

## Effect of ultrasound treatments on quality characteristics of table eggs during refrigerator storage

Haider Y. Abbas, Hussein H. Tariq and Shahrazad M.J. Al-Shadeedi\*

College of Veterinary Medicine, University of Baghdad, Baghdad, Iraq.

**\*Correspondence:**

[shahrazad@mracpc.uobaghdad.edu.iq](mailto:shahrazad@mracpc.uobaghdad.edu.iq)

**ORCID:**

<https://orcid.org/0000-0003-1706-8928>

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### ABSTRACT

Ultrasound was used as a green technology to preserving food and food products. So, an experiment was conducted to compare three periods of ultrasound treatment of table eggs, 1, 2, and 3 minutes, using a conventional ultrasound device, in terms of quality characteristics which included yolk height, yolk diameter, yolk index, white height, yolk weight and percentage and egg components percentage during 0, 1, 2, 4, and 8 weeks of refrigerated storage. A total of 240 fresh table eggs (red-shell eggs) were collected randomly from a flock of 20,000 Lohmann laying hens at Al-Amir Commercial Project Farm in Al-Musayyab city, Iraq. The eggs were divided into 4 treatments (60 eggs/treatment); T1: control, T2: ultrasound for 1 min. T3: ultrasound for 2 min. and T4: ultrasound for 3 min. The results of quality characteristics showed no significant differences between treatments up to two weeks of storage, then significant differences appeared in yolk height, yolk diameter, yolk index, white height, yolk weight of the ultrasound treatments eggs compared with control treatment which recorded the lowest quality characteristics after refrigerator storage for 2, 4, and 8 weeks. The second and third treatments (treatment with ultrasound for 1 and 2 minutes) recorded the best egg yolk height, yolk diameter, yolk index, white height, yolk weight and percentage, and egg white weight and percentage. Concluded that treating table eggs with ultrasound for 1 or 2 min. didn't affect internal quality characteristics of table eggs during storage in the refrigerator.

**Keywords:** Quality characteristics, Storage, Table eggs, Ultrasound.

### Introduction

Table eggs are important protein source in human nutrition and one of the most important protein sources because it contains all the essential amino acids needed by the human body, and the percentage of protein retained in the body of protein consumed is equal to 100% (Stadelman et al., 2017; Al-Obaidi and Al-Shadeedi, 2022). In addition, table eggs, specifically egg yolks, provide all the essential fatty acids and fat-soluble vitamins, and also provides with water, except for vitamin C, a large number of mineral elements, and low energy content, low calories (Abed et al., 2025). Being egg a low-cost animal protein, and eggs are one of the most consumed foods around the

world due to their multifunctional properties such as ease of preparation and delicious taste so, it included in many recipes and food industries for all ages, because it contains All the essential amino acids needed by the human body. (Obi and Igbokwe, 2007; Layman and Rodriguez, 2009; Al-Obaidi et al., 2019; Sabbah et al., 2024). All foods are destroyed with the increase in storage and preservation and need preservation methods to increase the duration of their consumption and eggs are perishable food due to their contain a high percentage of moisture, protein and amino acids as an important source for the growth of microorganisms (Al-Shadeed, 2023).

Fresh eggs initially have low microorganism counts. However, contamination and subsequent microbial growth begin rapidly once the egg contacts the environment, particularly within housing facilities and during handling and transport (Sabbah et al., 2024; Al-Shadeedi and Al-Obaidi, 2025). Also, egg contain three layers of protection; the calcareous shell, inner and outer shell membranes, each of these layers has an important and effective role in protecting the egg content and reducing or entry and invasion of microorganisms (Morsi et al., 2015; 2023; Salman et al., 2023).

There is no ideal method to store eggs that prevent them from spoilage or corruption, all methods of storing eggs are try to reduce the deterioration of quality characteristics and prolong shelf life. It is necessary that the fresh egg reaches the consumer with high quality using effective new processing techniques. (Dev, et al., 2008; Shenga et al., 2010; Al-Shadeedi, 2018; Oliviera et al., 2022).

The aim of this study was to determine the effect of treating fresh table eggs for different periods of time

(0, 1, 2 and 3) minutes in an ultrasound device as a means of studying its effect on its internal quality characteristics, egg components percentage and some bacterial indicators after storing it in the refrigerator for (0, 1, 2, 4 and 8) weeks.

