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EFFECT OF MILK AND XANTHAN AS AN EGG SUBSTITUTOR ON THE PHYSICAL PROPERTIES OF MAYONNAISE

Morna Anamaria*

*University of Oradea, Faculty of Environmental Protection, 26 Gen. Magheru St., 410048 Oradea, Romania, e-mail: amorna@uoradea.ro

Abstract

This paper compares the rheological and physical properties of conventional mayonnaise and mayonnaise with combinations of whole-milk and the decrease or removal (partial or total) of the egg.

The objectives we pursued in this paper were: analysis of the growth/cremation index of mayonnaise; analysis of heat stability of mayonnaise; analysis of the physical stability of mayonnaise; analysis of the variation of the apparent viscosity of mayonnaise depending on the temperature and shear rate; quantification of the size of the parameters of the Casson mathematical model affected by the state variables: the concentration and ingredients of mayonnaise.

All samples show the same shear force, regardless of the formula used, under conditions of a constant shear rate.

All samples of mayonnaise, regardless of the formula used, are non-Newtonian time-dependent liquids, thixotropic, which suffers a decrease in viscosity, with the change in the concentration of ingredients (egg, milk, xanthan) at a constant shear rate.

For all mayonnaise samples, the relationship between shear stress and shear rate was nonlinear, showing a behavior of thinning shear (pseudoplastic liquids).

Key words: mayonnaise, Casson mathematical model, rheological and physical properties.

INTRODUCTION

Mayonnaise is an oil-in-water emulsion prepared from vegetable oil, egg yolk, vinegar, sugar, salt, mustard and a variety of food additives (Juszczak et al. 2003). Among its ingredients, the egg is the most critical in terms of mayonnaise stability. Egg is considered a high profile ingredient due to its high nutritional value and multifunctional properties, including emulsification, coagulation, foaming and flavoring of the product (Narsimhan and Wang 2008).

Cholesterol is present in egg yolk in amounts ranging from 180 to 250 mg, depending on the type of chicken (Stadelman and Cotterill, 1995).

The desire to replace the egg in food systems has been brought about by a lot of concerns from consumers and processors who wanted to have low cholesterol and safe food (Liu et al. 2007). Thus, several studies have been done on the removal or reduction of the egg in mayonnaise (Takeda et al., 2001).

Emulsifiers generally act through one or more mechanisms, including reducing the surface tension between the oil and water phases or covering fat globules with a loaded layer to create a physical barrier that prevents flocculation (Walstra, 1986). Stabilizers, mainly polysaccharides, usually stabilize emulsions by increasing the viscosity of the aqueous phase.

Whey proteins are known to alter their adsorption behavior at fluid interfaces that respond both to different aqueous environmental conditions (Davis et al., 2004) and to the presence of several food additives, such as lipids and polysaccharides (Rodriguez Patino et al.2008; Hîlma, 2016), sugars (Yang et al. 2009), electrolytes (Marinova et al., 2009), polypeptides (Martinez et al., 2009).

Macromolecular interactions between whey protein in milk and Xanthan, both in solution and in the vicinity of the interface, depend on the type of protein and the relative concentration of the biopolymer in the aqueous subphase (Perez et al., 2009).

MATERIAL AND METHOD

This paper compares the rheological and physical properties of conventional mayonnaise and mayonnaise with combinations of whole milk and the decrease or removal (partial or total) of the egg.

The objectives we pursued in this paper were: analysis of the growth/cremation index of mayonnaise; analysis of heat stability of mayonnaise; analysis of the physical stability of mayonnaise; analysis of the variation of the apparent viscosity of mayonnaise depending on the temperature and shear rate; quantification of the size of the parameters of the Casson mathematical model affected by the state variables: the concentration and ingredients of mayonnaise.

In this paper we replaced the eggs with mixtures of milk and xanthan.

The substitution of eggs with milk and xanthan mixtures was selected from 0-100% and 0-0.2%, respectively (Nikzade, 2012; Hîlma, 2019).

