Foods and Raw Materials, 2021, vol. 9, no. 1

E-ISSN 2310-9599
ISSN 2308-4057

Research Article
Open Access

https://doi.org/10.21603/2308-4057-2021-1-19-23
Available online at http://jfrm.ru/en

Textural properties of low fat mayonnaise with whey protein concentrate and Tragacanth gum as egg and fat substitutes

Venus Habashi*, Amir Hossein Elhamirad, Ahmad Pedramnia

Islamic Azad University, Sabzevar Branch, Sabzevar, Iran

* e-mail: venushabashi@yahoo.com

Received May 04, 2020; Accepted in revised form May 19, 2020; Published online December 15, 2020

Abstract:
Introduction. Mayonnaise is a kind of oil-in-water emulsion that usually contains 70–80% of oil. However, modern food science keeps providing new knowledge about high-fat products, which makes it possible to solve the problems related to health concerns.
Study objects and methods. The research featured high-fat mayonnaise (20% of oil) with reduced oil stabilizer (1.75%) and without egg stabilizer. In experimental samples, egg stabilizer was replaced with 0.3, 0.4, and 0.5% of whey protein concentrate and 0.3, 0.5, and 1.0% of Tragacanth gum. Mayonnaise with 3.5% oil stabilizer and 0.3% egg stabilizer was used as control sample. The samples were tested for such textural attributes as firmness, consistency, adhesive force, and adhesiveness.
Results and discussion. The highest and the lowest textural values were demonstrated by the sample with 0.4% of whey protein concentrate and 0.5% of Tragacanth gum and the sample with 0.5% of whey protein concentrate and 1.0% of Tragacanth, respectively. The former showed textural characteristics similar to those of the control sample. The presence of hydrocolloids proved to affect the texture properties of mayonnaise, whereas Tragacanth gum reduced its elasticity. It formed a strong and complex gel-like structure in the continuous phase. As a result, oil droplets in the emulsion had a smaller diameter, which improved the texture properties of low-fat mayonnaise.
Conclusion. Whet protein concentrate and Tragacanth gum in amounts of 0.5% and 1.0%, respectively, can be used to replace egg stabilizer and reduce oil stabilizer in low-fat mayonnaise.

Keywords: Mayonnaise, textural attributes, whey protein, Tragacanth gum, protein concentrate

Please cite this article in press as: Habashi V, Elhamirad AH, Pedramnia A. Textural properties of low fat mayonnaise with whey protein concentrate and Tragacanth gum as egg and fat substitutes. Foods and Raw Materials. 2021;9(1):19–23. https://doi.org/10.21603/2308-4057-2021-1-19-23.

INTRODUCTION

According to the Iranian food standards developed by the Iranian Institute of Standards and Industrial Research, mayonnaise is a kind of seasoning produced by emulsifying edible vegetable oils in a liquid phase containing vinegar. This oil-in-water emulsion is then stabilized by the emulsifier compounds in egg yolk. Fats are necessary for human body as an important source of energy for growth. They provide both essential fatty acids and fat-soluble vitamins. Consumers' concern with the fact that high-fat foods may cause cardiovascular diseases, hypertension, and obesity has encouraged the food industry to develop healthier low-fat food products.

The consumption of oils and fats has increased significantly in recent decades. One of the reasons for this increase is that oil is widely used in many food products to obtain the appropriate textural properties. Not only is high oil content bad for health but it is also unprofitable for food producers. The general policy of global food industry is to produce fat-free or low-fat foods with a flavor similar to that of a natural product. Therefore, the use of proper fat substitutes in low-fat foods is inevitable. Fat substitutes are extremely diverse and include substitutes based on proteins, fats, and carbohydrates. Carbohydrate-based fat substitutes are a group of compounds derived from cereals, legumes, and herbs with digestible or non-digestible carbohydrates, including Tragacanth gum [2, 6]. Dried Tragacanth gum is obtained from a species of *Astragalus* genus that contains both water-soluble (tragacanthin) and water-insoluble (bassorin) fractions.