### Materials and Methods

**Ethical approval:** The animals of the study were conducted using the guidelines for the care and handling of animal accordance to the Palmtree Environmental and Agricultural Organization Committee (certificate no. 1F1801034, January 25<sup>th</sup> 2018), this research is a proposal in Poultry Products Technology, College of Veterinary Medicine, University of Baghdad, Baghdad, Iraq.

**Egg collection:** A total of 240 fresh table eggs (Brown shell eggs) were randomly collected from 20000 Luhman chicken layer flock at Al-Amir project commercial farm, Al-Musaib city, Iraq. The layers were fed a production ration as explain in Table (1).

**Table (1): Components and ingredients quantity of ration.**

Components	(%)
Corn	15.0
Soya Meal	25.0
Wheat	10.0
Wheat bran	10.0
Rice bit	20.0
Chickpea	10.0
Premix *	2.5
Vegetable oil	1.25
Limestone	6.25
Total	100 Kg
<b>Calculated analysis</b>	
Total protein %	18.75
Metabolic energy Kcal/Kg feed	2650
Lysine (%)	0.77
Methionine (%)	0.30
Methionine + cysteine (%)	0.59
Ca (%)	3.50
P Available (%)	0.35

\*Premix supplied diet the following: vitamin A: 12,000 IU; vitamin D3: 2500 IU; vitamin E: 30 IU; vitamin K3: 2 mg; thia- mine: 2.25 mg; riboflavin: 7.5 mg; pyridoxine: 3.5 mg; cobalamine: 0.02 mg; niacin: 45 mg; D-pantothenic acid: 12.5 mg; biotin: 0.125 mg; folic acid: 1.5 mg, zinc: 50; copper: 12; iodine: 0.3; cobalt: 0.2; iron: 100; selenium: 0.1.

**Period of the study:** This experiment was conducted at the food hygiene laboratory, College of Veterinary Medicine, University of Baghdad, from October 2<sup>nd</sup> 2024 to February 10<sup>th</sup> 2025, to compare between four periods of ultrasound treatments of shell table eggs which were 0-, 1-, 2-, and 3-minutes using ultrasound

device on its quality characteristics, egg components percentage and microbial counts during Zero, 1, 2, 4 and 8 weeks of refrigerator storage.

**Treatment groups:** After egg collection 240 eggs were immediately distributed into four groups of treatments; T1: 60 eggs were untreated eggs as

control group. T2: 60 eggs were ultrasound exposed for 1 min. T3: 60 eggs were ultrasound exposed for 2 min. T4: 60 eggs were ultrasound exposed for 3 min. All eggs were arranged in plastic eggs tray (30 eggs per tray) and refrigerator storage (3-7°C) immediately after treatment.

**Storage periods:** All eggs were refrigerator storage for 1, 2, 4 and 8 weeks. At each period 12 eggs from each treatment were randomly collected and individually weight and interior quality parameter which included yolk height, yolk diameter, yolk index, white height, yolk weight and percentage, egg components percentage and bacterial counts included total bacterial count and total coliform count were studied.

**Ultrasound device:** This device is a commercial ultrasonic device and is used to clean food and other delicate items using ultrasonic waves and water solution. This device is of the (GT SONIC) type, Chinese origin.

#### Parameters of the study:

**Egg weight:** 6 Egg weights were recorded for each egg separately and for each treatment, and after each storage period, a digital Sartorius balance scale (Göttingen, Germany) was used for this purpose, measuring to two orders of grams (Stadelman et al., 2017).

**Internal egg quality characteristics:** All studied egg quality (internal) traits were measured for all 6 eggs collected individually and according to the method of Kop-Bozbay (2024) and Stadelman et al. (2017), which included white high, yolk high and yolk diameter. The white and yolk height was measured by using vertical digital micrometer (China) for the white of each egg, from the midpoint between the edge of the outer white and the yolk membrane, the high of the yolk measured in the midpoint of the yolk. The diameter of the yolk was measured by using the digital Vernier scale (China).

