International Research Journal of Advanced Engineering and Science
ISSN (Online): 2455-9024

The Physicochemical Characteristics of Pasteurized Liquid Whole Egg with Different Percentages of Acetic Acid

Yuliana Mega Leony Simbolon, Herly Evanuarini, Imam Thohari
Department of Animal Products Technology, Faculty of Animal Science, University of Brawijaya, Malang (65145), East Java, Indonesia

Abstract— *Discoloration is a disadvantage of pasteurized liquid whole eggs. Functional properties need to be maintained by using acids for the sustainable production of pasteurized liquid whole eggs. Acetic acid (in vinegar) is widely used as a food preservative. This research aimed to determine the quality of pasteurized liquid whole eggs with the addition of acetic acid. The materials used were 64 fresh whole eggs (weight 60 ± 2 g), and acetic acid (commercial food vinegar). Pasteurization using a laboratory water bath for 3.5 minutes at 60°C. A laboratory experiment was used as the research method, with a completely randomized design. The treatments that replicated 4 times were without acetic acid (control), and various percentages of acetic acid addition (0.5%, 1%, 1.5%). Analysis of variance (ANOVA) was used as a data analysis method and further testing using Duncan's multiple range test. The acetic acid added was very significantly affected (P<0.01) on pH value, viscosity, foaming ability, color value (L*a*b*) and protein content of pasteurized liquid whole eggs. In conclusion, the addition of 1.5% acetic acid produced the best physicochemical characteristics of pasteurized liquid whole eggs.*

Keywords— *Liquid whole egg; pasteurization; discoloration; denaturation; acetic acid.*

I. INTRODUCTION

Eggs are an indispensable source of protein for human growth. Egg production is already one of the most environmentally friendly form of livestock production. Eggs contain high-quality protein because it has a complete composition of essential amino acids. The advantages of eggs are that they have can be digested easily and play an important role in the food industry. Eggs have functional properties (nutrition) and physicochemical properties such as emulsification, coagulation or gelation, foaming, impart color, aroma, flavor, and structure formation. The egg yolks can use as an emulsifier in the manufacture of mayonnaise (Prasetya and Evanuarini, 2019), while the egg white (albumen) can function as a binding agent in chicken nuggets production (Evanuarini, 2010). The number of hen eggs production is classified as high but has a high risk of physical damage (easy to break) and quality loss during distribution and storage. It is caused by many environmental factors (temperature, crash, microorganisms). Handling, preservation, and processing are needed so that eggs have a more prolonged shelf life. The method widely used to obtain safe and durable products is by thermal treatment using pasteurization techniques. One of them is pasteurized liquid whole egg products. Some of the advantages of pasteurized liquid whole eggs are practical, efficient, prolonged shelf life, and easy to distribute.

Pasteurization technology includes heating technology that is widely used to offer safety assurance and more prolonged the shelf life of food ingredients. Heating can change the composition of chemical structures, modify components that are not heat resistant, and affect the functional properties of food products. The pasteurization temperature and time used in the industry for liquid whole eggs is 60°C for 3.5 minutes or 64°C for 2.5 minutes (Yogesh, 2016). Pasteurization is a simple method using a heating process to preserve eggs. The most widely used pasteurization methods include the wet method and the dry method. The wet pasteurization method was carried out by placing the liquid eggs on a water bath (63°C for 3 minutes), while the dry method was carried out by placing the liquid eggs on an incubator (70°C for 60 minutes) (Siregar, Hintono, and Mulyani, 2012. The process of heating or pasteurizing eggs widely aims to prevent contamination and inhibit the growth of microbial on the egg liquid. Some studies state that pasteurization of liquid eggs can be using a temperature of 55.6°C with a time of 6.2 minutes or 56.7°C with a time of 3.5 minutes or 60°C with a time of 3.5 minutes, but the maximum temperature is 65°C. Heating at a higher temperature will damage the characteristics of the egg (Nahariah and Hikmah, 2021). The effect of heat through pasteurization on liquid whole egg (LWE) can cause functional properties and consistency to change. Protein denaturation occurs at higher temperatures, so food additives are needed to prevent protein quality degradation (Tokuşoğlu and Cánovas, 2018). Denaturation of egg protein generally occurs due to heat treatment, the addition of chemicals, and pressure. Heat treatment with high temperature or addition of chemicals that cause total and irreversible protein opening due to breaking of covalent bonds and aggregation of the protein molecules (Naderi et al., 2017).