Seven tests were used to achieve the objectives of the paper:

- standard control mayonnaise (F1) without hydrocolloids, 10% egg;
- mayonnaise (F2) 8% egg, 1.9% milk, 0.1% xanthan;
- mayonnaise (F3) 2% egg, 7.9% milk, 0.1% xanthan;
- mayonnaise (F4) 0% egg, 9.9% milk, 0.1% xanthan;
- mayonnaise (F5) 8% egg, 1.8% milk, 0.2% xanthan;
- mayonnaise (F6) 2% egg, 7.8% milk, 0.2% xanthan;
- mayonnaise (F7) 0% egg, 9.8% milk, 0.2% xanthan.

The standard temperature of the ingredients was 8° C.

Each formulation was prepared once and each experiment was performed in 3 replicates. After preparation, the samples were kept in the refrigerator (4-5ºC) until analysis (Liu et al., 2007).

The differences between the seven formulas of mayonnaise consist in changing the concentration of the ingredients, namely egg yolk, milk and xanthan hydrocolloid, the amount of other ingredients remaining unchanged.

In the standard formula (F1) I used 10% egg yolk, without hydrocolloids.

I changed the second formula (F2), decreasing the yolk concentration to 8%, but I increased the milk concentration to 1.9% and xanthan 0.1%.

In the third formula (F3) I decreased the egg yolk concentration to 2%, I increased the milk concentration to 7.9% and xanthan 0.1%.

In the fourth formula (F4) I replaced the liquid egg yolk with 9.9% milk and 0.1% xanthan.

In the fifth formula (F5) I increased the concentration of egg 8% and xanthan 0.2%, decreasing the concentration of milk to 1.8%.

The sixth formula (F6) contains 2% egg, 7.8% milk and 0.2% xanthan.

In the last formula (F7) I replaced the liquid egg yolk with 9.8% milk and 0.2% xanthan.

Viscosity measurements were performed on mayonnaise samples at room temperature (200C) with the Brookfield viscometer (Brookfield Engineering Inc, Model DV E) and 5 different Rpm speeds (5, 10, 20, 50, 100) with the LV 3C axis no. 67.

In order to achieve the objectives listed above, taking into account the physical properties of the product under analysis, I made the following determinations:

- Determining the growth/creaming index of mayonnaise;
- Determining the heat stability of mayonnaise;
- Determining the physical stability of mayonnaise;
- Determining the apparent viscosity, shear rate and shear stress of mayonnaise;
- Determining the Casson yield to characterize how mayonnaise will behave during consumption, in terms of quality.

RESULTS AND DISCUSSION

The first determination consisted in measuring the viscosity of the mayonnaise samples depending on the concentration of the ingredients: egg, milk, xanthan and 5 different Rpm speeds (5, 10, 20, 50, 100).

The results obtained at a constant torsion (48.71%) frame mayonnaise as a non-Newtonian thixotropic liquid.

Thus, all samples of mayonnaise, regardless of the formula used, are non-Newtonian time-dependent, thixotropic liquids that suffer from decreased viscosity, with the change in the concentration of ingredients (egg, milk, xanthan) at a constant shear rate.

Mayonnaise exhibits non-Newtonian behavior and the same behavior was observed in this paper.

The apparent viscosity of the mayonnaise samples decreased in all formulas with increasing shear rate and shear strength, except for the formula in which the egg was replaced 100% with milk and xanthan gum.

The apparent viscosity is inversely proportional to the shear rate and shear stress.

The apparent viscosity of the mayonnaise samples decreased with increasing shear rate, indicating a non-Newtonian liquid, and showed shear thinning behavior characterized by flow behavior values (Casson yield value) less than 1.

The flow curves for mayonnaise samples made from different amounts of milk, xanthan and egg are shown in Figure 1.

