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Research Article/Araştırma Makalesi

Investigation of the possibilities of using oleaster fruit flour in the production of low-fat- low-cholesterol mayonnaise

İğde meyve ununun az yağlı-düşük kolesterollü mayonez üretiminde kullanım olanaklarının araştırılması

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ABSTRACT

The aim of the study is to investigate the possible usage of oleaster fruit flour (OFF) (*Elaeagnus angustifolia*) in mayonnaise formulation by reducing the fat and egg yolk ratios. Mayonnaise samples with four different formulations as control, low-fat low-cholesterol mayonnaise-I (LFCM-I), low-fat low-cholesterol mayonnaise-II (LFCM-II) and low-fat low-cholesterol mayonnaise-III (LFCM-III) were produced. The oil, egg yolk and sugar ratios were decreased with the incremental percentage of OFF. The substitution of egg yolk and fat in the mayonnaise formula by the addition of OFF caused an increase in pH value, viscosity, firmness, consistency and work of shear, whereas a decrease in the acidity, total cholesterol content, peroxide value, TBARs value and conjugated dienes ratio. Considering all of the physical and chemical analysis results, the OFF can be used as a fat and egg yolk substitute in the mayonnaise formula; however, it was concluded that the mayonnaise-like sauce, which has higher emulsion stability and better physical characteristics, can be obtained by combining OFF with various stabilizers.

Key Words: Oleaster fruit flour, viscosity, cholesterol content, peroxide value, consistency

ÖZ

Bu çalışmanın amacı, mayonez formülasyonunda yağ ve yumurta sarısı yerine iğde meyvesi ununun (İMU) (*Elaeagnus angustifolia*) olası kullanımını araştırmaktır. Kontrol, düşük yağlı düşük kolesterollü mayonez-I (DYDKM-I), düşük yağlı düşük kolesterollü mayonez-II (DYDKM-II) ve düşük yağlı düşük kolesterollü mayonez-III (DYDKM-III) olmak üzere dört farklı formülasyona sahip mayonez örnekleri üretildi. Artan İMU yüzdesi ile yağ, yumurta sarısı ve şeker oranları düşürüldü. Mayonez formülünde yumurta sarısı ve yağın İMU eklenmesiyle ikame edilmesi mayonezin pH değerinde, viskozitesinde, katılığında, kıvamında ve kayma işinde artışa neden olurken; asitliğinde, toplam kolesterol içeriğinde, peroksit değerinde, TBA değerinde ve konjuge-dien oranında azalışa neden olmuştur. Tüm fiziksel ve kimyasal analiz sonuçları göz önüne alındığında, İMU'nun mayonez formülasyonunda yağ ve yumurta sarısı ikamesi olarak kullanılabileceği; ancak, daha yüksek emülsiyon stabilitesine ve daha iyi fiziksel özelliklere sahip olan mayonez benzeri sosun İMU'nun çeşitli stabilizatörlerle kombine edilmesiyle elde edilebileceği kanısına varılmıştır.

Anahtar Kelimeler: İğde meyvesi unu, viskozite, kolestrol içeriği, peroksit değeri, kıvam

Introduction

Oleaster (*Elaeagnus angustifolia*), also known as Russian olive, Bohemian olive and wild olive, is a member of the *Elaeagnaceae* family and grows in central Asia, various regions of Europe and North America (Beker et al., 2020). It has reddish-brown fruits approximately 6-10 mm wide and 9-

12 mm long (Kouhanestani et al., 2019). The fruit, which is rich in nutritional value, can be consumed either in raw or dried form after ripening in September. Due to the remarkable nutritional and functional properties, the possible usage of oleaster fruit in various food products such as ice cream (Çakmakçı et al., 2015), doughnut (Sarraf et al., 2017), yoghurt (Öztürk et al., 2018), cookies (Sahan et al., 2019), sponge cakes (Kouhanestani et al., 2019) was investigated.

Mayonnaise is a semi-solid oil-in-water emulsion prepared with the blending of vegetable oil, egg yolk, vinegar, and flavour ingredients. Mayonnaise contains a high ratio of vegetable oil (approximately 70-80%); therefore, it is a high-calorie food product. On the other hand, egg yolk used as an emulsifier in the mayonnaise formula contains a high level of cholesterol, lipoproteins, and phospholipids (Ouraji et al., 2020). Besides, the allergenic proteins in the egg yolk cause serious health problems for some consumers. For these reasons, the new trend in mayonnaise production is to reduce the fat and egg yolk content. Different attempts to reduce the egg yolk and fat in the mayonnaise formula have existed in the literature (Worrasinchai et al., 2006; Ghazaei et al., 2015; Carcelli et al., 2020; Ouraji et al. 2020; Raikos et al., 2020). However, there is no published report made in the open literature on reducing both fat and egg yolk in mayonnaise using the same substitute.