Pasteurized liquid eggs will experience discoloration to greenish during storage. This is thought to be due to the interaction between a combination of Iron(II) sulfide and fat-soluble carotenoids. The content in egg yolks, among others, is mostly iron and egg carotenoids, sulfur (in the form of reaction in the form of hydrogen sulfide). Alkaline heating treatment will cause these components to be easily separated from cysteine and methionine after, resulting in a reaction between sulfur and iron to form ferrous sulfide which forms a green color (Li et al., 2018). Food additives that can be added are organic acids. Organic acids such as citric, lactic, and acetic acids are relatively simple which have been widely used in the food processing industry (In et al., 2013). Acetic acid is an organic acid that has a function as a food additive, sour taste, and preservative. Acetic acid solution is glacial acetic acid that has been diluted to a level that is in accordance with the standard and is fit for consumption. The quality standard of food vinegar is regulated in SNI 01-3711-1995. Based on other research, vinegar can be made using two different basic methods, namely by using the fermentation method or by diluting pure acetic acid with water. Commercial vinegar products are edible products made from acetic acid which has been diluted with water, which contains 4-8% acetic acid (Pashova and Trichkova-Ablee, 2016). Vinegar acid solution is widely used as a food additive, namely as an acidifier, preservative, and also a food flavoring that has the ability to bind metals (Sari and Keman, 2005). The aim of this research was to find out the best percentage of the use of acetic acid in pasteurized liquid whole eggs (LWE) based on physicochemical characteristics and functional properties such as pH value, viscosity, foaming ability, color value ($L*a*b*$), and protein content.

II. MATERIALS AND METHODS

Materials

The raw materials in this research were 64 fresh whole eggs from laying hens with an average egg weight of 60 ± 2 g to be made into pasteurized liquid whole eggs. The acetic acid used as a treatment is commercial vinegar. The equipment used in the research for the manufacture of pasteurized liquid whole eggs were a laboratory water bath, beakers, and glass spatula. The research materials for testing variables include aquadest, buffer solutions pH 4 and pH 7, 0.1 N NaOH, phenolphthalein indicator, concentrated H_2SO_4, boric acid, tashiro indicator, 0.1 N HCl. The tools used for testing include a pH meter, beaker glass, measuring cups, viscometers, mixers, spatula, thermometer, analytical scale, laboratory Kjeldahl flasks, funnels, burettes, erlenmeyer, petri dish, and color reader.

Methods

The experimental method using experimental laboratory. Table 1 presents the experimental design using a completely randomized design (4 treatment groups and 4 replications).

TABLE 1. Experimental design and treatment groups code

Treatment groups code	Definition
T_0 (control)	Pasteurized liquid whole egg without acetic acid
T_1	Pasteurized liquid whole eggs added 0.5% acetic acid
T_2	Pasteurized liquid whole eggs added 1% acetic acid
T_3	Pasteurized liquid whole eggs added 1.5% acetic acid

Pasteurized liquid whole egg manufacture

Fresh chicken eggs are selected, and the shells are cleaned using warm water and less than 5 minutes. The whole eggs are separated from the shell and the chalazae is removed. Whole eggs are homogenized manually using homogenizer. Then the liquid whole eggs were pasteurized in a water bath for 3.5 minutes at 60°C (Naderi et al., 2017; Keerthirathne et al., 2017). The temperature of the pasteurized liquid whole egg is lowered to 30-40°C, add acetic acid (commercial vinegar) according to each treatment. Whole eggs pasteurized using acetic acid were analyzed for pH value, viscosity, foaming ability, color value ($L*a*b*$), and protein content.

Data analysis

Microsoft Excel is used to tabulate the data obtained from the test results for each variable. The method used to analyze the data is one-way analysis of variance (ANOVA). Then Duncan's Multiple Range Test (DMRT) was used for further testing if there were significant differences between each treatment groups. The final data presented in each table is the mean ± standard deviation (SD).

III. RESULTS AND DISCUSSION

pH value

The results presented that increasing the percentage of acetic acid addition gave a very significant effect ($P<0.01$) on decreasing the pH value of pasteurized liquid whole eggs. The data in Table 2 presents that a higher percentage of acetic acid addition resulted in lower pH values, with values ranging from 6.96 to 7.54.