**Egg components percentage:** After breaking the 6 eggs and separating the yolk from the white, by carefully lifting the yolk with a tablespoon so as not to contaminate it with the white, and placing the yolk on filter paper, where it was rotated on the paper to get rid of the white, if any, and the shell was dried by leaving it until the next day at room temperature, then the weights were recorded each components (yolk, shell with the membranes and white), then the percentage of the three components was calculated according to the method of Kop-Bozbay (2024) and Stadelman et al. (2017) by applying the following equations:

$$\text{Egg component (\%)} = \frac{\text{Egg component}}{\text{Egg weight}} \times 100$$

**Statistical analyses:** Data were analyzed by using the General Linear Model Procedure of SAS (2001). Means were compared by the Duncan's Multiple Range test at 5% probability.

### Results and Discussion

**Egg weight:** Table 2 shows no significant in egg weight after the treatments (zero time) and the values ranged between 63.41 to 63.42g for the four treatments. Also, no significant differences appeared after one week of refrigerator storage.

T1 (control) recorded the lowest values of egg weight after 2 weeks of storage and reached 61.56g ( $p < 0.05$ ) compared with ultrasound treatments (T2, T3 and T4) which their values ranged between 61.95 and 62.09g. The significant differences in egg weight continued after storage for a period of 4 and 8 weeks, where the T1 recorded the lowest values and reached 58.75 and 55.57g respectively, followed by T4 treatment (59.18 and 56.19g respectively), then T2 and T3 were recording the highest egg weights, reached (60.90 and 58.74g) and (61.10 and 58.81g), respectively ( $p < 0.05$ ).

**Interior egg quality:** Table 3 Shows no significant differences between treatments in the studied characteristics interior egg quality at zero time and after one week of refrigerator storage. As the refrigerator storage increased for 2 and 4 weeks, T2 and T3 recorded the best interior egg quality (yolk high, yolk diameter, yolk index and white high) then T4 and T1 recorded the lowest interior egg quality ( $p < 0.05$ ).

The maximum effect of ultrasonic treatments on the interior egg quality during refrigerator storage appeared at 8 weeks of storage with significant differences ( $p < 0.05$ ), yolk height was low in T1 treatment (11.38mm), followed by the T4 (11.75mm), where T2 and T3 recorded the best values which were (12.96 and 13.07mm) respectively. Egg yolk diameter, as the lowest values ( $p < 0.05$ ) were recorded in T2 and T3 treatments, which were (39.27 and 39.60mm) respectively. The highest value was recorded in T1 and T4 treatments (40.52 and 40.64mm) respectively ( $p < 0.05$ ). Accordingly, the calculated yolk index value was low in T1 (0.28), followed by the T4 (0.29), where T2 and T3 recorded the best values which were (0.33) respectively. Also, the egg white height was as the lowest value in the T1 (4.61mm), followed by the T4 (4.72mm), so T2 and T3 recorded the highest values (5.76 and 5.81mm) respectively ( $p < 0.05$ ).

**Table (2): Effect of ultrasound treatments on egg weight during refrigerator storage.**

Ultrasound Treatments	Zero Time	1 Week	2 Weeks	4 Weeks	8 Weeks
T1	63.41 ±0.87 <sup>a</sup>	62.28 ±0.88 <sup>a</sup>	61.56 ±0.85 <sup>b</sup>	58.75 ±0.79 <sup>c</sup>	55.57 ±0.81 <sup>c</sup>
T2	63.41 ±0.89 <sup>a</sup>	62.35 ±0.86 <sup>a</sup>	62.02 ±0.84 <sup>a</sup>	60.90 ±0.81 <sup>a</sup>	58.74 ±0.80 <sup>a</sup>
T3	63.42 ±0.87 <sup>a</sup>	62.37 ±0.84 <sup>a</sup>	62.09 ±0.85 <sup>a</sup>	61.10 ±0.81 <sup>a</sup>	58.81 ±0.81 <sup>a</sup>
T4	63.42 ±0.88 <sup>a</sup>	62.34 ±0.86 <sup>a</sup>	61.95 ±0.85 <sup>a</sup>	59.18 ±0.79 <sup>b</sup>	56.19 ±0.80 <sup>b</sup>
Significant	N.S.	N.S.	*	*	*

All data as mean ± SD, T1: Control, T2: ultrasound for 1 min., T3: ultrasound for 2 min., T4: ultrasound for 3 min., <sup>a, b, c</sup> superscripts in a column significantly differ, N.S. not significant, \* (p<0.05).