Considering the high caloric value and cholesterol content of mayonnaise, the aim of the study is to investigate the possible usage of OFF in mayonnaise formulation as a substitute for fat and egg yolk. It is thought that the mealy structure and functional properties of OFF can contribute to the physical and chemical properties of mayonnaise.

Material and Methods

Material

Oleaster fruit (*Elaeagnus angustifolia*), sunflower oil, sugar, salt, vinegar, and mustard were purchased from a local market in Şanlıurfa, Turkey. The egg yolk was supplied from Alfasol® (Gaziantep-Turkey). Cholesterol and 5-α-cholestane were obtained from Sigma-Aldrich (St Louis, MO, USA).

Methods

OFF production

Oleaster fruit was dried in a vacuum oven at 50°C for a day. Then the fruits were peeled manually. OFF was obtained by rubbing the fruits through the reverse side of a sieve. Afterwards, it was grounded using a grinder, and sieved through a sieve (62 mesh).

Table 1. Percentage of each ingredient in the mayonnaise samples

	FFM	LFLCM-I	LFLCM-II	LFLCM-III
Sunflower oil	75	60	45	30
Egg yolk	4	3.5	2.5	1.5
Water	15	22.5	30	42.5
Vinegar	3.25	3.25	3.25	3.25
Sugar	1.75	0.9	0.4	0
Salt	0.5	0.5	0.5	0.5
Mustard	0.5	0.5	0.5	0.5
OFF	0	8.85	17.85	21.75

Abbreviations: FFM: Full-fat mayonnaise, LFLCM: Low-fat-low-cholesterol mayonnaise

Production of mayonnaise

Mayonnaise samples were prepared using a mixer (Tefal Mastermix, İstanbul, Turkey) according to Table 1. The formulations were determined according to the results of our preliminary studies. The oil, egg yolk and sugar ratios were decreased with the incremental percentage of OFF. The mayonnaise samples were filled in glass jars covered with lids. The productions were carried out in duplicate.

Some physicochemical characteristics of mayonnaise samples

The pH value was measured using a laboratory pH meter (Model HQ40d, Hach Company) at a temperature of 20±0.5°C in triplicate after preparing 10% dispersion of mayonnaise in distilled water.

The acidity was determined by a simple titration method using 0.1 N NaOH and phenolphthalein as an indicator. Results were expressed as the percentage of acetic acid because vinegar was used in the mayonnaise formula.

The water activity of mayonnaise samples was determined using a water activity meter (AquaLab®, model 4TE, Decagon Devices Inc., Pullman, WA, USA) at 25 °C.

Colour values were measured using a Colour Instrument (Hunter Associates Laboratory, Inc., Reston, VA 22090, USA) to identify whether the addition of OFF influenced the colour parameters.

The viscosity of mayonnaise was measured at 25±2°C using a Viscometer (Brookfield DV-II +, USA) with a spindle (No. 5) rotation of 50 rpm. The readings were recorded at the 6th second of the measurement.

The cholesterol content of mayonnaise was determined using the method proposed by Madzlan (2008).

In order to determine the oil oxidation parameters, the oil phase was separated from the mayonnaise according to the procedure of Raikos et al. (2020). Peroxide value (PV), TBARs value and conjugated dienes were measured according to the method of AOAC (2000).

Textural characteristics of mayonnaise samples

Texture measurement was carried out using a Texture Analyser (TA-XT2, Stable Micro System Ltd., UK) based on the back extrusion and spreadability methods at 25 ± 2°C. Tests were carried out in a standard size glass jar (50 mm diameter).

Microscopic analysis of mayonnaise

An optical microscope (Leica Microsystems, Wetzlar, Germany) at 40× magnification was used to examine the mayonnaise samples. The images of samples were captured using LAS-EZ software (Leica Microsystems, Wetzlar, Germany).

Emulsion stability of mayonnaise

The emulsion stability (ES) of mayonnaise was determined according to the method suggested by Phuah et al. (2016).

