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Evaluation the Quality and Safety of Raw Table Eggs in North Palestinian Markets

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Abstract: This study aimed to evaluate the quality and safety of retail raw table eggs in north Palestinian markets. In this study, 480 eggs were collected in two different periods from various retail markets, both Palestinian governorates Tulkarm and Jenin. All collected eggs were evaluated for their safety and external and internal quality. The results showed that about 40.0% of the collected samples had eggshell abnormalities. A high variation in the egg's weight was detected in the eggs collected from Tulkarm. According to the Haugh unit, the results indicated that the most collected eggs were in class B. The average yolk color score of all periods in both governorates is around 8. Some eggs had yolk pH values of more than 6.6 in both governorates. Most collected eggs in both periods and governorates were fresh according to the yolk index. *Escherichia coli* was present in the eggshell collected from Jenin governorate. Meanwhile, *Salmonella enteritidis* was present in Tulkarm governorate. In conclusion, this study confirms that grading, cleaning, and cooling is not practiced before the sale, which may lead to microbiological health hazard to the general public. Thus, this study recommends avoiding eating raw or undercooked egg yolks and whites or their products.

Keywords: Egg Quality; Yolk Index; Egg Weight; Haugh Unit; Egg Safety.

Introduction

Egg production has increased worldwide, and table eggs are very economical, familiar, and easy-to-prepare food incorporated into many food dishes. They provide all essential nutrients for all human ages (Zaheer, 2015; Al-Shadeedi *et al*., 2019). Food quality and safety are central issues in food economics (Hisasaga *et al*., 2020; Petrescu *et al*., 2019; Grunert, 2005). Food quality can be defined as the characteristics of the food that can influence consumer's acceptance or rejection of the food (Kramer, 1951).

Egg quality refers to standards specifying internal and external rates, such as eggshell, albumen, and yolk characteristics (Kul and Seker, 2004). The quality and safety of table eggs vary according to many factors, including the laying hen age rearing conditions, laying hen health, feeding, egg storage conditions, and transportation (Gu *et al*., 2021). However, the marketing style of table eggs is different in each country according to their regulation and standers. Moreover, egg size, eggshell color, and shell cleanliness are the main factors consumers consider when purchasing eggs from the market (Abo Omar and Aref, 2000; Rizzi, 2021).

Eggs are treated as one of the most liable products due to their exposure to poor handling methods and storage conditions. This negatively affects the quality and safety of the table eggs, especially yolk and albumen, and also affects the loss of some essential nutrients. Al-Shadeedi et al. (2019) evaluated the effect of abnormal eggshells on the quality and microbial count of table eggs in Baghdad markets, and they concluded there is a significant relation between the shell abnormalities and higher microbial counts of commercial table eggs. The authors recommended rejecting all eggs containing abnormalities in the shell from the market. Moreover, Ahmed *et al*. (2019) measured the effect of handling and storage on eggs quality in Khartoum state, and they concluded the temperature and time of storage harm many egg properties such as egg weight, air cell, albumin index, albumin high, Hugh unit, and yolk shape these properties which are the basis of the current EU legislation. Commission Regulation (EC) No.589/2008 specifies that the shelf-life for table eggs is 28 days and a maximum air cell depth of not more than 6 mm. More importantly, the regulation provides that refrigerated storage of eggs is reserved exclusively for final consumers. Moreover, Gross *et al*, (2015) recommended cooling the table egg from the 18th day after laying, as required by legislation in Germany.

According to De Reu et al. (2008), the egg passes through the vent to the surrounding environment the eggshell surface becomes bacterially contaminated with 10^4 to 10^6 CFU/egg. *Salmonella* is one of the most microbial hazards on the eggshell surface and inside the egg. However, contaminating the surface of table eggs can lead to the spreading *Salmonella* to other foods in consumer's kitchens and refrigerators due to improper egg handling (Pasquali *et al*., 2015). Recently 24 spoilage bacteria strains were isolated from eggs in China (Liu *et al*., 2021). Zoonotic *Salmonella* isolates from table eggs collected from farms in the Menoua division, a western region of Cameroon, is a big challenge to the egg industry and public health (Kouam *et al.,* 2017). In addition, Kalupahana (2017) found that *Nontyphoidal salmonella* was indicated in the raw retail table eggs collected from the Kandy district of Sri Lanka, and it is considered a microbial hazard to the consumer.