**Table (3): Effect of ultrasound treatments on interior egg quality during refrigerator storage.**

Ultrasound Treatments (Min.)	Treatment Periods	Yolk high (mm)	Yolk diameter (mm)	Yolk index	White high (mm)
T1	Zero time	17.31 ±0.36 <sup>a</sup>	39.35 ±0.81 <sup>a</sup>	0.44 ±0.03 <sup>a</sup>	10.14 ±0.69 <sup>a</sup>
T2		17.30 ±0.37 <sup>a</sup>	39.32 ±0.79 <sup>a</sup>	0.44 ±0.05 <sup>a</sup>	10.18 ±0.72 <sup>a</sup>
T3		17.32 ±0.34 <sup>a</sup>	39.36 ±0.83 <sup>a</sup>	0.44 ±0.04 <sup>a</sup>	10.16 ±0.68 <sup>a</sup>
T4		17.31 ±0.32 <sup>a</sup>	39.34 ±0.81 <sup>a</sup>	0.44 ±0.04 <sup>a</sup>	10.13 ±0.69 <sup>a</sup>
Significant		N.S.	N.S.	N.S.	N.S.
T1	1 week	17.11 ±0.36 <sup>a</sup>	39.79 ±0.80 <sup>a</sup>	0.43 ±0.01 <sup>a</sup>	10.03 ±0.26 <sup>a</sup>
T2		17.14 ±0.37 <sup>a</sup>	38.95 ±0.78 <sup>a</sup>	0.44 ±0.03 <sup>a</sup>	10.08 ±0.28 <sup>a</sup>
T3		17.16 ±0.34 <sup>a</sup>	39.00 ±0.81 <sup>a</sup>	0.44 ±0.02 <sup>a</sup>	10.09 ±0.26 <sup>a</sup>
T4		17.12 ±0.32 <sup>a</sup>	38.91 ±0.80 <sup>a</sup>	0.44 ±0.01 <sup>a</sup>	10.06 ±0.27 <sup>a</sup>
Significant		N.S.	N.S.	N.S.	N.S.
T1	2 weeks	16.67 ±0.32 <sup>b</sup>	40.06 ±0.71 <sup>a</sup>	0.42 ±0.03 <sup>b</sup>	9.83 ±0.61 <sup>b</sup>
T2		16.84 ±0.32 <sup>a</sup>	39.16 ±0.70 <sup>c</sup>	0.43 ±0.02 <sup>a</sup>	9.93 ±0.63 <sup>a</sup>
T3		16.88 ±0.31 <sup>a</sup>	39.26 ±0.72 <sup>c</sup>	0.43 ±0.03 <sup>a</sup>	9.94 ±0.60 <sup>a</sup>
T4		16.74 ±0.33 <sup>b</sup>	39.86 ±0.71 <sup>b</sup>	0.42 ±0.02 <sup>b</sup>	9.88 ±0.63 <sup>b</sup>
Significant		*	*	*	*
T1	4 weeks	14.72 ±0.36 <sup>c</sup>	38.74 ±0.71 <sup>a</sup>	0.38 ±0.03 <sup>c</sup>	7.64 ±0.64 <sup>c</sup>
T2		15.16 ±0.37 <sup>a</sup>	37.90 ±0.72 <sup>c</sup>	0.40 ±0.03 <sup>a</sup>	8.17 ±0.65 <sup>a</sup>
T3		15.19 ±0.34 <sup>a</sup>	37.98 ±0.70 <sup>c</sup>	0.40 ±0.02 <sup>a</sup>	8.25 ±0.62 <sup>a</sup>
T4		14.93 ±0.35 <sup>b</sup>	38.29 ±0.71 <sup>b</sup>	0.39 ±0.03 <sup>b</sup>	7.81 ±0.67 <sup>b</sup>
Significant		*	*	*	*
T1	8 weeks	11.38 ±0.24 <sup>c</sup>	40.64 ±0.67 <sup>a</sup>	0.28 ±0.02 <sup>c</sup>	4.61 ±0.66 <sup>c</sup>
T2		12.96 ±0.22 <sup>a</sup>	39.47 ±0.63 <sup>b</sup>	0.33 ±0.02 <sup>a</sup>	5.76 ±0.65 <sup>a</sup>
T3		13.07 ±0.23 <sup>a</sup>	39.60 ±0.66 <sup>b</sup>	0.33 ±0.03 <sup>a</sup>	5.81 ±0.64 <sup>a</sup>

T4	11.75 ±0.22 <sup>b</sup>	40.52 ±0.65 <sup>a</sup>	0.29 ±0.02 <sup>b</sup>	4.72 ±0.62 <sup>b</sup>
Significant	*	*	*	*

All data as mean ± SD, T1: Control, T2: ultrasound for 1 min., T3: ultrasound for 2 min., T4: ultrasound for 3 min., <sup>a, b, c</sup> superscripts in a column significantly differ, N.S. not significant, \* (p<0.05).