Statistical analysis

All experiments were performed in triplicate, and the results were expressed as mean ± standard deviation. Statistical analysis was performed using Minitab software (Minitab. State College. Pa). Data obtained from the study were analysed using one-way ANOVA. The differences between the significant averages were tested using the Tukey multiple comparison test.

Result and Discussion

Effect of OFF on some physical and chemical properties of mayonnaise

Some physical and chemical properties of mayonnaise samples were presented in Table 2. The mean pH of the LFLCM samples was significantly ($P<0.01$) higher than FFM. This situation might be because of the dilution of acetic acid concentration with the increase in the water ratio. Contrary to our results, Worrasinchai et al. (2006) reported that the pH value of the mayonnaise decreased with the addition of β-glucan as a fat replacer into the mayonnaise formula. The pH of mayonnaise is an important factor for emulsion stability, microbiological and sensorial characteristics (Depree and Savage 2001). In contrast to our findings, Ghazaei et al. (2015) reported that pH of mayonnaise decreased with the increase in egg yolk substitutes. Depree and Savage (2001) reported that the highest stability and viscoelasticity is achieved in mayonnaise when the pH of mayonnaise is equal or close to the isoelectric point of egg yolk proteins. Considering this theorem, the decrease in the emulsion stability with the increase in OFF ratio could be related to the effect of pH on the

emulsion stability. Similar to the pH value, the mean acidity value of the LFLCM samples was significantly (P<0.01) higher than FFM. The organic acids in OFF can be the reason for the increase in the acidity of the mayonnaise samples. pH is the logarithm of the concentration of free hydrogen ions, whereas total acidity is a measuring test that is related to the total acid concentration in food. Therefore, there is no direct correlation between total acidity and pH (Tyl & Sadler, 2017). Sahan et al. (2015) reported that several organic acids such as citric acid, malic acid, acetic acid, oxalic acid, tartaric acid and fumaric acid were determined in oleaster flour. Similarly, Çakmakçı et al. (2015) reported that the acidity of ice cream increased with the increase of oleaster flour. The mean a_w value of the LFLCM samples was found significantly (P<0.01) lower than FFM. The slight decrease in the water activity in LFLCM might be due to the presence of organic soluble compounds in OFF that can bind water. In contrast to our results, Worrasinchai et al. (2006) reported that a_w value of the mayonnaise increased with increasing β-glucan ratio in the formula due to the increase of water content of the formulations.

Considering colour parameters (L^*, a^* and b^*) presented in Table 2, the colour parameters of mayonnaise were affected negatively with the addition of OFF. The brightness of the mayonnaise significantly (P<0.01) decreased with increasing the OFF ratio, whereas a^* and b^* value of the mayonnaise significantly (P<0.01) increased. Similarly, Maneerat et al. (2017) reported that the colour of salad cream turned into redder, less yellow, and darker colour after the addition of pectin extracted from banana peels into the mayonnaise formula as a fat replacer. In general, the pale yellowness of mayonnaise is sourced from the main ingredients such as egg yolk and oil. Therefore, the fat/egg yolk reduction caused the change in the colour parameters of mayonnaise. Besides, the colour pigments in OFF might be responsible for the colour change of mayonnaise. On the other hand, Worrasinchai et al. (2006) reported that the L^* value of mayonnaise samples, which contained β-glucan as a fat replacer, were lower than full-fat mayonnaise except for the mayonnaise that the fat content reduced to 50%. Furthermore, they reported that a^* value increased while b^* value decreased with increasing the β-glucan ratio in the mayonnaise formula.

The mean viscosity values of the LFLCM samples were significantly (P<0.01) higher than the FFM. The increase in the viscosity might be interrelated to the high water-holding-capacity of OFF. As the fat content decreased and the OFF ratio increased in the mayonnaise formula, the added water bounded with OFF, and consequently, the viscosity of the aqueous phase increased. Maneerat et al. (2017) reported that the viscosity of salad cream decreased with the addition of pectin extracted from banana peels into the mayonnaise formula as a fat replacer. Interestingly, the emulsion stability decreased with the addition of OFF into the mayonnaise formulation. This phenomenon is probably because of the decrease of egg yolk in the mayonnaise formula. Although OFF had an emulsifying capacity, the emulsion created by OFF had not enough stability compared to egg yolk. Similarly, Ghazaei et al. (2015) reported that control formulated with 100% egg yolk showed the highest emulsion stability up to two weeks compared to the mayonnaise samples contained octenyl succinic anhydride-modified potato starch.