The US Food and Drug Administration classifies Tragacanth gum as a healthy food additive, which can be used as a stabilizer, emulsifier, thickener, and fat substitute in the food industry [7, 15]. There has been a lot of research on the production of low-fat mayonnaise

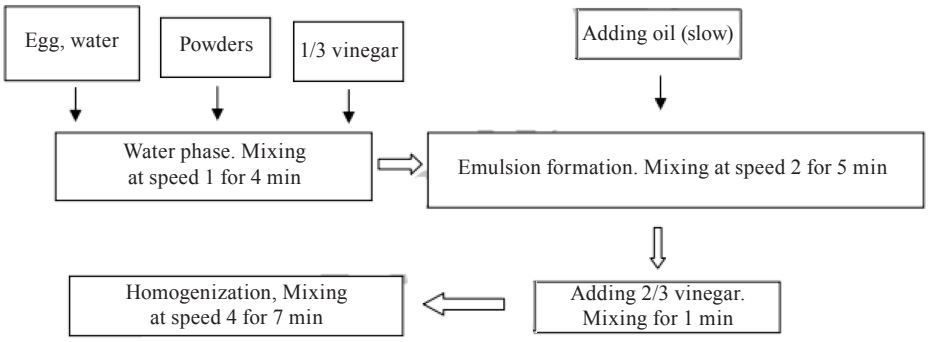
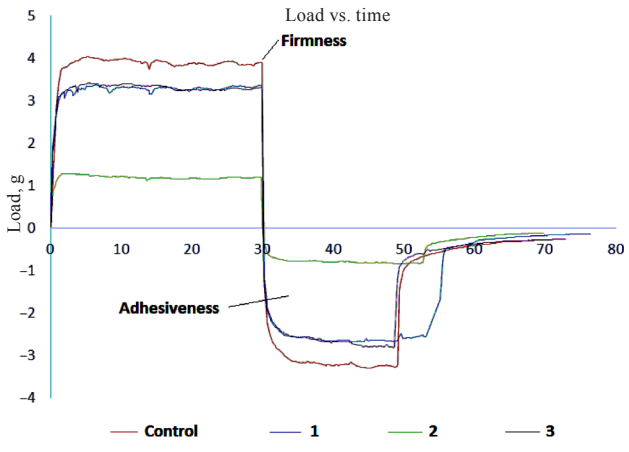


Figure 1 Production process of mayonnaise samples

using a variety of ingredients. Some studies featured the possibility of using pectin to reduce oil content [8, 5]. Pectin proved to be able to reduce the level of oil in mayonnaise from 80 to 40%, while the finished product possessed textural and sensory properties comparable to the high-fat control sample. Other studies [5, 17] tested beta-glucan for low-fat mayonnaise production. The finished product appeared more stable than low-fat mayonnaise. Replacing up to 50% of the initial oil content (from 82 to 41%) had no effect on the sensory properties of mayonnaise. 4α-GTASE-modified starch with xanthan gum also appeared effective in reducing oil content [10, 13]. The resulting product with 37.5% of oil, 5.6% of starch, and 0.1% of xanthan was similar in its appearance and rheological properties to the high-fat samples. Combined with citrus fiber and guar, xanthan was able to reduce oil from 73% to 36.5% [2, 16]. The mayonnaise sample with 1% of citrus fiber, 0.5% of guar, and 1.5% of xanthan gum had almost the same yield stress, viscosity, and flow behavior index as the control sample. In [5, 6, 14], scientists studied barley dextrin, maltodextrin with xanthan gum, and pre-gelatinized wheat starch in low-fat mayonnaise production, respectively.



control – 3.5% oil stabilizer + 0.3% egg stabilizer; 1 – 1.75% oil stabilizer + 0.3% whey protein concentrate + 0.3% Tragacanth gum; 2 – 1.75% oil stabilizer + 0.4% whey protein concentrate + 0.5% Tragacanth gum; 3 – 1.75% oil stabilizer + 0.5% whey protein concentrate + 1.0% Tragacanth gum.

Figure 2 TPA curves of mayonnaise samples obtained from the textural analysis device

Given the adverse effects of oil on human health, low concentrations of hydrocolloids, such as starches and gums, seem quite promising for mayonnaise production. As they have a remarkable effect on the properties of food systems, they can be used to modify food properties and formulate new ones. In addition, they often possess economic benefits [7, 9]. Most sauces contain gum. By increasing the continuous phase concentration, these polysaccharides decrease the adhesiveness and compress the fat droplets. They decrease the collision and attachment of these droplets to each other by reducing release and movement of dispersed emulsion droplets, which stabilizes the emulsion [9, 17].