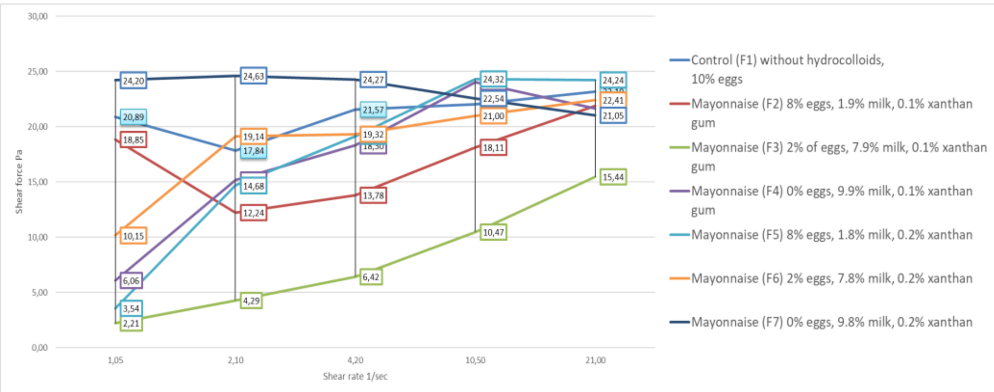

Fig. 1. Comparison of flow curves in mayonnaise samples

For all mayonnaise samples, the relationship between shear stress and shear rate was nonlinear, showing a behavior of thinning shear (pseudoplastic liquids).

As Rao wrote, the Casson model is considered a mathematical equation that describes rheological data, such as shear rate versus shear force, in a basic shear diagram, and provides a convenient and concise way to describe the data.

The Casson yield value is important in determining the consistency index.

The value of the Casson yield (Figure 2) or the consistency index of the mayonnaise samples decreased until the egg was replaced with milk and xanthan (mayonnaise (F4) 0% egg, 9.9% milk, 0.1% xanthan), but for the higher content, except for the 100% replacement, increased.

The lowest consistency index (31.91 Pa), was observed in the sample containing 100% milk together with 0.2% xanthan, and the highest (4.39 Pa) was recorded among the analyzed samples 9.9% replacement milk together with 0.1% xanthan.

Also, the highest shear thickening property was observed for the control and replacement of 100% milk together with 0.2% xanthan.

Also, for all samples, the flow behavior index showed a thin shear behavior.

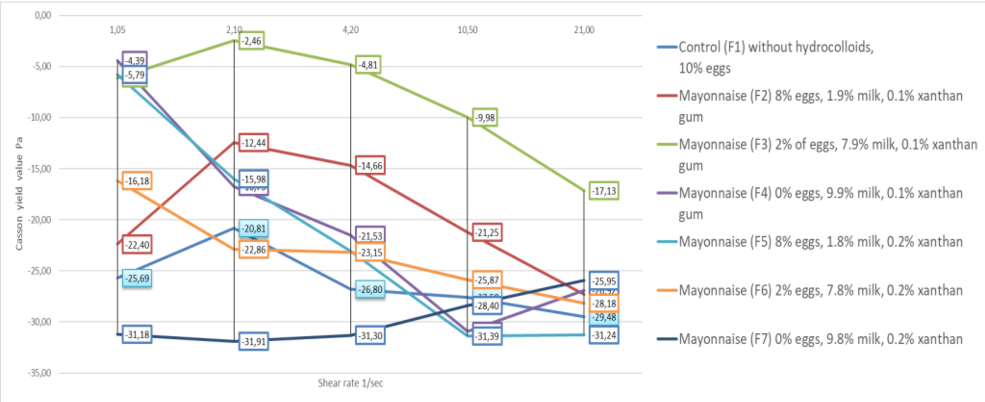

Fig.2. The value of Casson's yield in mayonnaise samples

The apparent viscosity of the mayonnaise samples decreased with increasing egg replacement from 20% to 80%, as the highest and lowest viscosity observed in the samples contained 100% (18.91 Pa s at shear rate 1.05 s^{-1}) and 80% replacement (5.18 Pa s at shear rate 1.05 s^{-1}) (Figure 3).

The increase in shear rate and the percentage of substitutes (milk and xanthan) led to a decrease in the apparent viscosity.

The apparent viscosity of the samples containing 20%, 80% and 100% egg substitutes compared to the control sample (100% egg) were lower.

The increase in the concentration of xanthan resulted in a decrease in the viscosity of the samples compared to the control.

Increasing the concentration of xanthan and milk decreased the viscosity of all samples, except where we replaced the egg 100%, being the highest viscosity recorded for sample F7 (18.91 Pa s) (99.8% milk and 0.2% xanthan gum).

All investigated mayonnaise samples containing milk proteins and xanthan gum showed a shear-thinning behavior (Raymundoa et al. 2002).

From this point of view, it can be concluded that milk with xanthan gum not only maintained the structure of mayonnaise, but had a greater effect on the viscosity and flow parameters of the mayonnaise samples compared to the egg.