TABLE 2. The pH value of the pasteurized liquid whole eggs

Treatment groups code	pH value
T_0 (control)	7.54 ± 0.04^d
T_1	7.21 ± 0.02^c
T_2	7.11 ± 0.05^b
T_3	6.96 ± 0.05^a

Note: a,b,c,d The various superscripts in the mean value column of pH showed very significant differences ($P<0.01$)

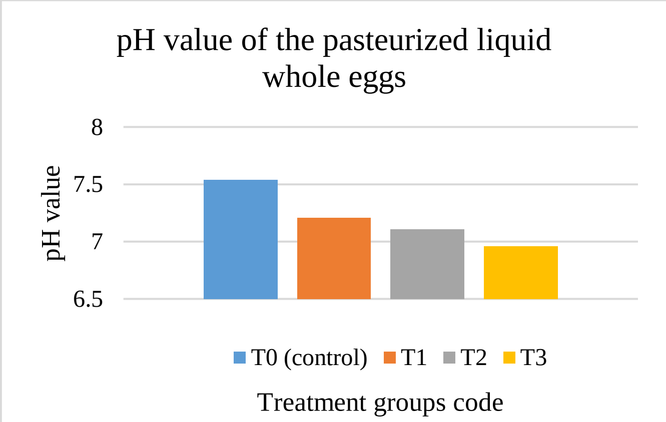

Fig. 1. Column chart of pH values of whole pasteurized liquid eggs

Figure 1 shows a decrease in the column chart, where T_3 has the lowest pH value compared to other treatments. Fresh liquid whole eggs have a pH value of around 7.46 (Monfort et al., 2012), while pasteurized liquid whole eggs are around 7.5 (Rossi et al., 2010). T_3 has the lowest pH value than the other treatment groups. Acetic acid is an organic acid, mostly found in kitchen vinegar or food vinegar. Acetic acid is acidic so the pH value of acetic acid is low. The pH value of commercial acetic acid which is widely used for food additives is around 4.5, so it is suspected that it causes the pH value to decrease (Gurtler & Mai, 2014). The nature of acetic acid makes it can be used as an antimicrobial that inhibits the growth of microorganisms. This is in line with the desire to maintain quality with a longer shelf life of liquid whole egg products (Braïek and Smaoui, 2021). Acetic acid is an organic acid that can inactivate or inhibit microbes as a function of decreasing pH (Pasau, 2013). The lower pH changes will cause a slight change in the charge on the protein molecules so that the water absorption in the protein molecules is slightly reduced (Radovčić et al., 2020).

Viscosity

The viscosity of pasteurized liquid whole eggs can be measured using a viscometer at room temperature (25°C) (Singh et al., 2011). The results presented that increasing the percentage of acetic acid addition gave a very significant effect ($P<0.01$) on decreasing the viscosity of pasteurized liquid whole eggs. The data in Table 3 presents that a higher percentage of acetic acid addition resulted in lower viscosity, with values ranging from 720.25 to 850.35cP.

TABLE 3. The viscosity of the pasteurized liquid whole eggs

Treatment groups code	Viscosity (cP)
T_0 (control)	850.35 ± 0.21^d
T_1	800.25 ± 0.25^c
T_2	755.20 ± 0.21^b
T_3	720.25 ± 0.08^a

Note: a,b,c,d The various superscripts in the mean value column of viscosity showed very significant differences ($P<0.01$)

