

Effect of Partially Replacing Egg Yolks with Ultrasonically Extracted Sesame Lecithin on the Physicochemical and Sensory Properties of Low-Cholesterol Mayonnaise

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Abstract

Mayonnaise is one of the most important oil-in-water food emulsions, and its traditional formulation relies on egg yolk as the primary emulsifying agent. However, the high cholesterol content of egg yolk has prompted the search for natural plant-based alternatives capable of maintaining product quality while reducing its cholesterol content. The aim of this study was to evaluate the feasibility of using ultrasonic-assisted lecithin extracted from sesame oil as a partial substitute for egg yolk in mayonnaise preparation, and to examine its effect on the physicochemical, microbial, and sensory properties of the final product.

Lecithin was extracted from sesame oil using ultrasonic technology; the extracted lecithin was then used to manufacture three mayonnaise formulations, in addition to a control sample without any substitution, and three treatments in which egg yolk was replaced with sesame lecithin at ratios of 25%, 50%, 75%. The chemical composition, cholesterol content, pH, emulsion stability, sensory characteristics, and microbiological tests of the resulting mayonnaise were then evaluated. The results showed that increasing the percentage of lecithin substitution led to a significant decrease in cholesterol content compared to the control sample, Emulsion stability also improved gradually with increasing lecithin content, reflecting the high emulsifying efficiency of the phospholipids present in it. pH values were not significantly affected and remained within the appropriate acidic range for mayonnaise.

Sensory evaluation showed that partially replacing egg yolk with sesame lecithin maintained acceptable sensory quality; the 25% replacement treatment achieved the highest acceptability scores among the replacement treatments, with a texture similar to that of the control sample. In contrast, higher substitution rates led to a gradual decline in color, taste, and overall acceptability. Microbial tests also showed no growth of *E. coli*, *Salmonella*, yeasts, or molds during the refrigerated storage period, while limited growth of total bacterial count was observed at the end of the 14-day storage period.

The results indicated that sesame lecithin can be used as a natural vegetable emulsifier in mayonnaise preparation and that replacing 25% of the egg yolks represents the optimal level for reducing cholesterol while maintaining the desired physicochemical and sensory characteristics of the product.

Keywords: Sesame lecithin, Mayonnaise, Egg yolk substitute, Cholesterol reduction, Emulsifier, Microbiological testing of mayonnaise, Sensory evaluation.

1 Introduction

Mayonnaise is one of the most widely consumed food emulsions in the world and is classified as an oil-in-water emulsion, in which oil droplets are dispersed within a continuous aqueous phase containing vinegar, water, and other ingredients. The stability of the emulsion depends primarily on the presence of effective emulsifying agents, foremost among which is egg yolk, which is rich in phospholipids and lipoproteins [35].

Mayonnaise is also characterized by its high oil content, which may exceed 70%, requiring a stable interfacial system capable of preventing droplet coalescence and phase separation during storage [24].

Lecithin is a complex natural mixture of amphipathic phospholipids; it has both a hydrophilic and a lipophilic portion, which enables it to localize at the interface between oil and water and reduce the surface tension between them, thereby promoting the formation and stability of emulsions [36].

The functional performance of lecithin is linked to its phospholipid composition, which is rich in phosphatidylcholine, phosphatidylethanolamine, and phosphatidylinositol, all of which play an important role in improving the physical stability, texture, and rheological properties of emulsified food systems [9][18]. Although commercial lecithin is primarily extracted from soybeans, interest has grown in recent years in identifying alternative plant sources with distinctive nutritional and functional properties.

Sesame (*Sesamum indicum* L.) is considered an important oilseed crop due to its high oil content and a range of bioactive compounds, and its oil contains phospholipids, which are the primary component of lecithin. This makes it a promising source for the production of plant-based lecithin with good emulsifying

properties that can be utilized in various food applications [25][27].

As [8] explained, sesame lecithin possesses effective emulsifying capacity due to its high content of phospholipids, which are capable of forming stable membranes around oil droplets in emulsions.

