

# Heat treatment of liquid egg yolk

EMNA AYARI<sup>1\*</sup> , CSABA NÉMETH<sup>2</sup>, KARINA ILONA HIDAS<sup>1</sup>,  
ADRIENN TÓTH<sup>1</sup>, DÁVID LÁNG<sup>2</sup> and LÁSZLÓ FRIEDRICH<sup>1</sup>

<sup>1</sup> Department of Refrigeration and Livestock Products Technology, Faculty of Food Science, Szent Istvan University, Budapest, Hungary

<sup>2</sup> Capriovus Ltd., Dunasor, 073/72. hrsz., 2317, Szigetcsép, Hungary

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## ABSTRACT

Starting from mechanical revolution, each day new methods and new equipment have emerged. Today, the Ultra Heat Treatment (UHT) is one of the important technologies that permits to the industry to reduce processing time while maintaining the same quality of the products. Egg and egg products are known as heat-sensitive products, so the UHT enables us to preserve their qualities after a heat treatment.

Our aim is to study the effect of UHT treatment (approximately 67 °C for 190 s) on the Liquid Egg Yolk (LEY). For twenty-one days, the color and the apparent viscosity were measured every seven days, we also studied the damage of protein using DSC (Differential Scanning Calorimetry).

Comparing the two graphs of DSC, the denaturation of protein is distinct. The endothermic peak decreased. This could be seen also on the rheological curves. The apparent viscosity is diminished from 231 mPa.s on the 1st day of storage to 224 mPa.s on 21st day. However, the treated LEY could be stored for longer period than the raw LEY.

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## KEYWORDS

UHT, egg, yolk

## INTRODUCTION

Poultry have become one of the major sources of human supplementary diet worldwide (Oladejo D. et al., 2015), due to the high-quality protein, essential vitamins, and minerals

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\* Corresponding author. E-Mail: ayari.mna@gmail.com

content that are needed for a healthy diet (Zaheer K., 2015). They can be an excellent substrate for spoilage related microorganisms and food-borne pathogens so they are a highly perishable product even under refrigeration (Mendes de Souza P. et al., 2015). For this reasons, many conservation methods are used to extend the shelf-life of eggs products and preserve their properties as coating the eggs with petroleum jelly (Vaseline), immersions in limewater and water glass (Oladejo D. et al., 2015). Coating of the egg shell takes a considerable duration of time to apply, but according to Mudannayka A.I. et al., 2016 coating with one of these materials (Beeswax, Gelatin and *Aloe vera* gel) can preserve the eggs for about 6 weeks of storage at 30 °C. Nowadays, Industries prefer using the liquid egg products because they are easy to handle. Microbiological safety of liquid products is mainly guaranteed by pasteurization (Lechevalier et al., 2017). Consequently, there are many standardizations of the heat-treatment. The USDA requires liquid egg pasteurization (conventional processing) to be conducted under a critical temperature–time condition where egg protein coagulation may not occur. Minimum temperature and holding time requirements for the egg yolk is 60 °C and 6.2 min. For the egg white and whole egg, minimum temperature and holding time requirements are 55.6 °C and 6.2 min., 60 °C and 3.5 min, respectively (Atilgan and Unluturk, 2008). At the same time, in France only microbiological result is determined by regulation. Classic treatment used to pasteurize liquid whole eggs ranges from 65 to 68 °C for 2–5 min in order to ensure 5 to 6 decimal reduction of vegetative micro-organisms and especially *Salmonella Enteridis* and *Listeria monocytogenes* (Lechevalier et al., 2017). However, intensive heat treatments have been reported to alter the physical and functional properties of eggs by inducing formation or destruction of covalent bonds, which promotes changes in egg quality due to severe thermal protein denaturation (Llave et al., 2018). Therefore, our aim is to study the effect of heat treatment on the liquid egg yolk because when it is thermally treated the gel network formation can cause unpredictable structure changes through protein denaturation (Blume et al., 2015).

## MATERIALS AND METHOD

All samples of raw and treated liquid egg yolk (LEY) were supplied from the production line of Capriovus Ltd (Szigetcsép, Hungary).

After collecting the LEY from the egg breaker machine, the LEY goes through a piston-gap homogenizer at 100 bars; the raw LEY is taken after the homogenization. Then, it goes directly to Ultra Heat Treatment (UHT) Tubular pasteurizer specialized for liquid egg. UHT treatment parameters for LEY are 67 °C 190 s. Samples were stored at a refrigeration temperature of 5 °C ± 2 °C in one-layer polyethylene bags for 21 days.

Color measurements were carried out using the Minolta Chroma Meter CR-200, five random points of the LEY bag were analyzed, and the average value was calculated for all samples. To prevent the influence of polyethylene bags, the calibration of the color-meter was realized with one-layer polyethylene bag.

