainly guaranteed by pasteurization. The USDA requires that liquid whole egg is at least heated at 60 °C for no less than 3.5 min, but in the United Kingdom the recommendations are to pasteurize at least at 64 °C for 2.5 min (Rossi et al. 2010; Korver and McMullen 2017). In France, there is no statutory heat treatment; only microbiological results are determined by regulations. To achieve this, the treatments classically used to pasteurize the whole egg vary from 65 to 68 °C for 2–5 min in order to ensure 5 to 6 decimal reductions of vegetative microorganisms and especially Salmonella Enteritidis and Listeria monocytogenes (Baron et al, 2010). Pasteurization temperatures used in the egg industry are limited by the sensitivity of egg proteins to heat treatment. Thus, pasteurization for 2–10 min from 60 to 68 °C modifies whole egg electrophoretic pattern by especially decreasing ovotransferrin, livetin, ovalbumin, apovitellenin, lysozyme and/or ovomucin band intensity (Bartlett and Hawke 1995; Rossi et al. 2010; Lechevalier, Guérin-Dubiard, Anton, Beaumal, David Briand, Gillard, Le Gouar, Musikaphun, Tanguy, et al. 2017).

Liquid egg white (LEW) and egg white-based products are usually regarded as functional foods for their excellent source of high-quality proteins, trace minerals, and for the ability of their components to coagulate, and to form foams when whipped. High hydrostatic pressure (HHP, or high pressure processing, HPP) is one of the most promising minimal processing technologies in the food industry, but only a few scientific studies are existing about HHP treatment and its effects on egg products (Toth et al. 2017). However, the risk of contamination by Salmonella is a real threat for human health and remains a major concern for egg production and processing. Contamination by Salmonella enterica serovar Enteritidis is widely studied because it represents the predominant serotype involved in the foodborne diseases (salmonellosis) due to egg or egg product consumption (BIOHAZ, 2014; Baron et al. 2016). In our study, the microbiological state and viscosity paramters are investigated in vitamin C enriched, pasteurized and HHP treated liquid egg white (LEW).

2. MATERIAL AND METHODS

2.1. Sample preparing

Homogenized liquid egg white (LEW) was taken directly from production of Capriovus Ltd. LEW had no additives or other treatments before sample preparing stored between 4 – 6°C. After vitamin C addition (1000 mg/100 mL). the samples were packaged in plastic bags.

Heat treatment was carried out in a water bath (57°C, 10 min), the samples were cooled down to 4°C. HHP treatment was carried out in Resato FPU 100 – 2000 HHP equipment using 350 MPa, 5 min holding time, speed of pressure increasing was 100 MPa/min, the treatment was carried out at room temperature. The trial of preservation technologies had different ways: the samples had a single heat treatment at 57°C, 10 min, or a single HHP treatment 350 MPa, 5 min, or samples had a combined treatment applying both technologies in different orders. The different treatments are summarized in Table 1.

Table 1. Applied treatments and parameters of samples

Sample nomination	Heat treatment	HHP
control	-	-
350 MPa	-	350 MPa, 5 min
57°C	57°C, 10 min	-
350 MPa + 57°C	57°C, 10 min	350 MPa, 5 min
57°C + 350 MPa	57°C, 10 min	350 MPa, 5 min

2.2. Inspection of viscosity attributes

Viscosity attributes were investigated with an Anton Paar MCR 92 viscosimeter. The sample temperature was 15°C and data were collected between 10 and 1000 1/min share rate. The flow charts were analyzed by Herschel-Bukley models. The analyzed constans are collected in Table 2.

Table 2. The nomenclature of Herschel-Bukley model parameters

Constant	Nomenclature
a	Empirical parameter 1
b	Empirical parameter 2
p	Fluid behavior index
R^2	Goodness of the fitted model

[a] source: (Elgaddafi, Ahmed, and Growcock 2016)

2.3. Microbiological testing

In microbiological testing samples were taken in sterile conditions. The storage temperature before measurement was 4-6°C. After treatments, the samples were examined for mesophyll aerobes and Enterobacteriaceae cell counts (using Nutrient agar and usual incubation of 30 °C for 48 hours) (Baron et al. 2010; Hudson et al. 2016).

3. RESULTS AND DISCUSSION

3.1. Inspection of viscosity attributes

The viscosity was influenced by the different treatments. Flow chart is shown in Figure 1. Single treatments had a lower impact on viscosity than the combined treatments. Heat treated sample had very similar flow curve than the control sample. HHP had a higher impact than heat treatment at 57°C. The combinations of treatments had different influences on viscosity as well. But the order of the treatments had no significant effects on viscosity.