In recent years, there has been growing interest in developing low-cholesterol mayonnaise products in response to consumers' increasing awareness of the importance of limiting dietary cholesterol intake; Egg yolks are the primary source of cholesterol in traditional mayonnaise, which has prompted researchers to investigate the possibility of replacing or reducing their proportion using plant-based alternatives with suitable emulsifying properties [23]. Studies indicate that plant-based lecithin can provide effective emulsifying properties while reducing cholesterol content and maintaining emulsion stability when the formulation is designed appropriately [10][35]. Furthermore, replacing egg yolk with plant-based lecithin not only affects the nutritional content of the product but also influences its physical and sensory properties, as well as the stability of the emulsion during storage [38][18].

One of the modern techniques used to extract phospholipids and lecithin from vegetable oils is ultrasonic-assisted extraction, which relies on the phenomenon of acoustic cavitation, leading to enhanced mass transfer and improved efficiency in separating phospholipids from the oil, as well as reducing extraction time and improving yield compared to traditional methods [11][7].

This technique has demonstrated high efficiency in the extraction of lecithin from vegetable oils, making it a promising option for industrial and food applications.

Therefore, this study aimed to evaluate the effect of partially replacing egg yolk with ultrasonically extracted sesame lecithin on certain physicochemical properties of mayonnaise, with a focus on cholesterol content, pH, emulsion stability, and

sensory evaluation, with the goal of developing a low-cholesterol mayonnaise product with suitable quality characteristics and applicability in the food industry.

2 Material and Methods

1-2 Preparation of Lecithin

Ultrasonically extracted sesame crude lecithin was used, following the method described by [29] with some modifications: an ultrasonic bath operating at a frequency of 30 kHz and a temperature of 60°C was used for different times (10, 20, 30) minutes. After comparing the extraction yields, the crude lecithin extracted for 10 minutes was selected because it yielded the highest extraction yield and was used as a vegetable emulsifier to partially replace egg yolks in the production of low-cholesterol mayonnaise.

2-2 Mayonnaise preparation

Ingredients	T1	T2	T3	T4
oil(ml)	60	60	60	60
egg yolk(gm)	10	7.5	5	2.5
Vinegar(ml)	5	5	5	5
water(ml)	10	10	10	10
salt(gm)	1.5	1.5	1.5	1.5
sugar(gm)	2.5	2.5	2.5	2.5
Corn Starch(gm)	1.5	1.5	1.5	1.5
mustard(gm)	0.8	0.8	0.8	0.8
white pepper(gm)	0.6	0.6	0.6	0.6
lecithin(gm)	-	2.5	5	7.5

Table1: Ingredients in Mayonnaise Formulas

T1 is the control sample 10% egg yolk; **T2** is mayonnaise 25% of the egg yolk has been replaced with lecithin; **T3** is mayonnaise 50% of the egg yolk has been replaced with lecithin; **T4** is mayonnaise 75% of the egg yolk has been replaced with lecithin .

The method described by [4] was followed with some modifications; the mayonnaise preparation recipe included the ingredients and their quantities listed in Table (1). The control sample (T1), containing 10% egg yolk, was prepared, while in the other treatments, the egg yolk was partially replaced with sesame crude lecithin at a rate of 25% (2.5 g lecithin) in T2, 50% (5 g lecithin) in T3, and 75% (7.5 g lecithin) in T4, with the remaining ingredients kept unchanged. The ingredients were mixed using an electric mixer to obtain a homogeneous emulsion, and then the samples were packaged in sterile, airtight containers and stored refrigerated until analysis.

3-2 Determination of approximate compounds:

The moisture, ash, crude protein, fat, and carbohydrate contents of the mayonnaise samples were determined using standard methods approved by [5].

4-2 Cholesterol Assessment

The cholesterol content in the mayonnaise samples was determined after preparation

using an alcoholic cholesterol extraction method as described by [3] .

The cholesterol concentration was then measured according to the instructions provided with several commercial kits (Cholesterol Assay Kit) from the Spanish company Spinreact, and the results were expressed in mg/100 g of product.