Color-difference ( $\Delta E_{ab}^*$ ) was calculated using CIELAB system where  $L^*$  is lightness (black point  $L^* = 0$ , white point:  $L^* = 100$ ),  $a^*$  is characteristic to red-green color ( $+a^*$  red,  $-a^*$  green), and  $b^*$  is the blue yellow color ( $+b^*$  yellow,  $-b^*$  blue).



$$\Delta E_{ab}^* = \sqrt{(\Delta a^*)^2 + (\Delta b^*)^2 + (\Delta L^*)^2}$$

For the protein denaturation, it was examined on Micro DSC III (differential scanning calorimeter). In each case approximately 778.5 ± 5 mg of samples was taken; the reference was distilled water. The programmed temperature control was carried out using SetSoft 2000 as the temperature was raised reaching to 95 °C and then cooled down again; The rate of heating and cooling was 1.5 °C/min. Callisto 7.6 software was used to evaluate DSC thermo-grams.

Rheology tests were performed and investigated by the MCR 92 rotational rheometer (Anton Paar, Les Ulis, France). Properties of the probe are the following: cup diameter 28.920 mm, bob diameter 26.651 mm, bob length 40.003 mm, active length 120.2 mm, positioning length 72.5 mm. The device was operated using Anton Paar RheoCompass™ software. The flow curves of the samples were recorded at an increasing shear rate of 10–1,000 1/s and 1,000 to 10, 1/s in the deceleration phase at 25 °C. Three parallel measurements were performed per sample. For one measurement, 25 mL of liquid egg is needed.

On the 7th day of storage, the reference samples (raw LEY) showed such a high microbial load that their tests were stopped while the treated samples retained their properties until the 21st day.

## RESULTS

### Color

$\Delta E_{ab}^*$  allows to compare the color between the reference, which in this case is the raw LEY, and the sample, which is the UHT LEY. The results are shown in Table 1. The major color difference is in the end of the storage period (8.46 ± 1.21), while the minimum difference is registered on the first week of storage (5.18 ± 0.28).

### Protein denaturation

In recent studies, the mechanism of egg yolk protein gelation has been investigated by different techniques (Blume et al., 2015). The result of DSC is shown in Fig. 1. As the thermograms show the thermal denaturation of LEY during heating takes place above 60 °C, just as mentioned in the literature.

The peak maximum temperatures of UHT LEY protein are 78.22 °C ± 0.08 and 77.69 °C ± 0.91, respectively on the 1st and 14th day. For the first day of storage, the peak maximum of raw egg yolk protein is 77.78 °C ± 0.08; which is less than that of the UHT LEY for the 1st day.

On the last day of the study, the endothermic peak of UHT LEY decreases to 76.72 °C ± 0.28. That could be caused by the microbiological load growth.

Table 1.  $\Delta E_{ab}^*$  between raw and UHT LEY

	Day 0	Day 7	Day 14	Day 21
Raw LEY-UHT LEY	7.43 ± 1.12	5.18 ± 0.28	8.04 ± 0.61	8.46 ± 1.21



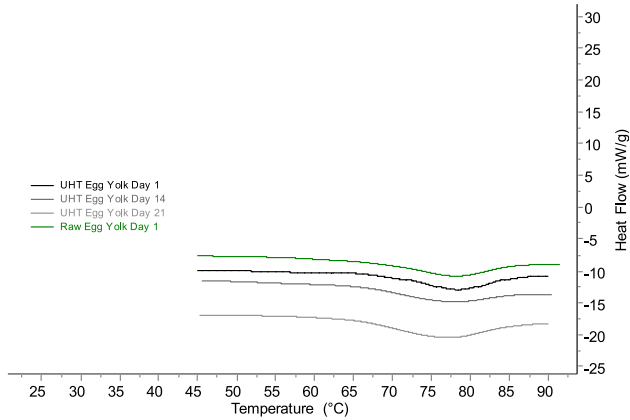


Fig. 1. DSC results of raw and UHT egg yolk

### Rheological measurement

The results of apparent viscosity are represented in Figs. 2 and 3. Table 2 shows the Shear Stress ( $\tau$ ) and the apparent viscosity ( $\eta$ ) on point number 10 on the first and final date of storage. According to Mezger (2015), the rheometer starts to register the correct apparent viscosity starting from point 10. The rheological measurement were carried out at 25 °C because it is the suitable temperature at which the rheometer works precisely and the rheological properties are

