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THE EFFECT OF ADDING DIFFERENT OILS ON LIQUID EGG PRODUCTS CHEMICAL AND PHYSICAL PROPERTIES

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Abstract

Egg products are widely used and are known for their easy use and long shelf life when compared to regular eggs. In the food industry the most used egg product is pasteurized liquid whole eggs, it's usually used in bakery products, fresh and dried pasta, and ice cream. 20% of total egg consumption around Europe is represented by egg products. According to European regulation the term "egg product" is all processed egg foodstuffs that are intended for human consumption. Adding flavors and fortifying egg products with oils to check the effect it has on its properties is the aim of this study. Olive oil, and sunflower oil have a great antioxidant activity and phenolic content, olive oil for example is known for its positive effect on inhibiting foodborne pathogens and enhancing cardiovascular health. On the other hand about 90% of fatty acids that are found in sunflower oils are unsaturated oleic and linoleic acids that can decrease plasma lipoproteins and total cholesterol.

2.5, 5, 7.5% V/V of olive oil, and sunflower oil were added to pasteurized liquid whole eggs. Then pH, color, and viscosity were measured to evaluate the effect. pH was measured at 4 ^{0}C using a portable digital pH meter (206-pH2, Testo SE, Germany). Tristimulus color measurements were performed with a Konica-Minolta CR-410 chroma-meter (Konica Minolta Sensing, Japan) at 4 ^{0}C. Viscosity measurement was performed by MCR 92 rheometer (Anton PaarFrance) at 15 ^{0}C.

Adding both oils did not significant effect on liquid whole egg pH significantly, on the other hand both oils effected L*, b* and a* color parameter significantly in comparison to the control group. Sunflower oil effected a* values significantly in comparison to control and significantly in comparison to all other kinds of oils. Regarding the viscosity of liquid whole eggs, both oils changed Herschel-Bulkley parameters, Tau0, K and n changing the flow behavior of liquid whole eggs from shear thinning to shear thickening fluid.

Adding olive and sunflower oils to liquid whole egg can affect its chemical and physical properties.

***Key words**: Liquid Egg products, Liquid whole Eggs, Olive Oil, Sunflower Oil.*

1. Introduction

Egg proteins are considered a very important kind of protein for human consumption. They are distributed in egg yolk and egg white. Both yolk and white proteins are complete proteins containing all essential and needed amino acids for muscle growth and repairing. Egg proteins are known to have a high biological dietary protein value, which means that they are efficiently converted into body tissue. Egg proteins are divided into: yolk proteins, which are mainly low density lipoproteins, high density lipoproteins, phosvitin, and livetin all homogeneously found in an emulsified fluid. On the other hand egg white contains almost 40 kinds of different proteins such as: ovomucoid, ovoalbumin, and ovotransferrin [1]. Eggs are also loaded with other kinds of proteins including flavoprotein and avidin. Eggs have great benefits in enhancing body muscle mass, beside egg high protein content it has several nutrients such as vitamins, minerals and lipoproteins. Several studies indicated that consuming whole eggs can promote the synthesis of myofibrillar protein at higher rates than consuming egg white alone in young men but no significant effect was seen when muscle hypertrophy was investigated in young men performing resistance training [2].

Egg composition, in specific egg proteins, are the reason for its great manufacturing properties. Due

to their protein coagulation and denaturation at different temperatures forming a stable matrix, eggs are used in several manufacturing including cakes, meringues, soufflés, and custards [3]. Due to the fact that eggs are fragile and a great substrate of spoilage and food-borne pathogens, a need for a new more stable product of eggs had been considered. Liquid egg products obtained by individually breaking eggs using machines that can separate the white and yolk as well as removal of the shell. After separation egg white, yolk or whole eggs are filtered and pasteurized to produce liquid egg products. Pasteurization of liquid egg products is necessary in order to extend its shelf life and lower its food- borne related salmonellosis. In fact, all kinds of processes are designed to improve egg products hygiene and functional quality. On the other hand, this kind of heat treatment can negatively affect egg chemical, physical, and nutritional properties as well as sensory attributes [4, 5].

It is well known that consuming olive oil can increase the individual intake of antioxidant and bioactive compounds like oleuropein and oleanolic acid which are anti-inflammatory and cardioprotective compounds. Consuming olive oil is linked with decreasing the incidence of many diseases which are results of inflammation such as arthritis and cancer [6, 7].