Table 3 summarizes the calculated parameters of Herschel-Bukley model fitted on rheological results. The parameters a and b were highly influenced by the different treatments. Parameter p (fluid behaviour index) shows higher decrease in case of combined treatments. The changes in parameter p means the difference from Newtonian fluids. According to this parameter our samples show slightly pseudoplastic and dilatant behaviour. But in fact, the flow curves do not prove that.

In other studies LEW is reported as a solution with decreased viscosity affected by different treatments like high intensity ultrasonication (Sheng et al. 2018).

Table 3. The results of Herschel-Bukley model fitted on LEW samples

Constant	control	350 MPa	57°C	350 MPa + 57°C	57°C + 350 MPa
a	1,30	1,61	1,53	3,12	3,08
b	3,62E-07	3,67E-07	3,78E-07	4,762E-07	4,88E-07
p	2,49	1,53	0,91	0,88	0,92
R^2	0,997	0,997	0,999	0,999	0,998

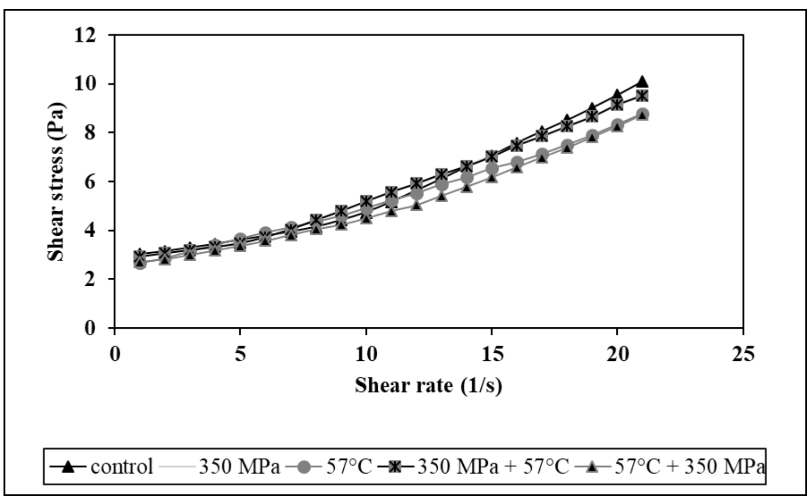

Figure 1. Flow charts of LEW treated with HHP, heat treatment and their combinations

3.2. Microbiological testing

Enterobacteriaceae cell count was under detection level in every sample. An obvious choice for finding out the effects of applied treatments on Enterobacteriaceae may be a challenge test using predefined initial cell count.

Mesophilic aerobe cell count is shown in Figure 2. Single treatments had lower efficiency in microbiological aspects than the combined treatments. Single HHP treatment had less effect on viable cell count. But the order of combined treatment had no difference in their effects. Using single HHP processing may have not enough lethality in LEW, or higher pressure have to be used for providing appropriate microbiological food safety (Fort et al. 2008; Sanz-Puig et al. 2017).

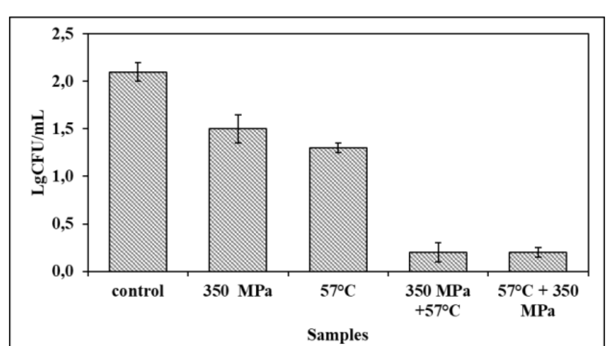

Figure 2. Meshophyllic aerobe cell counts of samples treated with HHP, heat treatment and their combinations

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4. CONCLUSIONS

Our study investigated the rheological and microbiological effects of HHP and mild heat treatment combined with vitamin C enrichment on LEW. Our results point out that viscosity changes are depending on combined or single use of treatments, but the orders of HHP and heat treatment do nott differ in aspects of viscosity attributes.
Mesophyllic aerobe cell count is highly influenced by the different treatments. The most effective treatments were the combined heat and HHP treatments, but no significant differences are in different orders of application.

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