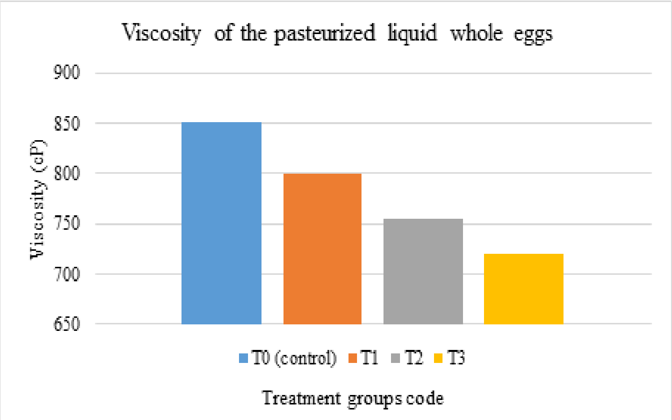

Fig. 2. Column chart of viscosity of whole pasteurized liquid eggs

Figure 2 shows a decrease in the column chart, where T_3 has the lowest viscosity compared to other treatments. The decrease in viscosity comes from the addition of acetic acid, presumably because acetic acid is classified as an acidic liquid, causing molecular changes. Viscosity or viscosity is the ability of a liquid to withstand the flow of liquid in it. Viscosity is closely related to the molecular weight and chain length of the amino acids in the product. The higher the concentration of acetic acid added will cause a decrease in the viscosity of the food product, because the amino acid chain in the product will be broken (Pantow et al., 2016).

Foaming ability

The results presented that increasing the percentage of acetic acid addition gave a very significant effect ($P<0.01$) on increasing the foaming ability of pasteurized liquid whole eggs. The data in Table 4 presents that a higher percentage of acetic acid addition resulted in higher foaming ability, with values ranging from 131.37 to 207.94%.

TABLE 4. The foaming ability of the pasteurized liquid whole eggs

Treatment groups code	Foaming ability (%)
T_0 (control)	131.37 ± 0.73^a
T_1	157.28 ± 0.63^b
T_2	182.32 ± 0.61^c
T_3	207.94 ± 0.66^d

Note: a,b,c,d The various superscripts in the mean value column of foaming ability showed very significant differences ($P<0.01$)

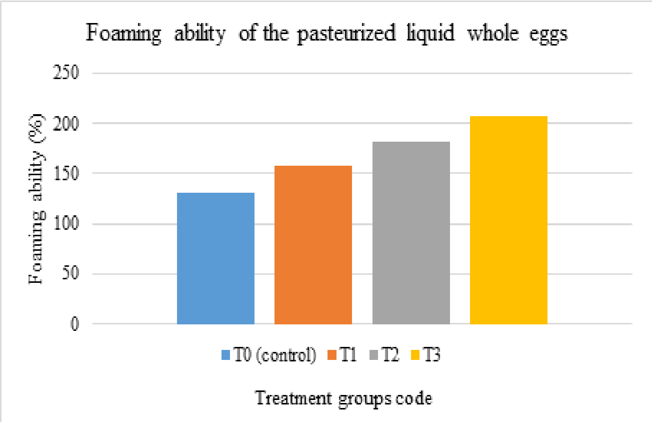

Fig. 3. Column chart of foaming ability of whole pasteurized liquid eggs

Figure 3 shows an increase in the column chart, where T_3 produces the highest foaming ability compared to other treatments. An increase in the percentage of acetic acid resulted in an increase in foaming ability, because the acid served to help maintain the functional properties of eggs, including the ability to foam. Pasteurized eggs have a higher foaming ability than unpasteurized eggs. Wet and dry pasteurization methods have no significant effect on the foaming ability of eggs (Siregar, Hintono, and Mulyani, 2012). The lower foaming ability occurs due to the formation of insoluble macromolecular groups and cross-linking with egg protein, which is easily adsorbed onto the gas-water interface (Liu et al., 2020). The increase in foaming capacity was thought to be due to the added citric acid interacting with the proteins in the egg liquid. Then there is increased spread of the protein through the air-liquid interface and results in more air incorporation (Radovčić et al., 2020). The foaming ability of eggs is related to pH because ovalbumin which plays a role in foam formation will change to s-ovalbumin due to evaporation of CO_2 and H_2O (Wibowo, Sudjatinah, and Sampurno, 2020).

*Color value (L*a*b*)*

The color value of pasteurized liquid whole eggs can be measured using a color reader (Monfort et al., 2012), with the *L*a*b** color space as shown in Figure 4 (Sinaga, 2019). The results presented that increasing the percentage of acetic acid addition gave a very significant effect ($P<0.01$) on the color value (*L*a*b**) of pasteurized whole eggs. The data in Table 5 presents that the increase in *L** (lightness) and *b** (yellowness) color values, and the decrease in *a** (redness) color values of pasteurized liquid whole eggs were in line with the increase in the percentage of acetic acid addition. The color value of *L** ranged from 42.57 to 47.27, the value of *a** ranged from 9.47 to 13.83, and the value of *b** ranged from 28.86 to 33.66.