This study aimed to produce mayonnaise with whey protein concentrate as a substitute for eggs and Tragacanth gum as a substitute for fat. We also examined the textural attributes of the product obtained.

STUDY OBJECTS AND METHODS

The mayonnaise formulation included sunflower oil, sugar, salt, oil stabilizer[I], egg stabilizer[II], citric acid, vinegar, mustard powder, sodium benzoate, potassium sorbate, drinking water, Tragacanth gum, and whey protein concentrate.

Preparation of mayonnaise. According to the Iranian standards, a mayonnaise with 50% oil is a low-fat mayonnaise. The research featured three mayonnaise samples. A control sample contained 3.5% of oil stabilizer and 0.3% of egg stabilizer. The three experimental samples included a reduced oil stabilizer (1.75%), no egg stabilizer, whey protein concentrate (0.3, 0.4, and 0.5%), and Tragacanth gum (0.3, 0.5, and 1.0%). The mayonnaises were made according to the formulation in Fig. 1.

Textural properties examination. Textural analysis device (QTS 25 Faranel CNS, UK) was used to examine

[I] Modified Starch Hydroxypropyl distarch phosphate (E1442)
[II] Modified Starch Sodium Actinyl Succinate (E1450)

Table 1 Raw materials used to produce different samples of mayonnaise, %

Samples	Control	Sample No. 1	Sample No. 2	Sample No. 3
Sunflower oil	20	20	20	20
Egg stabilizer	–	–	–	0.3
Oil stabilizer	1.75	1.75	1.75	1.75
Tragacanth gum	–	0.3	0.5	1.0
Whey protein concentrate	–	0.3	0.4	0.5
Vinegar	5.2	5.2	5.2	5.2
Salt	1.5	1.5	1.5	1.5
Sugar	5	5	5	5
Citric acid	0.13	0.13	0.13	0.13
Mustard	0.3	0.3	0.3	0.3
Sodium benzoate	0.07	0.07	0.07	0.07
Potassium sorbate	0.07	0.07	0.07	0.07

the mayonnaise samples for such textural properties as firmness, consistency, adhesive load, and adhesiveness. The measurement was done by back-estrogen method using a measuring vessel with a height of 58 mm and 50 mm in diameter, as well as a probe with a diameter of 45 mm. The penetration depth of the probe into the sample was 40 mm. The probe and other parameters were selected according to the manufacturer's instructions. The textural properties, such as firmness, cohesiveness, and adhesiveness, were plotted by the device in the form of load–time curves (Fig. 2) [8]. As a result, the textural properties were defined as follows:

Firmness: Maximum load during first compression rotation.

Cohesiveness: area ratio of level 2 to level 1.

Adhesiveness: the area of negative load resulting from the first plunge and indicating the work required to pull the probe out of the sample.

Statistical analysis. The experiments were conducted in a completely randomized design with three replications. The mean comparison of treatments was performed by Duncan test at 95% confidence level. SPSS 16.0 and Excel 2007 were used for data analysis and drawing charts, respectively. For this purpose, appropriate equations were plotted by the abovementioned software to show the relationship of each of the dependent variables in the regression model with the independent variables. The R^2 values were determined to evaluate the accuracy.

RESULTS AND DISCUSSION

Compounds known as hydrocolloids with a high ability to absorb water and to develop texture are widely used in the production of low-fat products. This research featured the physical performance of whey protein concentrate and Tragacanth gum in the texture formation. Both whey protein concentrate and Tragacanth gum proved to possess water-absorbing capacity and improved textural properties.

Both compounds revealed a good potential as egg and fat substitutes to obtain desirable texture. They provided the same texture that high-fat mayonnaise owes to large quantities of oil. In addition to its fat-replacement role, Tragacanth appeared capable of enhancing the consistency of low-fat mayonnaise samples and reducing their caloric value. Since Tragacanth gum can bond with water in the continuous phase, it improved the stability of the emulsion. Therefore, it can be used as a fat substitute in the low-fat mayonnaise formulation. In spite of the fact that the use of Tragacanth gum in mayonnaise production requires further research, the present study was an effective step towards self-sufficiency and localization of this product.