5-2 Determination of pH

The pH of the mayonnaise samples was measured according to the standard method approved by [5] using a digital pH meter that had been calibrated with standard calibration solutions, and the readings were recorded at room temperature.

6-2 Measurement of the Emulsion stability

The emulsion stability was determined using the method previously described [26][28] by subjecting 15 g of mayonnaise samples to centrifugation at 5,000 rpm for 30 minutes. The separated oil layer was then removed, and the emulsion stability was calculated as the ratio of the separated phase to the total sample mass, and the results were expressed as a percentage using the equation:

$$\text{Emulsion Stability (\%)} = \frac{\text{Weight of Emulsified Layer}}{\text{Initial Sample Weight}} \times 100$$

7-2 Microbiological Tests

Microbial tests were conducted on mayonnaise samples in accordance with international standard methods, with some modifications to the media used. The total bacterial count was determined according to [15], the coliform count according to [14], and detection of *Salmonella* was performed according to [16]. Meanwhile, yeast and mold counts were determined according to [13]. Microbial counts were

calculated and expressed in Log CFU/g in accordance with the guidelines set forth in [17] .

8-2 Sensory Evaluation

The sensory evaluation of the mayonnaise samples was conducted at the Department of Food Science at the University of Kufa by 12 trained faculty members specializing in the field. The samples were presented to the evaluators at random and coded with numerical identifiers to minimize bias in the sensory assessment, and each evaluator assessed all samples ,The attributes of color, odor, taste, texture, and overall acceptability were evaluated as described by [12] The attribute scores and the sensory evaluation form were determined in accordance with the guidelines provided by [25].

Statistical Analysis

The data were statistically analyzed using GenStat v.12.1 (GenStat., 2009) according to a completely randomized design (CRD) for chemical composition and microbial tests, while sensory evaluation data were analyzed according to a completely randomized block design (RCBD), with the evaluators serving as blocks. An analysis of variance (ANOVA) was performed to test for differences between treatments, and means were compared using Duncan's multiple range test at a significance level of $P \leq 0.05$.

3. Results and Discussion

The Effect of Partial Replacement of Egg Yolk with Sesame Lecithin on the Chemical Composition of Mayonnaise

The results of the chemical analysis of the mayonnaise samples showed a clear and significant effect of replacing egg yolk with ultrasonically extracted sesame lecithin on the basic components of

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mayonnaise, as illustrated in the table (2) which indicated that an increase in the proportion of lecithin replacing egg yolk, led to a gradual decrease in the moisture, fat, protein, and ash content, accompanied by a calculated increase in the carbohydrate content.

This change reflects a genuine shift in the balance between the oil phase and the aqueous phase and their associated components, rather than a random fluctuation.

Moisture content decreased significantly from 34.157% in the control sample T1 to 27.990% in the substitution treatment T4; this is attributed to the reduction in the amount of egg yolk, since egg yolk contributes to the aqueous phase of the system, whereas lecithin is a phospholipid used in smaller quantities and does not compensate for the moisture added by the egg yolk. [35] stated that mayonnaise is an oil-in-water emulsion, and that its main ingredients, including oil and egg yolk, directly affect the system's structure and the distribution of the aqueous phase within it. [2]also noted that changing the ingredients in the mayonnaise formulation leads to a change in the product's moisture content.

The fat content also decreased from 55.570% in the T1 control sample to 50.890% in the T4 treatment. This is explained by the fact that egg yolk does not function solely as an emulsifier but also serves as a fat component that contributes to the overall composition of mayonnaise. Therefore, reducing its proportion and replacing it with lecithin led to a decrease in fat content. This is consistent with the findings of [2], who noted that egg yolk contains phospholipids, proteins, and fat components that contribute to the fat composition of mayonnaise, as well as the findings of [35]also demonstrated that the proportion

of oil and its associated components is a key factor in determining the composition of mayonnaise; thus, the lower fat content in the substituted formulations is due to the reduced contribution of egg yolk to the final composition.