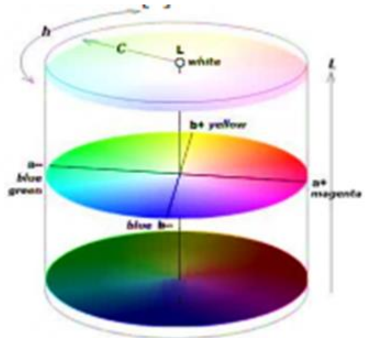

Fig. 4. The *L*a*b** color space (Sinaga, 2019)

TABLE 5. The color value (*L*a*b**) of the pasteurized liquid whole eggs

Treatment groups code	*L**	*a**	*b**
T_0 (control)	42.57 ± 0.46[a]	13.83 ± 0.51[d]	28.86 ± 0.58[a]
T_1	43.48 ± 0.19[ab]	12.58 ± 0.33[c]	30.34 ± 0.74[b]
T_2	45.47 ± 0.65[b]	10.73 ± 0.36[b]	32.75 ± 0.45[c]
T_3	47.27 ± 0.64[c]	9.47 ± 0.53[a]	33.66 ± 0.36[c]

Note: a,b,c,d The various superscripts in the mean value of color (*L*a*b**) column showed very significant differences (P<0.01)

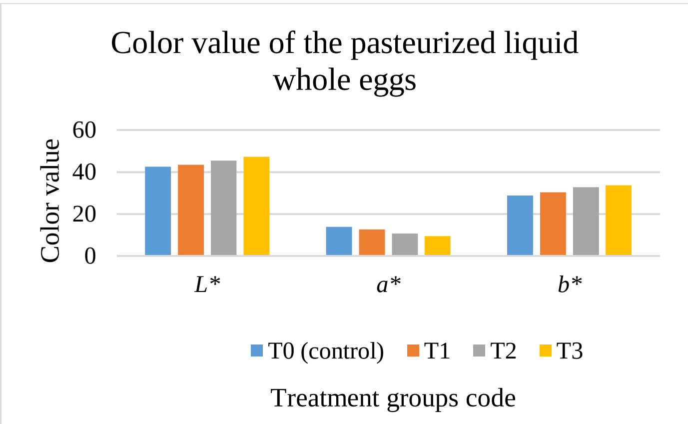

Fig. 5. Column chart of color value of whole pasteurized liquid eggs

Figure 5 shows that the column chart increases for the values of *L** and *b**, and decreases for the values of *a**. T_3 has a highest color value (*L** and *b**) than the other treatment groups. The increase in color value, and decrease color *a** in value were only influenced by the addition of acetic acid. Acetic acid is classified as an acid in the form of a watery liquid and can contribute in separating the color of the product to be lighter. The added acetic acid affects the *L** and *b** values in the T_1, T_2, and T_3, which resulted in a lighter and more yellow color than the T_0. The addition of acetic acid had no effect on increasing the *a** value. An increase in *a** value is known to indicate the presence of a Fe-conalbumin complex formed. Conalbumin and Fe^{3+} ions when forming a complex will produce a red color. The *b** value is the level of the yellow color value which is influenced by pigment such as xanthophyll, lutein, and zeaxanthin found in egg yolks. An acid can be used as a color stabilizer. The difference in concentration of the addition of acid causes a difference in the pH value and affects the color change of liquid whole egg (LWE) [(Radovčić et al., 2020).

Protein content

The protein content of pasteurized liquid whole eggs can be measured using the Kjeldahl's method (Wibowo, Sudjatinah, and Sampurno, 2020). The results presented that increasing the percentage of acetic acid addition gave a very significant effect (P<0.01) on increasing the protein content of pasteurized liquid whole eggs. The data in Table 6 presents that a higher percentage of acetic acid addition resulted in higher protein content, with values ranging from 12.37 to 13.89%.