Sunflower oil contains mainly oleic and linoleic acids, when compared to olive oil sunflower oil has a relatively higher content of linoleic acid. Research suggests that linolenic acid may play a role in reducing the risk of cardiovascular disease by lowering blood pressure, improving lipid profiles, and reducing inflammation. It has been associated with potential anti-inflammatory effects, making it beneficial for conditions such as arthritis, asthma, and inflammatory bowel disease. Linolenic acid is also involved in maintaining brain health and cognitive function, with studies suggesting its potential protective effects against age-related cognitive decline and neurodegenerative diseases. Additionally, linolenic acid is crucial for optimal skin health, as it helps maintain skin barrier function and may alleviate symptoms of skin disorders like eczema. It has also been linked to improved eye health, including a potential protective role against age-related macular degeneration. Furthermore, linolenic acid has been investigated for its potential anticancer properties, although further research is needed to establish its role in cancer prevention and treatment [8, 9].

According to European regulation the term "egg product" is all processed egg foodstuffs that are intended for human consumption. Adding flavors and fortifying egg products with oils to check the effect it has on its properties was the aim of this study.

2. Materials and Methods

2.1 Materials and sample preparation

Pasteurized homogenized liquid whole eggs were obtained from a liquid egg plant (Capriovus Ltd., Szigetcsép, Hungary). 2.5, 5, and 7.5 % W/W of extra virgin olive oil and sunflower oil were added to 200 mL of liquid whole eggs and mixed at 10 ^{0}C. Then measurements were made in comparison to control samples which are plain liquid whole eggs. Olive oil and sunflower oil were obtained from Uncle Chris - Greek and Floriol - Hungary respectively.

2.2 pH measurement

The pH was measured at 4 ^{0}C using a portable digital pH meter (206-pH2, Testo SE, Titisee-Neustadt, Germany) in triplicate.

2.3 Color measurement

Tristimulus color measurements were performed with a Konica-Minolta CR-410 chromameter (Konica Minolta Sensing, Osaka, Japan) 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 at 4 ^{0}C. Measurements were performed five times.

2.4 Determination of rheological properties

Rheological properties of liquid whole egg and oil mixture samples were analyzed by Anton Paar MCR 92 rheometer (Anton Paar, France) in rotational mode equipped with a concentric cylinder (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) temperature was kept constant at 15 ^{0}C. Anton Paar RheoCompass software was used to control the equipment. Shear stress was measured in increasing and decreasing shear rate intervals between 1 and 1,000 x s^{-1} for 31 measurement points with a period of 3 s. The Herschel-Bulkley model was used to analyze the flow curves using the following equation:

$$\tau = \tau 0 + K\dot{\gamma}^{n}$$

Where: τ refers to shear stress (Pa); $\tau 0$ indicates the yield stress (Pa); $\dot{\gamma}$ is the shear rate (1/s), K refers to the consistency coefficient (Pa·sn) and n is the flow behavior index [10].

2.5 Statistical analysis

The data was statistically analyzed using the statistical package for social science (SPSS, version 27.0, 2020, Chicago, IL). A two way analysis of variance (ANOVA) test was performed to test the difference between the treatments. Followed by mean separation using Tukey HSD Analysis. Means with different superscripts A, B, C, and D differ significantly at $p < 0.05$.

3. Results and Discussion

3.1 Change in pH

The pH of raw whole liquid egg for this experiment was 5.93 at the beginning but the readings were increasing with the increase of the added percentage of both oils. The extra virgin olive oil concentration increased the pH of liquid whole egg to: 6.04, 6.05 and 6.1 with the percentages: 2.5, 5, and 7.5% W/W respectively, on the other hand sunflower oil increased the pH of liquid whole egg to: 6.05, 6.06, and 6.07, with the percentages: 2.5, 5, and 7.5% W/W respectively. The increase of pH caused by both oils was insignificant at all percentages ($p < 0.05$) in comparison to the control group.

Although that extra virgin olive oil is considered to be an acidic oil itself, but it doesn't significantly alert the pH values of liquid whole eggs, on the other hand sunflower oil in known to be a neutral oil with pH around 7, this can be explained by the fact that eggs have very complex matrix that was insignificantly affected by the oils pH levels. pH values are affected by compounds that can accept and release hydrogen ions, due to the fact that oils are lipids which have a small amount of such molecules their effect on pH values of food is minimal [11]. The 2.5, 5, and 7.5% which was added of both oils to liquid whole eggs was insignificant to the total 200 mL of liquid whole egg.