As for protein, its content decreased from 2.140% in the T1 control sample to 0.717% in the T4 treatment. This is directly related to the nature of lecithin, as it is a phospholipid and not a protein; therefore, it does not replace the proteins and lipoproteins present in egg yolk. This is consistent with [2], who noted that egg yolk contains proteins and lipoproteins in addition to phospholipids; consequently, replacing it with lecithin leads to a decrease in the product's protein content.

The ash content decreased from 1.927% in T1 to 1.010% in T4. This is attributed to the fact that egg yolk has a complex composition that includes vitamins and minerals in addition to phospholipids and proteins, making it a richer source of mineral components compared to the lecithin used. This is consistent with the findings of [18] regarding the complex composition of egg yolk, and with the observation by [2] that ash content is affected by modifications to the mayonnaise formulation.

As for the increase in carbohydrates, this is due to the difference-based calculation method, as the simultaneous decrease in moisture, fat, protein, and ash leads to an increase in the calculated carbohydrate content, which is consistent with the findings reported in [22].

The Effect of Substitution on the Cholesterol Content of Mayonnaise

The results showed a clear, statistically significant decrease in cholesterol content as the proportion of egg yolk replaced by sesame lecithin increased, As shown in

Table (3), the control sample T1 recorded the highest cholesterol content at 101.6 mg/100 g, while treatment T4, in which 75% of the egg yolk was replaced with lecithin, recorded the lowest value of 39.93 mg/100 g.

This decrease is directly attributable to the reduction in the amount of egg yolk—the main source of cholesterol in traditional mayonnaise—and its replacement with cholesterol-free vegetable lecithin. This result is consistent with the findings of [30], who noted that egg yolks possess good functional properties but are characterized by high cholesterol content.

[1] also pointed out that a single egg yolk contains approximately 275 mg of cholesterol. Furthermore, [31] noted that reducing or eliminating egg yolks from mayonnaise formulations is an important goal in the development of mayonnaise products for health reasons, including lowering cholesterol levels. Thus, the results indicate that using sesame lecithin as a partial substitute for egg yolks is an effective approach for producing low-cholesterol mayonnaise while maintaining the required emulsifying function.

Table 2. Chemical Composition of Mayonnaise Samples

samples	%Percentage of Ingredients				
	moisture	lipids	protein	ash	carbohydrates
T1	34.157 d	55.570 d	2.140 a	1.927 a	6.21 a
T2	32.863 c	53.703 c	1.673 b	1.567 b	10.19 b
T3	31.053 b	51.597 b	1.020 c	1.207 c	15.12 c
T4	27.990 a	50.890 a	0.717 c	1.010 c	19.39 d
sample		Cholesterol (mg/100 g)			

Different letters within the same column indicate a statistically significant difference between the means of the treatments at the ($P \leq 0.05$) level.

Values are expressed as the arithmetic mean of three replicates.

T1: Control sample containing 10% egg yolk; **T2:** Mayonnaise with 25% of the egg yolk replaced by lecithin; **T3:** Mayonnaise with 50% of the egg yolk replaced by lecithin; **T4:** Mayonnaise with 75% of the egg yolk replaced by lecithin.

Table 3: Cholesterol Content in Mayonnaise

T1	101.6±0.3987 d
T2	63.07±0.2539 c
T3	53.05±0.1666 b
T4	39.93±0.1410 a

Different letters within the same column indicate a statistically significant difference between the means of the treatments at the ($P \leq 0.05$) level.

Values are expressed as the arithmetic mean of five replicates.

T1: Control sample containing 10% egg yolk; **T2:** Mayonnaise with 25% of the egg yolk replaced by lecithin; **T3:** Mayonnaise with 50% of the egg yolk replaced by lecithin; **T4:** Mayonnaise with 75% of the egg yolk replaced by lecithin.