Textural properties. Table 2 shows the textural properties of the mayonnaise samples under study. Firmness is one of the most important factors affecting mayonnaise as it is believed to affect customers' attitude. The control sample (with egg stabilizer) and the sample with 0.4% whey protein concentrate and 0.5% Tragacanth gum demonstrated the highest and the lowest firmness, respectively. Similarly, they had the highest and the lowest consistency, adhesiveness, and firmness, respectively. Regression coefficients of firmness, adhesiveness, and textural cohesiveness showed that the experimental samples fit the model well: the coefficient of determination was 99.96, 99.78, and 98.72, respectively.

The firmness percentage increased when egg stabilizer was replaced with 0.3% whey protein concentrate and 0.3% Tragacanth gum (Table 2). 0.4% whey protein concentrate and 0.5% Tragacanth gum decreased firmness, while 0.5% whey protein concentrate and 1.0% Tragacanth gum increased it again. The results of this study were consistent with [17].

Table 2 Effect of whey protein concentrate and Tragacanth gum on textural properties of mayonnaise

Samples	Adhesive force, N	Adhesiveness, $N \cdot s^{-1}$	Consistency, $N \cdot s^{-1}$	Firmness, N
Control (no WPC and TG)	70.92	3.37	117.30	4.14
0.3% WPC + 0.3% TG	65.32	2.73	98.93	3.45
0.4% WPC + 0.5% TG	22.10	0.85	36.22	1.32
0.5% WPC + 1.0% TG	61.63	2.88	100.10	3.50

WPC – whey protein concentrate

TG – Tragacanth gum

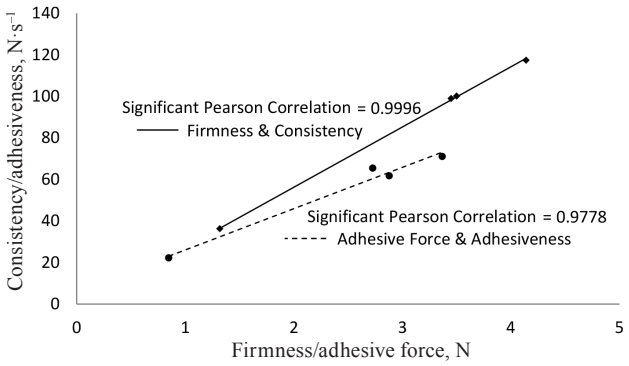


Figure 3 Firmness vs. consistency and adhesive force vs. adhesiveness correlation

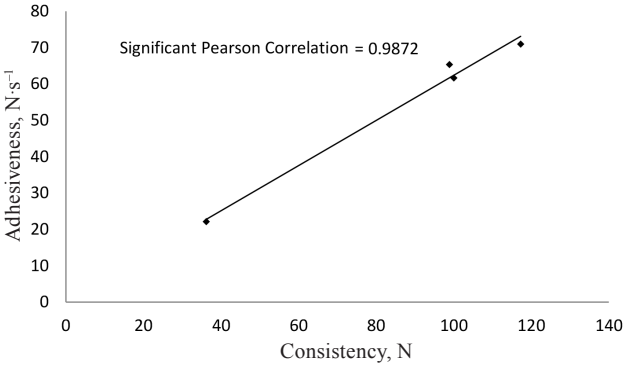


Figure 5. Correlation between adhesive force and consistency

In other studies, 50% and 75% beta-glucan increased the firmness of low-fat mayonnaise [16]. The highest consistency was observed in the control sample (177.30 $N \cdot s^{-1}$) and sample with 0.5% whey protein concentrate and 1.0% Tragacanth gum (100.10 $N \cdot s^{-1}$). The lowest consistency was observed in the sample with 0.4% whey protein concentrate and 0.5% Tragacanth gum (36.22 $N \cdot s^{-1}$). The highest (3.37 $N \cdot s^{-1}$) and the lowest (0.85 $N \cdot s^{-1}$) adhesiveness was observed in the control sample and the sample with 0.4% whey protein concentrate and 0.5% Tragacanth gum, respectively.