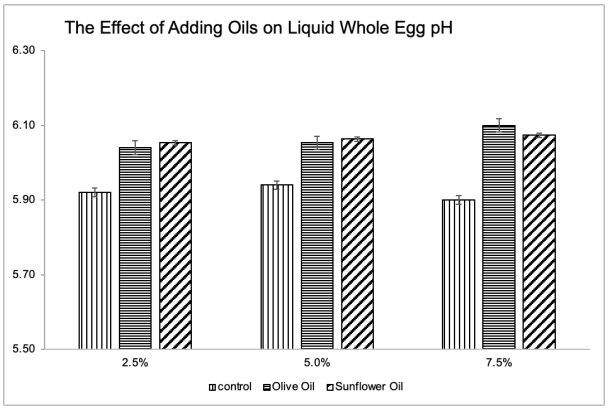

Figure1. The effect of adding 2.5, 5 and 7.5% of extra virgin olive oil and sunflower oil to liquid whole egg pH values in comparison to the control group. Different letters are for significantly different groups (Tukey's $p < 0.05$)

3.2 Change in color parameters

Oils are known to enhance the overall color and appearance when added to food, this effect differs based on the original color of food and the color of added oil. Color of food can influence the consumer choices by adding, since olive oil has natural pigments, and it enhances the yellowish color of egg yolk which results in a deeper yellower overall whole egg color. Color properties of liquid whole egg samples are shown in Figure 2, Figure 3, and Figure 4 below.

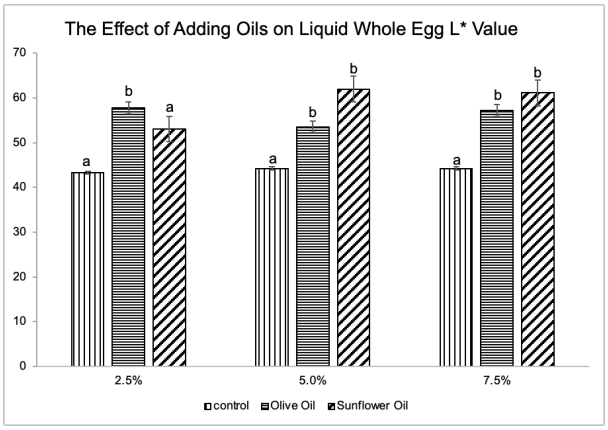

Figure2. The effect of adding 2.5, 5 and 7.5% of extra virgin olive oil and sunflower oil to liquid whole egg L* values in comparison to the control group. Different letters are for significantly different groups (Tukey's $p < 0.05$)

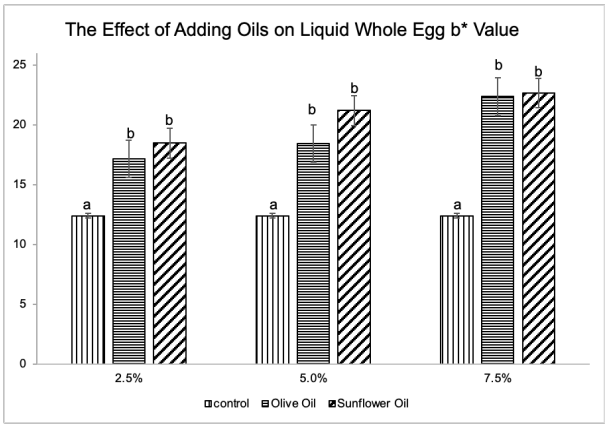

Figure3. The effect of adding 2.5, 5 and 7.5% of extra virgin olive oil and sunflower oil to liquid whole egg b* values in comparison to the control group. Different letters are for significantly different groups (Tukey's $p < 0.05$)

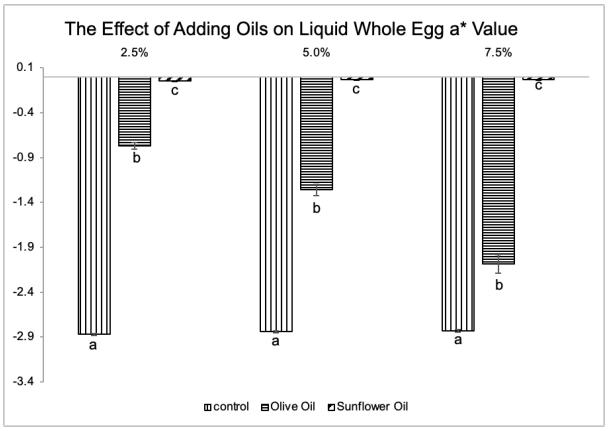

Figure 4. The effect of adding 2.5, 5 and 7.5% of extra virgin olive oil and sunflower oil to liquid whole egg a* values in comparison n to the control group. Different letters are for significantly different groups (Tukey's $p < 0.05$)