The Effect of Substitution on the pH of Mayonnaise

The pH measurement results showed no statistically significant differences in pH values among the four formulations, and the pH values of the mayonnaise formulations remained within the acidic range appropriate for mayonnaise, as shown in Figure(1), This is attributed to the fact that the percentage of vinegar used in production remained constant across all treatments; therefore, the partial replacement of egg yolks with sesame lecithin did not result in a significant change in the acidity of the final product, and the recorded values fall within the appropriate range for mayonnaise. [22] indicated that the pH value of typical mayonnaise ranges between 3.5 and 4.5, and [19] confirmed that the pH of mayonnaise does not exceed 4.1 to ensure the product's nutritional and microbial safety. Thus, all prepared mayonnaise samples maintained an appropriate pH, which is an important characteristic for the quality and safety of mayonnaise.

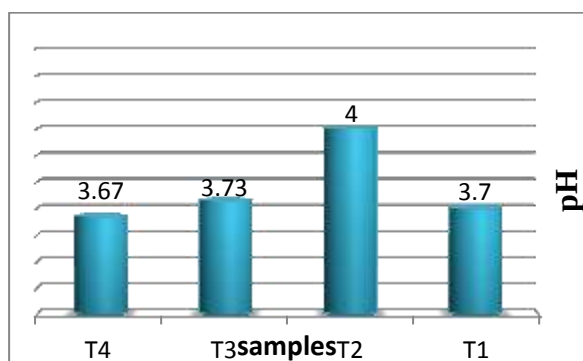


Figure 1: pH of the mayonnaise samples

Values are expressed as the arithmetic mean of three replicates.

T1: Control sample containing 10% egg yolk; **T2:** Mayonnaise with 25% of the egg yolk replaced by lecithin; **T3:** Mayonnaise with 50% of the egg yolk replaced by lecithin; **T4:** Mayonnaise with 75% of the egg yolk replaced by lecithin.

The Effect of Substitution on Emulsion Stability

The emulsion stability results showed a clear improvement as the proportion of egg yolk replaced by sesame lecithin increased. The control sample T1 recorded the lowest emulsion stability value of 93.11%, while it rose to 95.49% in T2 and 96.07% in T3, with no statistically significant difference between these two treatments, and reached its highest value in T4 at 98.20%, with treatment T4 showing statistical superiority over the other treatments. The improvement in emulsion stability is attributed to the increased lecithin concentration, as lecithin has an amphipathic nature due to its hydrophilic and lipophilic groups, which help it concentrate at the oil-water interface and form a stable film around the oil droplets, thereby reducing droplet coalescence and oil separation [33] [36].

This result is consistent with the findings of [20], as replacing egg yolk with sesame and peanut milk improved emulsion

stability, and the complete substitution ratios recorded the highest values for physical stability. As noted by [8], the highest emulsion stability in the formulations using water-extracted sesame

oil lecithin as an emulsifier in margarine production reached 98%, confirming the ability of sesame lecithin to act as an effective emulsifier.

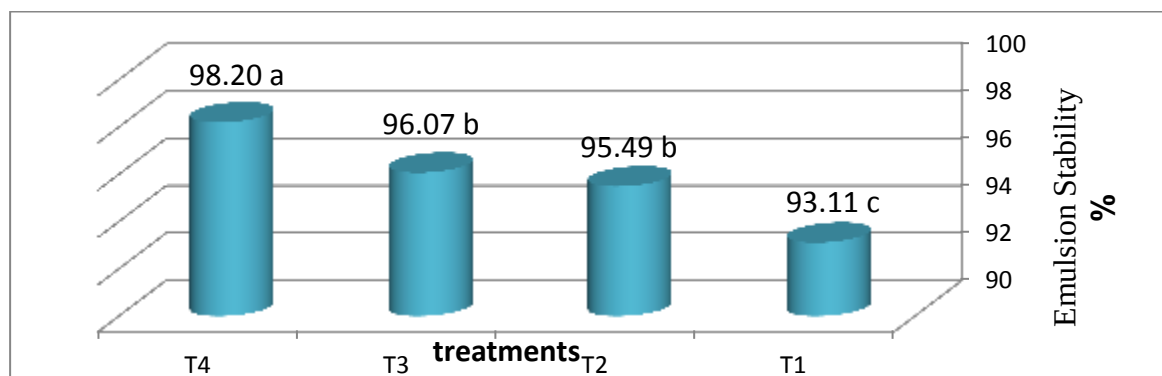


Figure 2: Emulsion Stability of Mayonnaise Samples

Different letters indicate a statistically significant difference between the means of the treatments at the ($P \leq 0.05$) level, as determined by Duncan's multiple range test.