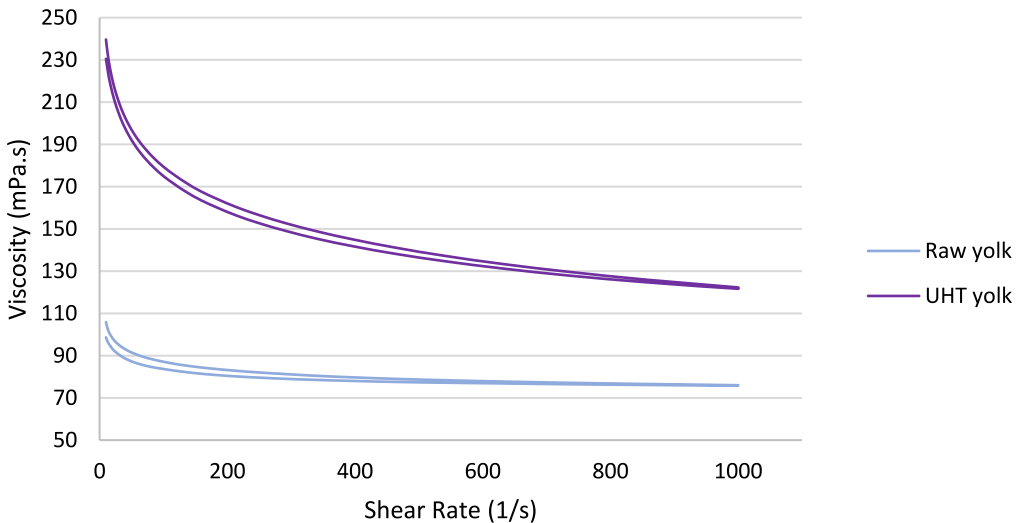


Fig. 2. Rheological graph of LEY on the 1st day



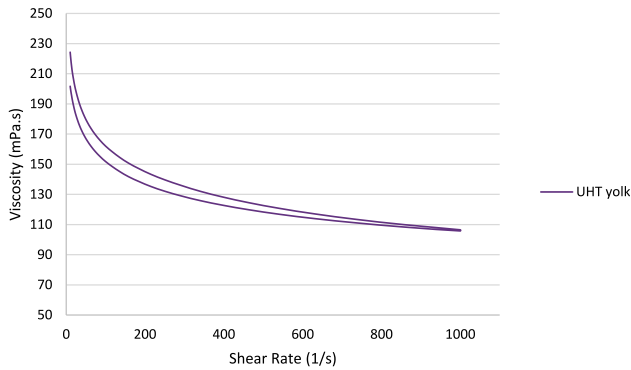


Fig. 3. Rheological graph of LEY on 21st day of storage

Table 2. Shear Rate, Tau and Eta of point 10 of LEY

		Point	Shear rate	Tau	Eta
Day 1	UHT LEY	10	39.8	8.07 ± 0.05	202.83 ± 1.40
	Raw LEY	10	39.8	3.70 ± 0.44	93.07 ± 11.25
Day 21	UHT LEY	10	39.8	7.39 ± 0.40	185.66 ± 10.05

highly dependent on temperature. Atılgan and Unluturk (2008) concluded that the rheological behavior of liquid egg products showed no thixotropy and time-dependency at 25 °C.

Samples in all cases showed non-Newtonian behavior. Apparent viscosity curves had yielded stress and they showed pseudoplastic flow behavior.

As shown in Table 2, there is a difference on the apparent viscosity of the UHT and raw LEY; even though the curve looks the same, but the apparent viscosity of the UHT LEY is much higher than that of the raw LEY in each measurement point. On the last day of storage, the apparent viscosity of UHT LEY is 224.32 ± 13.10 mPa.s, although it decreased but it is still higher than that of of the raw LEY on the 1st day.

## DISCUSSION

All the  $\Delta E_{ab}^*$  values are higher than 3 from the 1st day of storage, that signifies that the color difference between the samples is noticeable. This can suggest that the UHT treatment affects some nutrients responsible for coloration on the egg yolk, such as the carotenoids, which represent about 1% of the lipids of egg yolk, mainly carotene and xanthophylls (lutein, cryptoxanthin, and zeaxanthin) as mentioned in Anton. M. (2007) and Wu (2014).

Differential Scanning Calorimeter was used by Cordobés et al. (2004) in order to investigate thermal transition in egg yolk proteins and to provide information on the conversion from native to heat-denatured states (Blume et al., 2015). The result of DSC for Cordobés et al. (2004) showed that the endothermic peak was in the range of 81.8 and 86.2 °C when they used egg yolk



gel with 51 wt% while the endothermic peak of our samples is in the range of 76.52 and 78.28 °C. While the endothermic starts at 60 °C, in the case of our experiment it started at 65 °C.

Even the apparent viscosity decreased on the last day of storage. This can be explained by the fact that the composition of LEY changed.

## CONCLUSION

As the results showed, the UHT treatment did not accentuate the denaturation of the protein of LEY, and it increased the apparent viscosity of LEY. However, it can denature the components responsible for coloration, such as carotenoid, polyphenol. . .

The UHT treatment could affect the functional properties of LEY such as the emulsification ability and its stability. Heat stability test of mayonnaise could show how much this treatment affected this functional characteristic.

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