The presence of hydrocolloids proved to played a significant part in developing the texture properties of mayonnaise. Accordingly, the maximum load recorded in histometry test, known as the sample tolerance for flow initiation, was obtained for the control sample and then the sample with 0.5% whey protein concentrate and 1.0% Tragacanth gum. The sample with 0.4% whey protein concentrate and 0.5% Tragacanth gum showed the lowest value of this parameter. Based on the obtained results, the sample with the highest levels of whey protein concantrate (0.5%) and Tragacanth gum (1.0%) demonstrated the closest texture behavior to the control sample containing egg stabilizer (Figs. 3–5). Other studies had similar results: gum reduced the elasticity due to the formation of a strong gel-like structure in the continuous phase [7, 9, 11]. The gum made the structure firmer and more complex while affecting the formation of oil droplets with smaller diameter in the emulsion, thus improving the texture properties of low-fat mayonnaise.

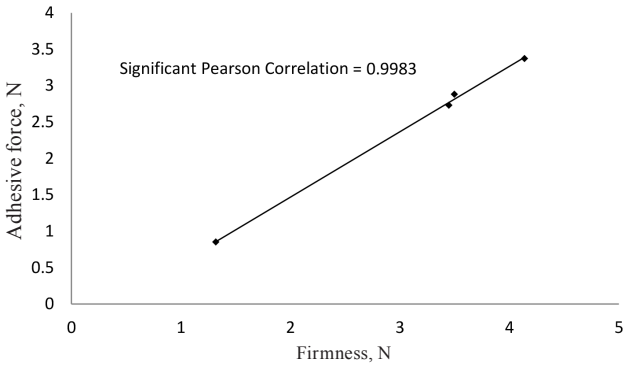


Figure 4 Correlation between adhesive force and firmness

CONCLUSION

Given the importance of such food emulsions as mayonnaise, the qualitative properties of this high-fat seasoning require careful scientific attention. Texture is one of the factors that affect the quality of this product. Gum is one of the most important compounds used to achieve a proper texture. Considering the effect this irreplaceable component has on the quality properties, localization of this product is impossible without introducing the native Tragacanth gum into the formulation and studying its functionality.

The research objective was to measure the effect of Tragacanth gum as a partial substitute for fat on the textural properties of low-fat mayonnaise. All the samples proved acceptable in terms of pH and acidity according to Iranian National Standard. However, different levels of whey protein concentrate and Tragacanth gum changed the texture properties of mayonnaise. The synergistic effect of whey protein concentrate and Tragacanth gum at amounts of 0.5% and 1.0 %, respectively, improved the product's texture.

CONTRIBUTION

The authors were equally involved in writing the manuscript and are equally responsible for any possible plagiarism.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interests related to this article.

ACKNOWLEDGEMENTS

The authors would like to thank the Institute of Bio-technology and Food Technology, Islamic Azad University Sabzevar Branch (Iran), and our colleagues for the technical and equipment support.