The cholesterol content of egg yolk used in the mayonnaise production was determined as 2064.98±28.30 $mg.100g^{-1}$. Naturally, the substitution of egg yolk with OFF resulted in a decrease in the total cholesterol content of the mayonnaise. The total cholesterol content of the LFLCM samples was significantly (P<0.01) lower than FFM (Table 2). The reduction of the egg yolk content to 3.5% (LFLCM-I), 2.5% (LFLCM-II) and 1.5% (LFLCM-III) resulted in the 24.68%, 44.62% and 63.24% reduction of the total cholesterol, respectively. Similarly, Ghazaei et al. (2015) reported that 75% and 100% substitutions of the egg yolk resulted in the 84% and 97% reduction in the cholesterol of the mayonnaise.

Table 2. Some physical and chemical properties of mayonnaise samples

	FFM	LFLCM-I	LFLCM-II	LFLCM-III
pH	4.02±0.01^{c}	4.11±0.02^{b}	4.18±0.01^{a}	4.17±0.03^{a}
Acidity (% AA)	0.24±0.03^{c}	0.50±0.02^{b}	0.66±0.03^{a}	0.64±0.05^{a}
a_w	0.96±0.00^{a}	0.94±0.00^{c}	0.94±0.00^{c}	0.95±0.00^{b}
Colour values L^*	80.17±0.18^{a}	72.40±0.04^{b}	65.82±0.05^{c}	61.62±0.38^{d}
a^*	2.21±0.05^{d}	2.65±0.03^{c}	4.71±0.09^{b}	5.73±0.09^{a}
b^*	18.91±0.08^{b}	19.43±0.04^{c}	23.38±0.19^{a}	24.42±0.27^{a}
Viscosity (cP)	14407.67±417.55^{d}	16907.67±866.32^{c}	33648.00±816.53^{a}	21770.00±1175.93^{b}
Emulsion stability (%)	95.96±0.06^{a}	85.19±1.04^{b}	71.54±0.47^{d}	75.97±0.01^{c}
Total cholesterol (mg.100 g^{-1})	73.09±0.09^{a}	55.05±4.13^{b}	40.48±2.02^{c}	26.87±0.89^{d}
PV (mEq O_2.kg^{-1})	13.47±0.33^{a}	5.98±0.04^{b}	5.78±0.17^{b}	3.03±0.04^{c}
TBARs (mg malonaldehyde.kg^{-1})	23.01±1.94^{a}	21.93±2.93^{a}	17.90±1.33^{ab}	15.60±1.51^{b}
Conjugated dienes (%)	0.92±0.01^{a}	0.31±0.01^{bc}	0.29±0.01^{b}	0.25±0.00^{c}

Abbreviations: FFM: Full-fat mayonnaise, LFLCM: Low-fat-low-cholesterol mayonnaise, AA: Acetic acid, a_w: Water activity
Means in the same row with different small letters are significantly different (P<0.01).

Peroxide value, TBARs value and conjugated dienes ratio were used to determine the oil oxidation in the mayonnaise samples. The peroxide value and conjugated dienes were used to measure primary oxidation products, while TBARs value was used to measure the secondary oxidation products. According to the results presented in Table 3, the oil oxidation parameters in the LFLCM samples was significantly (P<0.01) lower than FFM. It is worthy to note that the observed decrease in the oil oxidation parameters was reflective of the protective effect of phenolic compounds that naturally existed in OFF such as rutin, isorhamnetin, luteolin (Darvishzadeh & Orsat, 2022).

Effect of OFF on the textural characteristic of mayonnaise

The results of the textural characteristics of the mayonnaise samples obtained with the back extrusion method and spreadability profiling were presented in Figure 1. All the textural parameters were significantly (P<0.01) affected by the OFF ratio. The firmness, consistency and work of shear of the mayonnaise increased with increasing the OFF ratio, while the cohesiveness and work of cohesion decreased with increasing the OFF ratio. The firmness value generally indicates the strength of the emulsion. The emulsion stability decreased with increasing the OFF ratio, although the firmness of the mayonnaise samples increased with increasing of the OFF ratio. This situation could be related to the insufficient emulsifying ability of OFF compared to the egg yolk. On the other hand, the increase in the firmness of the mayonnaise could be assigned to the thickening ability and water holding capacity of OFF. The observed increase in the firmness, consistency and work of shear of the mayonnaise could be a reflection of the increase in viscosity of mayonnaise samples (Liu et al., 2007). Similar to our results, Carcelli et al. (2020) reported that firmness value of the reduced-fat mayonnaise samples was higher than full-fat mayonnaise. In contrast to our findings, Raikos et al. (2020) reported that the firmness, adhesiveness and adhesiveness force decreased with the increase of the aquafaba ratio.