TABLE 6. The protein content of the pasteurized liquid whole eggs

Treatment groups code	Protein content (%)
T_0 (control)	12.37 ± 0.28[a]
T_1	13.20 ± 0.10[b]
T_2	13.50 ± 0.10[bc]
T_3	13.89 ± 0.09[c]

Note: a,b,c,d The various superscripts in the mean value column of protein content showed very significant differences (P<0.01)

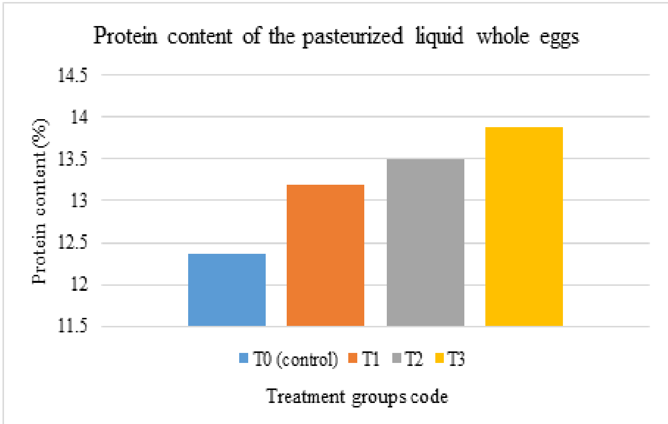

Fig. 6. Column chart of protein content of whole pasteurized liquid eggs

Figure 6 shows an increase in the column chart, where T_3 has the highest protein content compared to other treatments. The increase in protein content was influenced by the addition of acetic acid because acetic acid degrades proteins into simpler parts. The higher concentration of citric acid significantly increases the protein solubility of liquid whole egg (LWE) (Radovčić et al., 2020). The protein content in fresh whole eggs is known to be around 12%, in egg yolks about 16% and in albumin or egg whites around 11% (Naderi et al., 2017), while pasteurized liquid whole egg products have a protein content of about 11.9% per 100 g (Rossi et al., 2010).

IV. Conclusion

The conclusion of this research based on the results and discussion of the addition of acetic acid with different levels can be used as a food additive to maintain the physicochemical quality of pasteurized whole eggs. The addition of 1.5% acetic acid to pasteurized liquid whole eggs resulted in the best treatment with a pH value of 6.96, viscosity 720.25cP, foaming ability 207.94%, color value *L** 47.27, *a** 9.47, and *b** 33.66, and protein content 13.89%.

References

[1]. Braïek, O. B., and Smaoui, S. 2021. Chemistry, safety, and challenges of the use of organic acids and their derivative salts in meat preservation. *Journal of Food Quality*, *10*(1), 1-20. doi: 10.1155/2021/6653190.

[2]. Evanuarini, H. 2010. Kualitas chicken nuggets dengan penambahan putih telur. *Jurnal Ilmu dan Teknologi Hasil Ternak*, *5*(2), 17-22.

[3]. Gurtler, J. B., & Mai, T. L. 2014. *Traditional preservatives - organic acids* (2nd ed.). Encyclopedia of Food Microbiology. p119-130. London: Academic Press. doi: 10.1016/B978-0-12-384730-0.00260-3.

[4]. In, Y.-W., Kim, J.-J., Kim, H.-J., and Oh, S.-W. 2013. Antimicrobial activities of acetic acid, citric acid and lactic acid against shigella species. *Journal of Food Safety*, *33*(1), 19-85. doi: 10.1111/jfs.12025.

[5]. Keerthirathne, T. P., Ross, K., Fallowfield, H., and Whiley, H. 2017. Reducing risk of salmonellosis through egg decontamination processes. *Int. J. Environ. Res. Public Health*, *14*(3), 1-10. doi: 10.3390/ijerph14030335.

[6]. Li, J., Wang, C., Zhang, M., Zhai, Y., Zhou, B., Su, Y., and Yang, Y. 2018. Effects of selected phosphate salts on gelling properties and water state of whole egg gel. *Food Hydrocolloids*, *77*(1), 1-7. doi: 10.1016/j.foodhyd.2017.08.030.

[7]. Liu, T., Lv, B., Zhao, W., Wang, Y., Piao, C., Dai, W., Hu, Y., Liu, J., Yu, H., and Sun, F. 2020. Effects of Ultrahigh Temperature Pasteriuzation on the Liquid Components and Functional Properties of Stored Liquid Whole Eggs. *BioMed Research International*, *1*(1), 1-10. doi: 10.1155/2020/3465465.

[8]. Monfort, S., Mañas, P., Condón, S., Raso, J., and Álvarez, I. 2012. Physicochemical and functional properties of liquid whole egg treated by the application of pulsed electric fields followed by heat in the presence of triethyl citrate. *Food Research International*, *48*(2), 484–490. doi: 10.1016/j.foodres.2012.04.015.