As seen in the results the color of the whole egg changed significantly ($p < 0.05$) for different oils and concentration [12]. L*, and b* values showed an increasing tendency with the increase in the concentration for both oils, this increase was significant for all concentration of both oils of L* except the sample with 2.5% of sunflower oil. On the other hand, when it comes for a* adding olive and sunflower oils increase a* significantly toward the red axis which means it shifted the color from green to more reddish, and that enhances the overall color of the product. Both of extra virgin olive oil and sunflower oil are bright yellowish oils, adding them to liquid whole egg can increase the brightness of the product which explains the significant increase in L* values [13]. Due to the yellowish hue of both oils, b* values of liquid whole eggs increased significantly, the concentration of olive oil and sunflower oil added affected the degree of color change in the liquid whole eggs. Higher amounts of oils lead to a more noticeable shift in the b* value. The change in L* and b* which was caused by both oils due to their yellowish hue moved the a* values from the green axis more to toward the red axis, which cause the a* values to increase significantly [14].

3.3 Rheological measurement

Liquid egg products are known as shear-thinning fluids, the viscosity of liquid whole egg and liquid egg white is typically dependent on the shear rate. This shear-thinning behavior is primarily due to the presence of proteins in the liquid eggs. Proteins, particularly egg white proteins, can unfold and reorganize when subjected to shear stress, resulting in a decrease in viscosity. The unfolding of proteins leads to the formation of a more dispersed and less entangled network, making the liquid eggs flow more easily [15].

Table 1. Measured results of Herschel-Bulkley model at different concentrations of olive, and sunflower oil values in comparison to the control group. Different letters are for significantly different groups (Tukey's $p < 0.05$)

Sample	Tau0	K	n
Control	0.073	0.028	0.968
Olive oil 2.5%	0.086	0.003	1.144*
Olive oil 5%	0.124*	0.003	1.154*
Olive oil 7.5%	0.083	0.004	1.167*
Sunflower oil 2.5%	0.140*	0.003	1.184*
Sunflower oil 5%	0.100*	0.003	1.192*
Sunflower oil 7.5%	0.079	0.003	1.197*

τ0 values calculated by the Herschel-Bulkley model varied between 0.073 for the control group and 0.14 for sunflower 2.5% sample Pa (Table 1). The highest flow behavior index "n" was calculated for all samples; it was found to be increasing with the increase of oil percentages in both cases of olive and sunflower oils. If $n > 1$, the flow behavior is considered as dilatant or shear thickening. When compared control group to all other groups n increased with the increase of added oils percentage, the increase in viscosity occurs due to the interactions between the components of the eggs and oils. When olive oil and sunflower oil are added, the oil molecules can interact with the fat, proteins, and other components in the eggs, creating a network or emulsion structure [16, 17]. This network or emulsion structure traps and holds water and other components, resulting in a thicker consistency [18, 19]. Both oils act as a thickening agent, enhancing the viscosity of the liquid whole eggs.

4. Conclusions

- Liquid eggs offer convenience and time-saving benefits. They eliminate the need for cracking and separating eggs, which can be time consuming. Some customers may choose liquid egg products that contain specific oils, such as olive oil or sunflower oil or any other cooking oils to spare time and effort.

- This work provides information for the egg industry about the effect of adding extra virgin olive oil and sunflower oil on the physical properties of liquid whole eggs. Liquid whole eggs were fortified with different percentages of extra virgin olive oil and sunflower oil then pH, color and rheological properties were measured.
- The addition of both oils had no significant effect on the pH values of liquid whole eggs, on the other hand both oils effected L*, b* and a* significantly by increasing the intensity of liquid whole eggs color which increases its customer acceptance.
- Regarding rheological properties adding both oils to liquid whole eggs increased its viscosity. The presence of these oils can contribute to the formation of emulsion structures or networks, leading to a thicker consistency in the mixture.

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