**Egg component percentages:** Table 4 Shows the effect of ultrasonic treatments on the components of fresh table eggs during refrigerator storage. There were no significant differences in egg components weight or percentages during refrigerator storage at Zero-time, 1 and 2 weeks. The significant differences in components started at 4 weeks of refrigerator storage and it maximized at 8 weeks, so yolk weight percentage recorded the highest values in T1 (16.69gm, 30.04%) then T4 (16.91gm, 30.10%), while the lowest values were recorded in T2 (17.23gm, 29.34%) and T3 (17.25gm, 29.33%) (p<0.05).

Although, shell weight recorded significant differences between treatments, which the lowest values in T2 and T4 treatments (5.37 and 5.43g), and the highest value were recorded in T2 and T3 (5.67 and 5.69g) (p<0.05), the shell percentage showed no significant difference between all treatments. Egg white weight and percentage reached the lowest value in T1 (33.50g, 60.23), followed by T4 (33.84g, 60.29), while the highest value was reached in T2 (35.83g, 60.0%) and T3 (35.87g, 61.01) (p<0.05).

**Table (4): Effect of ultrasound treatments on egg components weight and percentage during refrigerator storage.**

Ultrasound Treatments (Min.)	Storage periods (Week)	Yolk weight (gm)	Yolk (%)	Shell weight (gm)	Shell (%)	White weight (gm)	White (%)
T1	Zero time	18.25 ±0.87 <sup>a</sup>	28.78 ±1.45 <sup>a</sup>	6.07 ±0.22 <sup>a</sup>	9.58 ±0.40 <sup>a</sup>	39.13 ±1.17 <sup>a</sup>	61.71 ±2.53 <sup>a</sup>
T2		18.24 ±0.87 <sup>a</sup>	28.76 ±1.51 <sup>a</sup>	6.05 ±0.20 <sup>a</sup>	9.54 ±0.43 <sup>a</sup>	39.12 ±1.20 <sup>a</sup>	61.70 ±2.53 <sup>a</sup>
T3		18.26 ±0.89 <sup>a</sup>	28.80 ±1.44 <sup>a</sup>	6.06 ±0.21 <sup>a</sup>	9.56 ±0.41 <sup>a</sup>	39.13 ±1.21 <sup>a</sup>	61.70 ±2.50 <sup>a</sup>
T4		18.26 ±0.86 <sup>a</sup>	28.79 ±1.42 <sup>a</sup>	6.07 ±0.21 <sup>a</sup>	9.57 ±0.41 <sup>a</sup>	39.12 ±1.22 <sup>a</sup>	61.69 ±2.53 <sup>a</sup>
Significant		N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
T1	1 week	17.94 ±0.82 <sup>a</sup>	28.80 ±1.42 <sup>a</sup>	5.97 ±0.12 <sup>a</sup>	9.59 ±0.42 <sup>a</sup>	38.42 ±1.17 <sup>a</sup>	61.69 ±2.45 <sup>a</sup>
T2		17.95 ±0.82 <sup>a</sup>	28.79 ±1.43 <sup>a</sup>	5.95 ±0.14 <sup>a</sup>	9.55 ±0.40 <sup>a</sup>	38.46 ±1.16 <sup>a</sup>	61.69 ±2.43 <sup>a</sup>
T3		17.97 ±0.81 <sup>a</sup>	28.81 ±1.41 <sup>a</sup>	5.97 ±0.13 <sup>a</sup>	9.57 ±0.42 <sup>a</sup>	38.47 ±1.14 <sup>a</sup>	61.68 ±2.46 <sup>a</sup>
T4		17.96 ±0.82 <sup>a</sup>	28.81 ±1.40 <sup>a</sup>	5.97 ±0.14 <sup>a</sup>	9.59 ±0.41 <sup>a</sup>	38.46 ±1.16 <sup>a</sup>	61.69 ±2.45 <sup>a</sup>
Significant		N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
T1	2 weeks	17.80 ±0.80 <sup>a</sup>	28.91 ±1.47 <sup>a</sup>	5.92 ±0.17 <sup>a</sup>	9.62 ±0.40 <sup>a</sup>	37.94 ±1.25 <sup>a</sup>	61.47 ±2.36 <sup>a</sup>
T2		17.86 ±0.81 <sup>a</sup>	28.79 ±1.46 <sup>b</sup>	5.95 ±0.19 <sup>a</sup>	9.60 ±0.43 <sup>a</sup>	38.21 ±1.23 <sup>a</sup>	61.61 ±2.37 <sup>a</sup>
T3		17.89 ±0.81 <sup>a</sup>	28.81 ±1.48 <sup>b</sup>	5.97 ±0.16 <sup>a</sup>	9.61 ±0.41 <sup>a</sup>	38.24 ±1.26 <sup>a</sup>	61.58 ±2.33 <sup>a</sup>
T4		17.92 ±0.82 <sup>a</sup>	28.92 ±1.46 <sup>a</sup>	5.95 ±0.18 <sup>a</sup>	9.60 ±0.43 <sup>a</sup>	38.09 ±1.24 <sup>a</sup>	61.48 ±2.35 <sup>a</sup>
Significant		N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
T1	4 weeks	17.24 ±0.77 <sup>c</sup>	29.35 ±1.56 <sup>a</sup>	5.67 ±0.21 <sup>b</sup>	9.65 ±0.47 <sup>a</sup>	35.83 ±1.13 <sup>c</sup>	61.00 ±2.27 <sup>b</sup>