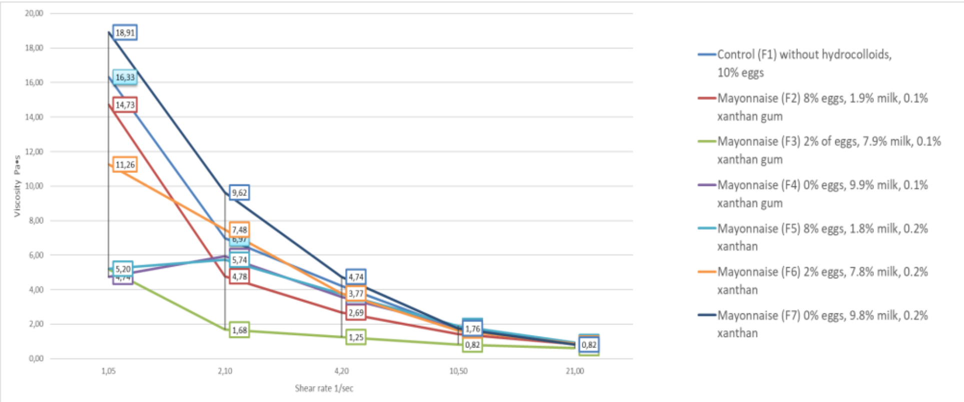

Fig.3. Apparent viscosity compared to the shear rate for the various samples of mayonnaise

During the 7-day storage period, samples of mayonnaise 3, 4 and 5 were greater than 50%, except for samples 1, 2, 6 and 7.

The highest stability was recorded for samples 4 and 5 (80 %) and the lowest for sample 7 (26.66%) compared to the control sample.

The samples of mayonnaise 4 and 5 for 7 days of storage showed more than 80% stability and there were no significant differences between them.

In this study, all mayonnaise samples, except samples 1, 2, 6 and 7, showed heat stability of more than 50% during the 7-day storage period.

The highest heat stability recorded for samples 4 and 5 (80%) and the lowest for sample 7 (26.66%) were significantly different compared to the control sample.

The rest of the samples during the 7-day storage had higher heat stability and did not have significant differences between them.

In this study, the addition of milk with xanthan (as an egg substitute) to mayonnaise protected the separation of the emulsion phases compared to the control sample during the 4-day storage period.

Sun et al. explained similar cremation behaviors with different concentrations of XG in mayonnaise. (2007).

Hennoc et al. (1984) reported that in emulsions containing 60% oil, the presence of xanthan to prevent phase separation is essential.

This is due to the strong increase in viscosity that prevented the liquid from moving by decreasing the burning rate (McClements, 2004).

But the phenomenon of creaming or growth was observed in the samples containing 1.9% milk, 0.1% xanthan (F2), 7.9% milk, 0.1% xanthan (F3) and 9.8% milk, 0.2% xanthan (F7) substitutes after 4 days storage due to large particle size and low viscosity.

CONCLUSIONS

This paper compares the rheological and physical properties of conventional mayonnaise and mayonnaise with whole-milk combinations and the decrease or removal (partial or total) of the egg. All samples show the same shear force, regardless of the formula used, under conditions of a constant shear rate. The results obtained at a constant torsion (48.71%) frame mayonnaise as a non-Newtonian thixotropic liquid. All samples of mayonnaise, regardless of the formula used, are non-Newtonian time-dependent liquids, thixotropic, which suffers a decrease in viscosity, with the change in the concentration of ingredients (egg, milk, xanthan) at a constant shear rate.

The highest shear thickening property was observed for the control and replacement of 100% milk together with 0.2% xanthan.

For all samples, the flow behavior index showed a thin shear behavior. The increase in shear rate and the percentage of substitutes (milk and xanthan) led to a decrease in the apparent viscosity.

The apparent viscosity of the samples containing 20%, 80% and 100% egg substitutes compared to the control sample (100% egg) were lower.

The increase in the concentration of xanthan resulted in a decrease in the viscosity of the samples compared to the control.

The increase in the concentration of xanthan and milk decreased the viscosity of all samples, except where we replaced the egg 100%, the highest viscosity being recorded for the F7 sample.

The highest stability was recorded for samples 4 and 5 and the lowest for sample 7 compared to the control sample.