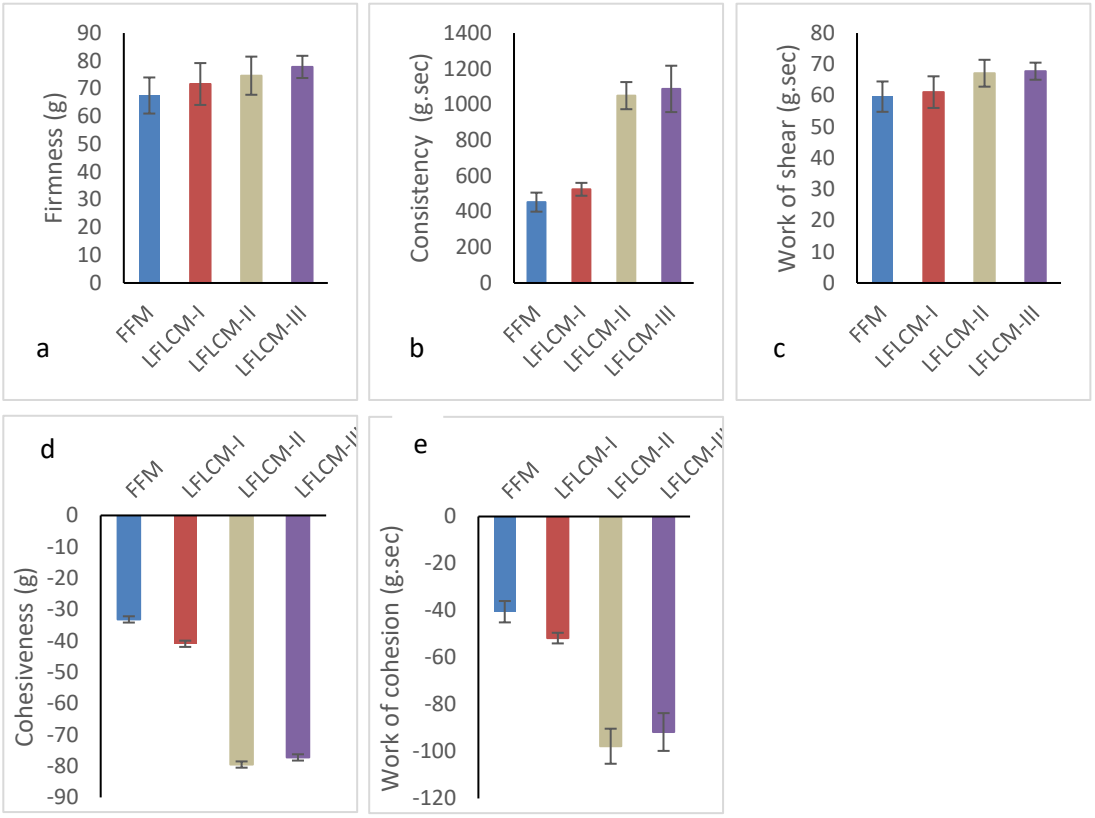

Figure 1. Textural characteristics of the mayonnaise samples obtained with back extrusion and spreadability methods. (a) Firmness, (b) Consistency, (c) Work of shear, (d) Cohesiveness, (e) Work of cohesion.

Effect of OFF on mayonnaise microstructure

The microstructure of mayonnaise samples was exhibited in Figure 2. As the fat ratio reduced in the mayonnaise formula, a decrease in the number of the oil droplets and an increase in the number of interspaced void spaces were observed in the micrographs. The microstructure of the mayonnaise is an indicator of the textural characteristics and viscosity. In general, the large contact surface area between oil droplets limits the free-flowing of emulsion, thereby increasing its viscosity (El-Bostany et al., 2011). The highest uniformity in droplet size was observed in the FFM and LFLCM-I formulations. An increase in the degree of polydispersity (different size) was observed with increasing the OFF ratio compared to the micrograph of the FFM. Similarly, Carcelli et al. (2020) reported that both droplet aggregation and intermittent void areas increased with decreasing fat amount in the microstructural images of reduced-fat mayonnaise compared to full-fat mayonnaise. Maneerat et al. (2017) reported that the number of oil droplets in reduced fat salad cream formulas was lower than the control sample that contained 50% oil. Furthermore, they observed the largest oil droplets and the most extensive agglomeration in the reduced-fat cream formula prepared with water-extracted banana peel pectin. In contrast, Raikos et al. (2020) reported that all mayonnaise samples contained aquafaba at three different ratios (15%, 20% and 25%) showed well dispersed and spheric oil droplets in the aqueous medium.