T2		17.62 ±0.80 <sup>a</sup>	28.94 ±1.52 <sup>b</sup>	5.87 ±0.20 <sup>a</sup>	9.64 ±0.46 <sup>a</sup>	37.40 ±1.17 <sup>a</sup>	61.42 ±2.22 <sup>a</sup>
T3		17.69 ±0.79 <sup>a</sup>	28.96 ±1.55 <sup>b</sup>	5.90 ±0.22 <sup>a</sup>	9.65 ±0.48 <sup>a</sup>	37.50 ±1.15 <sup>a</sup>	61.39 ±2.24 <sup>a</sup>
T4		17.32 ±0.81 <sup>b</sup>	29.27 ±1.53 <sup>a</sup>	5.70 ±0.21 <sup>b</sup>	9.64 ±0.46 <sup>a</sup>	36.16 ±1.14 <sup>b</sup>	61.10 ±2.25 <sup>b</sup>
Significant		*	*	*	N.S.	*	*
T1	8 weeks	16.69 ±0.86 <sup>b</sup>	30.04 ±1.46 <sup>a</sup>	5.37 ±0.22 <sup>b</sup>	9.67 ±0.46 <sup>a</sup>	33.50 ±1.17 <sup>c</sup>	60.29 ±2.14 <sup>b</sup>
T2		17.23 ±0.85 <sup>a</sup>	29.34 ±1.48 <sup>b</sup>	5.67 ±0.20 <sup>a</sup>	9.65 ±0.44 <sup>a</sup>	35.83 ±1.16 <sup>a</sup>	61.01 ±2.11 <sup>a</sup>
T3		17.25 ±0.86 <sup>a</sup>	29.33 ±1.47 <sup>b</sup>	5.69 ±0.23 <sup>a</sup>	9.67 ±0.45 <sup>a</sup>	35.87 ±1.18 <sup>a</sup>	61.00 ±2.13 <sup>a</sup>
T4		16.91 ±0.85 <sup>b</sup>	30.10 ±1.59 <sup>a</sup>	5.43 ±0.22 <sup>b</sup>	9.67 ±0.45 <sup>a</sup>	33.84 ±1.17 <sup>b</sup>	60.23 ±2.14 <sup>b</sup>
Significant		*	*	*	N.S.	*	*

All data as mean ± SD, T1: Control, T2: ultrasound for 1 min., T3: ultrasound for 2 min., T4: ultrasound for 3 min., <sup>a, b, c</sup> superscripts in a column significantly differ, N.S. not significant, \* (p<0.05).