All mayonnaise samples, with the exception of samples 1, 2, 6 and 7, showed heat stability of more than 50% during the 7-day storage period.

The addition of milk together with xanthan (as an egg substitute) to the mayonnaise protected the separation of the emulsion phases compared to the control sample during the 4-day storage period.

From this point of view, it can be concluded that milk with xanthan gum not only maintained the structure of mayonnaise, but had a greater effect on the viscosity and flow parameters of the mayonnaise samples compared to the egg.

REFERENCES

1. Davis, J.P., Foegeding, E.A., Hansen, F.K., 2004, Colloids Surf. B: Biointerfaces
1. Hîlma Elena, 2016, The threshold embedding essential fatty acids in yogurt, International Symposium "Risk Factors for Environment and Food Safety", Oradea 2016 p. 169-176, Analele Universității din Oradea, Fascicula: Ecotoxicologie, Zootehnie si Tehnologii de Industrie Alimentară, VOL XV/A, I.S.S.N. 1583-4301
2. Hîlma Elena, 2019, Comparison between the maximum degree of incorporation of essential fatty acids in yogurt compared to fresh spun paste cheese International Symposium "Risk Factors for Environment and Food Safety", Oradea 2019, p. 69-75, Analele Universității din Oradea, Fascicula: Ecotoxicologie, Zootehnie si Tehnologii de Industrie Alimentară, VOL XVIII/A, I.S.S.N. 1583-4301
2. Hennoc, M., Rahalkar, R.R., and Richmond, P., 1984, Effect of xanthan gum upon the rheology and stability of oil in water emulsions. Journal of Food Science
3. Juszczak L, Fortuna T et al., 2003, Sensory and rheological properties of polish commercial mayonnaise. Die Nahrung
4. Liu, H., Xu, X.M., and Guo., Sh.D., 2007, Rheological, texture and sensory properties of low fat mayonnaise with different fat mimetics. Journal of Food Science and Technology
5. Marinova, K.G., Basheva, E.S., Nenova, B., Temelska, M., Mirarefi, A.Y., Campbell, B.,Ivanov, I.B., 2009, Food Hydrocolloids 23
6. Martinez, M.J., Carrera, C., Rodriguez Patino, J.M., Pilosof, A.M.R., 2009, Colloids Surf. B:Biointerfaces 68
7. McClements DJ., 2004, Food emulsions: principles, practices, and techniques: CRC.
8. Narsimhan G,Wang Z., 2008, Guidelines for processing emulsion-based foods. In: Hasenhuettl GL, Hartel RW (eds) Food emulsifiers and their applications. Springer Scince BusinessMedia, New York.
9. Nikzade, V., Mazaheri Tehrani, M., Saadatmand-Tarzjan, M., 2012, Optimization of low–cholesterol-low–fat mayonnaise formulation: Effect of using soy milk and some stabilizer by amixture design approach. Food Hydrocolloids.
10. Perez, A, A., Sanchez, C, C., Rodriguez Patino, J, M., Rubiolo, A, C., Santiago, L,G., 2010, Milk whey proteins and xanthan gum interactions in solution and at the air–water interface: A rheokinetic study. Colloids and Surfaces B: Biointerfaces
11. Raymundoa, A., Francob, J. M., Empisc, J., and Sousad, I., 2002, Optimization of thecomposition of cow-fat oil-in-water emulsions stabilized by white lupin protein. JAOCS
12. Rodriguez Patino, J.M., Rodriguez Nino, M.R., Carrera, C., Curr. Opin., 2007, Colloid Interface
13. Stadelman, W. J., & Cotterill, O. J., 1995, Egg science and technology (3rd ed.) Wesport: AVI Publischer Company
14. Sun, C., Gunasekaran, S., & Richards, M. P., 2007, Effect of xanthan gum on physicochemical properties of whey protein isolate stabilized oil-in-water emulsions. Food Hydrocolloids
15. Takeda K, Matsumura Yet al., 2001, Emulsifying and surface properties of wheat gluten under acidic conditions. J Food Science
16. Walstra, P., 1986, Overview of emulsion and foam stability. In Food Emulsion and Foams, ed. E. Dickinson. The Royal Society Of Chemistry, London
17. Yang, X., Berry, T.K., 2009, Foegeding, E.A., J. Food Science.