Values are expressed as the arithmetic mean of three replicates.

T1: Control sample containing 10% egg yolk; **T2:** Mayonnaise with 25% of the egg yolk replaced by lecithin; **T3:** Mayonnaise with 50% of the egg yolk replaced by lecithin; **T4:** Mayonnaise with 75% of the egg yolk replaced by lecithin.

Microbiological Testing of Mayonnaise

Table(4) shows the results of microbial tests on mayonnaise samples over a period of fourteen days. The test results indicated that no growth of yeast, mold, coliform bacteria, or Salmonella was detected in any of the samples during the refrigerated storage periods of 1, 3, 7, and 14 days, indicating the high hygiene standards followed during preparation and storage, as well as the suitability of the product's acidic nature in limiting the growth of these microbial populations.

As for the total count of aerobic bacteria, significant differences were observed among the treatments on the 14th day, with

the control sample T1 recording the highest value of 3.025 log CFU/g, followed by treatment T2 with an average of 2.901 log CFU/g, with no significant difference between them, whereas the count decreased significantly in treatments T3 and T4 to 2.624 and 2.360 log CFU/g, respectively. This indicates that increasing the proportion of egg yolk replaced with sesame lecithin contributed to a reduction in the total bacterial load in the mayonnaise samples.

This decrease can be explained by the fact that replacing part of the egg yolk with sesame lecithin reduced the contribution of the egg yolk as a relatively rich source of proteins, fats, and nutrients that may support the growth of certain

microorganisms. Furthermore, the improved emulsion stability provided by lecithin may reduce phase separation within the product and limit the availability of free water or the formation of localized areas conducive to microbial growth.

[39] used flaxseed gum as a functional substitute for egg yolk in mayonnaise, demonstrating that plant-based substitution

vinegar, as the low pH and the presence of acetic acid are important factors in inhibiting the growth of many spoilage or pathogenic bacteria. [37] explained that the safety of mayonnaise is largely related to the ratio of eggs to vinegar, and that the low pH resulting from the vinegar makes the environment less suitable for bacterial growth.

days	Microbiological Testing	T1	T2	T3	T4
1	Total Bacterial Count	N.D	N.D	N.D	N.D
	Yeast and Mold	N.D	N.D	N.D	N.D
	Total Coliform Bacteria Count	N.D	N.D	N.D	N.D
	Salmonella Detection	N.D	N.D	N.D	N.D
3	Total Bacterial Count	N.D	N.D	N.D	N.D
	Yeast and Mold	N.D	N.D	N.D	N.D
	Total Coliform Bacteria Count	N.D	N.D	N.D	N.D
	Salmonella Detection	N.D	N.D	N.D	N.D
7	Total Bacterial Count	N.D	N.D	N.D	N.D
	Yeast and Mold	N.D	N.D	N.D	N.D
	Total Coliform Bacteria Count	N.D	N.D	N.D	N.D
	Salmonella Detection	N.D	N.D	N.D	N.D
14	Total Bacterial Count	3.025 a	2.901 a	2.624 b	2.360 c
	Yeast and Mold	N.D	N.D	N.D	N.D
	Total Coliform Bacteria Count	N.D	N.D	N.D	N.D
	Salmonella Detection	N.D	N.D	N.D	N.D

can preserve the functional properties of mayonnaise without causing undesirable changes in microbial counts, while keeping bacterial counts low in the mayonnaise samples.

The low microbial growth can also be attributed to the acidic nature of mayonnaise resulting from the presence of

[32] also confirmed that properly prepared mayonnaise and acidic sauces possess an inhibitory system based primarily on a low pH and the presence of acetic acid in the aqueous phase, which limits the growth or survival of many pathogenic bacteria such as *Salmonella* and *E. coli*.