[9]. Naderi, N., House, J. D., Pouliot, Y., and Doyen, A. 2017. Effects of high hydrostatic pressure processing on hen egg compounds and egg products. *Comprehensive Reviews in Food Science and Food Safety*, *16*(4), 707-720. doi: 10.1111/1541-4337.12273.

[10]. Nahariah, N., and Hikmah, H. 2021. The effect of temperature levels on antioxidant activity in chicken eggs. *IOP Conf. Series: Earth and Environmental Science*, *788*(1), 1-5. doi: 10.1088/1755-1315/788/1/012099.

[11]. Pantow, I. M, Sompie, M., Mirah, A. D., and Karisoh, L. C. M. 2016. Pengaruh perbedaan konsentrasi larutan asam asetat (CH_3COOH) terhadap karakteristik gelatin kulit kaki ayam. *Jurnal Zootek*, *36*(1), 23-32. doi: 10.35792/zot.36.1.2016.9348

[12]. Pashova, S., and Trichkova-Ablee, M. 2016. A comparative study on quality of vinegar and acid products available commercially. *Commodity Science in A Changing World - Science and Economics Varna*, *23*(1), 1-9.

[13]. Pasau, C. 2013. Efektivitas penggunaan asam asetat pada pemeraman biji kakao segar sebagai analog fermentasi. *J. Agrotekbis*, *1*(2), 133-120.

[14]. Prasetya, D. A., and Evanuarini, H. 2019. Kualitas mayonnaise menggunakan sari belimbing wuluh (Averrhoa bilimbi L.) sebagai pengasam ditinjau dari kestabilan emulsi, droplet emulsi dan warna. *Jurnal Ilmu dan Teknologi Hasil Ternak*, *14*(1), 20-29. doi: 10.21776/ub.jitek.2019.014.01.3.

[15]. Radovčić, N.M., Karlović, S., Medić, H., and Jambrak, A.R. 2020. Effect of citric acid addition on functional properties of pasteurized liquid whole eggs. *J. Food Sci. Technol*. 58 (4), 1-12.

[16]. Rossi, M., Casiraghi, E., Primavesi, L., Pompei, C., and Hidalgo, A. 2010. Functional properties of pasteurised liquid whole egg products as affected by the hygienic quality of the raw eggs. *LWT – Food Science and Technology*, *43*(3), 436-441.

[17]. Sari, F. I., and Keman, S. 2005. Efektifitas larutan asam cuka untuk menurunan kandungan logam berat cadmium dalam daging kerang bulu. *Jurnal Kesehatan*, *1*(2), 120-129.

[18]. Sinaga, A. S. 2019. Segmentasi ruang warna L*a*b. *Jurnal Mantik Penusa*, *3*(1), 43 – 46.

[19]. Singh, J., Sharma, H. K., Premi, M., and Kumari, K. 2011. Effect of Storage Conditions of Egg on Rheological Properties of Liquid Whole Egg. *J. Food Sc. Technol*. 51 (3): 543–550.

[20]. Siregar, R. F., Hintono, A., and Mulyani, S. 2012. Perubahan sifat fungsional telur ayam ras pasca pasteurisasi. *Animal Agriculture Journal*, *1*(1), 521-528.

[21]. Tokuşoğlu, Ö., and Cánovas, B. G. 2018. The improving quality and shelf life of table eggs. *J. Food Health Technol. Innov*., *1*(1), 34-63. doi: 10.1155/2021/6653190.

[22]. Wibowo, C.H., Sudjatinah, and Sampurno, A. 2020. Perbandingan sifat fungsional putih telur cair pada penyimpanan selama 7 (tujuh) hari dengan dan tanpa penambahan asam benzoat. *Pengembangan Rekayasa dan Teknologi*, *16*(1), 1-8. doi: 10.26623/jprt.v16i1.2441.

[23]. Yogesh, K. 2016. Pulsed electric field processing of egg products: a review. *J. Food. Sci. Technol*., *53*(2), 934-945. doi: 10.1007/s13197-015-2061-3.

Corresponding author: Dr. Herly Evanuarini, S.Pt., MP., Department of Animal Products Technology, Faculty of Animal Science, University of Brawijaya, Malang, Indonesia (herlyfptub@ub.ac.id)