Eggs are a perishable food and require proper storage and preservation to avoid rapid spoilage and quality loss (Negi, 2012; Stadelman et al., 2017). The preservation and cold storage need at once they are produced from the fields in order to preserve the qualitative characteristics for the longest possible period during storage and to deliver them to the consumer with the best quality and least deterioration (Al-Shadeedi, 2010; Al-Obaidi and Al-Shadeedi, 2022).

The results obtained from Table (2) indicate no significant differences between treatments at (Zero-time) and after 1 week of refrigerated storage in egg weight. This is a natural result, as cold and chilled storage is one of the most important methods approved for preserving table eggs (Sabliov et al., 2005; NCCES, 2006). Also, storing eggs in the refrigerator and cold storage are recommended by USDA (2007) for up to 2 weeks with no decreases in egg weight and interior quality. This result is agreed with many studies, as refrigeration contributes to maintaining gas exchange between the internal egg contents and the external environment for up to two weeks and preserve a good internal quality of table eggs (Salman et al., 2023; Ismail et al., 2024). As the storage period progresses, gas exchange occurs between the internal egg contents and the external environment, as CO<sub>2</sub> and moisture begin to escape from the egg to the external environment, causing a decrease in egg weight. This occurred after the second week of storage. The highest rates of weight loss were observed for the first and fourth treatments. This result is consistent with numerous

studies on table eggs (Silversides and Scott, 2001; Stadelman et al., 2017).

Tables (3) indicated a deterioration in the interior quality represented by the yolk height, yolk diameter, yolk index, and white height. These characteristics are closely linked to the decrease in the concentration of CO<sub>2</sub> gas and moisture inside the egg (specially egg white). The more CO<sub>2</sub> gas escapes from inside the egg to the outside through the pores in the egg shell, the less natural gelatinous consistency of the egg white decreases and it turns into a liquid (Al-Obaidi and Al-Shadeedi, 2022). Since the egg white is a colloidal watery solution with a high concentration of water and therefore easy for water to exit from inside of the egg to the outside through shell pores, this is due to the rise of egg pH towards alkalinity causes the disintegration of egg white proteins and increases the fluidity of the gelatinous consistency and the exit of water from it (Silversides and Scott, 2001; Salman et al., 2023). At the same time, migration and penetration of water occurs from the white (with the high concentration) to the egg yolk (with the lower concentration) through the yolk membrane (vitelline), causing an increase in the volume of the yolk, which is relatively reflected in the volume of the yolk, causing a decrease in the height of the yolk and an increase in its diameter. Consequently, the arithmetic yolk index (Al-Shadeedi and Rashad, 2017; Stadelman et al., 2017; Ismail et al., 2024) decreases, and this result was clear with the increase in the storage period, specifically in the eggs of T1 and T4 treatments.

Tables (4) were revealed the results of the main egg components (albumen, yolk and shell) and its

percentages, these data are compatible with the other characters in the previous tables (table 2 and 3). As, the increasing of storage period up to 4 weeks led to decrease in the weight and percentage of egg white. This is a result of water evaporation from inside of the egg especially from egg white to the outside of the egg, as it clear in T1 (control), followed by T4 treatment. However, the differences in the weight and percentage of the shell were not significant, as its components are relatively stable and not significantly affected by current storage conditions (Salman et al., 2023; Ismail et al., 2024). The total percentages of egg white, yolk and shell under normal conditions are equal 100%, with the percentage of egg white constituting approximately 60%, the yolk 30%, and the shell 10% (Al-Shadeed, 2023). These percentages can be affected by several factors; genetic (strain, breed and variety) and environmental (nutrition, season and diseases) (Al-Obaidi et al., 2010; Ismail et al., 2024). Any changes in the percentage of any of these components will affect the remaining percentage, especially the percentages of the white and yolk, as they constitute the largest percentages (90%) (Al-Obaidi and Al-Shadeedi, 2022). The shell percentage showed no significant difference between all treatments, indicating that ultrasound does not affect the relative shell percentage up to 8 weeks of refrigerator storage.

### Conclusions

Application of ultrasound treatment for 1 or 2 min. preserves a good interior quality and components of table eggs during refrigerator storage up to 8 weeks. Thus, ultrasound treatment is a good technique for extending the storage shelf life of shelled table eggs and suggestion further studies on treating table eggs during ambient storage and for hatching eggs.

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