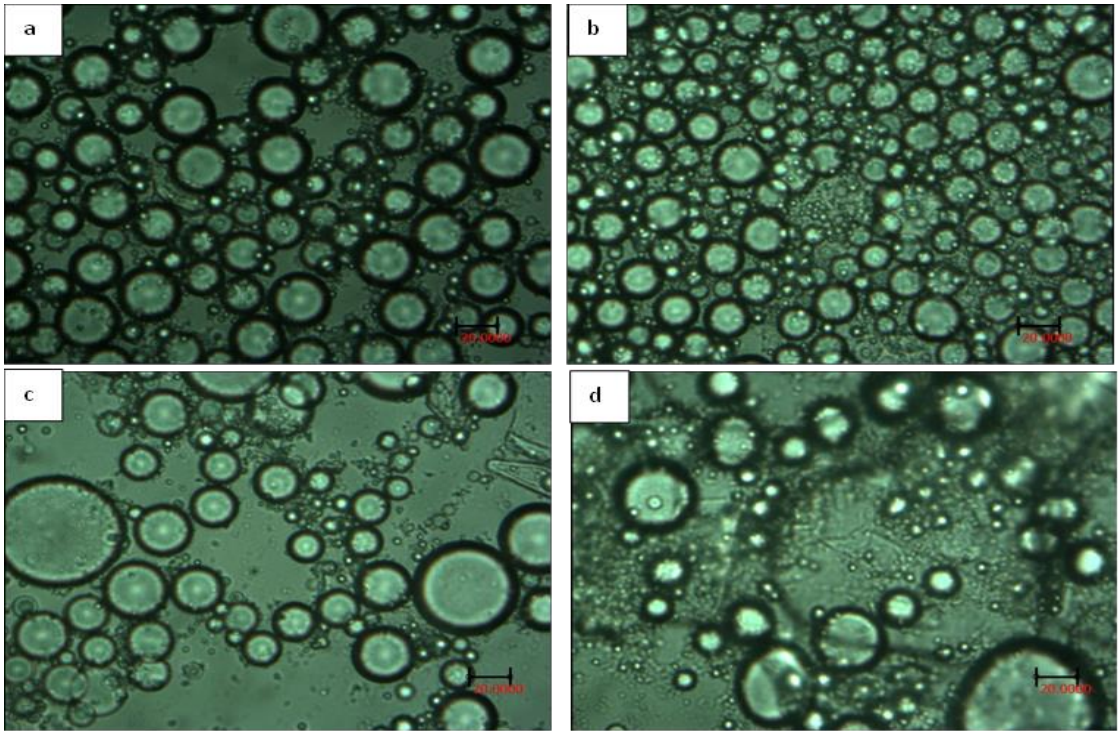

Figure 2. Microstructure of the mayonnaise samples (a) FFM, (b) LFLCM-I, (c) LFLCM-II, (d) LFLCM-III

Conclusion

The substitution of egg yolk and fat in the mayonnaise formula by the addition of OFF caused an increase in pH value, whereas a decrease in the acidity compared to FFM. The colour parameters of mayonnaise affected negatively with the addition of OFF. Higher viscosity and lower emulsion stability were observed in LFLCM samples. The increase in viscosity of LFLCM samples compared to FFM was also reflected in the textural characteristics, and thus an increase in the firmness, consistency and work of shear was observed in LFLCM samples compared to FFM. A significant decrease in the total cholesterol content was observed with the egg yolk substitution in the mayonnaise formula. Considering all of the physical and chemical analysis results, the OFF can be used as a fat and egg yolk replacement in the mayonnaise formula; however, it was concluded that the mayonnaise-like sauce, which has higher emulsion stability and better physical characteristics, can be achieved by combining OFF with various stabilizers.

Conflicts of Interest: The authors declare no conflict of interest.

Author Contributions: Naciye ÜNVER was responsible for the investigation, methodology, validation, visualization, writing original draft, writing-review & editing. Şerafettin ÇELİK directed and supervised the research. Sema SAYAR and Berfin ERGÜN. were responsible for the laboratory analysis. Yasin YAKAR was responsible for the methodology and the laboratory analysis.

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