Table 4: Logarithmic averages of microbial counts (log CFU/g) for samples of mayonnaise manufactured and refrigerated at 4°C for 14 days

Values are expressed as the arithmetic mean of three replicates , **N.D.** stands for “not detected.”

Different letters indicate a statistically significant difference between the means of the treatments at the $P \leq 0.05$ level.

T1 is the control sample containing 10% egg yolk; **T2** is mayonnaise with 25% of the egg yolk replaced by lecithin; **T3** is mayonnaise with 50% of the egg yolk replaced by lecithin; **T4** is mayonnaise with 75% of the egg yolk replaced by lecithin.

Sensory evaluation

The results of the sensory evaluation showed significant differences among the mayonnaise formulations in all the attributes studied; the control samples T1 and T2 recorded the highest acceptability scores for most attributes, and no statistically significant differences were observed between them in color, odor, taste, and overall acceptability, indicating that the partial replacement of egg yolks with 25% sesame lecithin did not adversely affect the sensory attributes of the mayonnaise; overall acceptability scores were 9.79 and 9.42 for T1 and T2, respectively. In contrast, increasing the substitution rate to 50% and 75% led to a statistically significant decrease in most

sensory attributes, as overall acceptability decreased to 8.58 in T3 and 7.79 in T4. This can be explained by the fact that egg yolk does not merely play an emulsifying role, but also contributes to the color, taste, aroma, texture, and mouth feel of mayonnaise. Therefore, a significant reduction in its proportion may alter the

sensory balance of the product. Furthermore, vegetable lecithin helps improve emulsion stability and texture due to its ability to concentrate at the oil-water interface, however, increasing its proportion does not fully compensate for the multiple sensory and structural functions of egg yolk. This explains the superiority of the partial replacement treatment T2 compared to the high-replacement treatments T3 and T4, and is consistent with the findings of multiple studies [34] [35] [18] regarding the role of egg yolk and lecithin in the stability and texture of mayonnaise.

Based on this, it can be concluded that the partial replacement of egg yolk with extracted sesame lecithin was most suitable at a 25% level, as treatment T2 maintained sensory characteristics similar to those of the control sample, with a clear improvement in texture, while higher replacement levels led to a gradual decrease in overall sensory acceptability due to changes associated with the reduction of traditional egg yolk components.

Table 4: Results of the Sensory Evaluation of Mayonnaise Samples

treatment	color	smell	taste	texture	overall
T1	9.67 a	9.79 a	9.50 a	9.58 bc	9.79 a
T2	9.50 a	9.67 a	9.17 a	9.83 c	9.42 a
T3	8.67 b	9.00 b	7.83 b	9.00 b	8.58 b
T4	8.00 b	8.08 c	7.75 b	8.08 a	7.79 c

Different letters indicate a statistically significant difference between the means of the treatments at the $P \leq 0.05$ level.

1: Highly unacceptable, 2: Largely unacceptable, 3: Moderately unacceptable, 4: Slightly unacceptable, 5: Average, 6: Slightly acceptable, 7: Moderately acceptable, 8: Largely acceptable, 9: Highly acceptable.

T1: Control sample containing 10% egg yolk; **T2:** Mayonnaise with 25% of the egg yolk replaced by lecithin; **T3:** Mayonnaise with 50% of the egg yolk replaced by lecithin; **T4:** Mayonnaise with 75% of the egg yolk replaced by lecithin.

4 Conclusion

The study results demonstrate the potential of using ultrasonically extracted sesame lecithin as a partial substitute for egg yolk in the preparation of low-cholesterol mayonnaise, as increasing the substitution rate contributed to reducing cholesterol content and improving emulsion stability without causing a significant change in pH. Furthermore, the 25% replacement level demonstrated the best balance between health benefits and sensory acceptability, as it maintained sensory characteristics similar to those of the control sample while showing a clear improvement in texture. Microbiological results confirmed the absence of *E. coli*, *Salmonella*, yeasts, and molds in all treatments, indicating the product's microbiological suitability under the studied preparation and storage conditions. Thus, a 25% replacement rate

can be adopted as the optimal level for preparing low-cholesterol mayonnaise that is sensorially acceptable.

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