REFERENCES

1. Abedinzadeh S, Torbati M, Azadmard-Damirchi S. Some qualitative and rheological properties of virgin olive oil-apple vinegar salad dressing stabilized with xanthan gum. Advanced Pharmaceutical Bulletin. 2016;6(4):597–606. https://doi.org/10.15171/apb.2016.074.
2. Akoh CC. Fat replacers. Food Technology. 1998;52(3):47–53.
3. Amir-Kavi Sh, Fatemi H, Sahari M. Formulation and technology of low calorie salad dressing production. Agricultural Science and Technology. 2005;8:181–190. (In Persian).
4. Ataie MJ, Shekarabi SPH, Jalili SH. Gelatin from bones of bighead carp as a fat replacer on physicochemical and sensory properties of low-fat mayonnaise. Journal of Microbiology, Biotechnology and Food Sciences. 2019;8(4):979–983. https://doi.org/10.15414/jmbfs.2019.8.4.979-983.
5. Dehghan A, F arahnaki A, Mesbahi Gh, Majzoobi M. Wheat and corn pregelatinized starch production by roller drier and its substitution with native starch to produce salad dressing. 18th congress on food science and technology. Mashhad; 2008.
6. Dyshluk LS, Sukhikh SA, Ivanova SA, Smirnova IA, Subbotina MA, Pozdnyakova AV, et al. Prospects for using nut products in the dairy industry. Foods and Raw Materials. 2018;6(2):264–280. https://doi.org/10.21603/2308-4057-2018-2-264-280.
7. El Khouri D, Balfour-Ducharme S, Joye IJ. A review on the gluten-free diet: Technological and nutritional challenges. Nutrients. 2018;10(10). https://doi.org/10.3390/nu10101410.
8. Institute of standards and industrial research of Oiran, isir number 2454. Mayonnaise and salad dressing specification. (In Persian).
9. Farahnaki A, Majzoobi M, Mesbahi Gh. Properties of hydrocolloids, food and pharmaceutical applications. Tehran: Agricultural science of Iran; 2010. 11–15 pp. (In Persian).
10. Liu H, Xu XM, Guo ShD. Rheological, texture and sensory properties of low fat mayonnaise with different fat mimetics. LWT – Food Science and Technology. 2007;40(6):946–954. https://doi.org/10.1016/j.lwt.2006.11.007.
11. Maghsoudi Sh. The technology of sauces producing. Tehran: Marzedanesh Press; 2004. 119–130 pp. (In Persian).
12. Majeed M, Anwar S, Khan MU, Asghar A, Shariati MA, Semykin V, et al. Study of the combined effect of pectin and Banana powder as carbohydrate based fat replacers to develop low fat cookies. Foods and Raw Materials. 2017;5(2):62–69. https://doi.org/10.21603/2308-4057-2017-2-62-69.
13. Mirzanajafi-Zanjani M, Yousefi M, Ehsani A. Challenges and approaches for production of a healthy and functional mayonnaise sauce. Food Science and Nutrition. 2019;7(8):2471–2484. https://doi.org/10.1002/fsn3.1132.
14. Mun S, Kim Y-L. Kang C-G, Park K-H, Shim J-Y, Kim Y-R. Development of reduced-fat mayonnaise using 4αGTASE modified rice starch and xanthan gum. International Journal of Biological Macromolecules. 2009;44(5):400–407. https://doi.org/10.1016/j.ijbiomac.2009.02.008.
15. Nejatian M, Abbasi S, Azarikia F. Gum Tragacanth: Structure, characteristics and applications in foods. International Journal of Biological Macromolecules. 2020;160:846–860. https://doi.org/10.1016/j.ijbiomac.2020.05.214.
16. Netipramook M. Development of reduced calorie salad dressings. Bangkok: Kasetsart University; 1991. 93–103 pp.
17. Raymundoa A, Francob JM, Empisc J, Sousad I. Optimization of the composition of low-fat oil-in-water emulsions stabilized by white lupin protein. Journal of the American Oil Chemists' Society. 2002;79(8):783–790. https://doi.org/10.1007/s11746-002-0559-6.
18. Shen R, Luo S, Dong J. Application of oat dextrine for fat substitute in mayonnaise. Food Chemistry. 2010;126(1):65–71. https://doi.org/10.1016/j.foodchem.2010.10.072.
19. Su H-P, Lien C-P, Lee T-A, Ho J-H. Development of low fat mayonnaise containing polysaccharide gum as functional ingredients. Journal of the Science of Food and Agriculture. 2010;90(5):806–812. https://doi.org/10.1002/jsfa.3888.
20. Treshchuk LV, Starovoytova KV, Ivashina OA. Practical aspects of the use of emulsifiers in manufacturing emulsion fat-and-oil products. Foods and Raw Materials. 2018;6(1):30–39. https://doi.org/10.21603/2308-4057-2018-1-30-39.
21. Worrasinchai S, Suphantharika M, Pinjai S, Jamnong P. *β*-Glucan prepared from spent brewer's yeast as a fat replacer in mayonnaise. Food Hydrocolloids. 2005;20(1):68–78. https://doi.org/10.1016/j.foodhyd.2005.03.005.
22. Yilmazer G, Carrillo AR, Kokini JL. Effect of propylene glycol alginate and xanthan gum on stability of o/w emulsions. Journal of Food Science. 1991;56(2):513–517. https://doi.org/10.1111/j.1365-2621.1991.tb05316.x.

ORCID IDs
Amir Hossein Elhamirad https://orcid.org/0000-0002-4483-2568