The main factors that can determine *Salmonella* growth in table eggs are storage time and temperature. *Salmonella* can grow inside the egg when the egg yolk membrane breaks down, depending on improper storage conditions (Pasquali *et*

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al., 2015; Gross *et al.,* 2015). Many researchers evaluated the impact of different feeding and their supplementation of laying hens on the quality of table eggs. Batkowska *et al.* (2021) recently demonstrated no adverse changes in table egg's quality when linseed and soybean oil are added to laying hen feed. Moreover, Popova *et al*. (2020) evaluated the quality of eggs from layers reared under alternative and conventional systems. Also, they concluded that the weight of the eggs obtained from the layer reared under the alternative approach was significantly heavier than the conventional ones, whereas lower in their shell thickness and Haugh units. The egg color from the alternative method was darker compared to the eggs obtained from the hens reared conventionally.

The objectives of this study were to evaluate the quality of the commercial retail raw table eggs, including the outer part (egg weight and abnormalities) and internal part (Haugh unit, yolk index, yolk color, and yolk pH) of collected eggs at two different periods (3 weeks between each collection period), in the north of Palestinian market (Tulkarm and Jenin governorates).

Materials and Methods

Eggs collection

Randomly commercial retail raw table eggs (480 eggs) that were available at room temperature inside egg tray cartons were purchased from two governorates (Tulkarm and Jenin) markets. The eggs were purchased in two different periods (120 eggs) for each period at both governorates, and the period between each collection time was three weeks. In each governorate, the eggs were purchased from different retail markets, considering the north, south, west and east regions of each governorate (Tulkarm and Jenin) markets in Palestine from September to October 2020. Then the eggs were transferred to the laboratory of the Department of Nutrition and Food Technology at An-Najah National University for analysis of the external and internal egg quality and for microbial analysis.

External egg quality and egg weight

The external eggshell quality was evaluated by observation of neck eyes, the eggs surface and counting the quantity of the eggs that contained any of the eggshell abnormalities such as dirty with feces or blood, misshapen shell, cracks, stained eggs, fly marks, and pimples. The egg photos were taken using a cell phone. Egg weight was measured using analytical balance using an electronic scale with an accuracy of 0.01g

Egg internal quality

All the collected eggs were broken onto the flat plate to evaluate internal quality, including yolk index (YI), Haugh unit (HU), yolk pH, and yolk color. YI was calculated by dividing the yolk height by the yolk diameter measured by dial calipers. HU was calculated based on the following equation (Eisen et al., 1962):

$$HU = 100 \log (H - (1.7 \times W^{0.37} + 7.6) \quad (1)$$

Where: HU: Haugh unit, H: height of albumin (mm), and W: egg weight (g). ORKA's Digital Haugh tester was used to measure the height of egg albumen.

Egg yolk pH was measured for all collected eggs sample via separated the yolk into a beaker carefully and then stirring it before measuring the pH value by using calibrated pH meter (Jenway pH Meter 3310). Yolk color intensity was evaluated according to Hisasaga *et al*., (2020) by visual comparison to a (Dutch State Mines (DSM)) yolk color fan.

Microbiological analysis of the surface table eggs

Escherichia coli (*E-coli*) and *Salmonella enteritidis* were analyzed for the surface of the table eggs, according to Pasquali *et al.* (2015), with some modifications. Briefly, the shell eggs from each governorate (Tulkarm and Jenin) were broken, and the inner contents were discarded 10 g of crushed egg shell using a sterile pestle, were transferred into 100 ml of tryptic soy broth, and incubated at 35°C for 24 h. After that, 1 mL of tryptic soy broth was transferred to the 10 mL of tetrathionate brilliant-green broth as selective enrichment broth, then incubated at 35ºC for 24 h, then by loopful that dipped in the tetrathionate brilliant-green and dispersed into the selective agar media xylose lysine desoxycholate agar and brilliant green agar to isolated the colonies then incubated at 35ºC for 24h. Biochemical confirmation was used to confirm the presence or absence of salmonella by using the triple sugar iron agar.

MacConkey agar was used for *Escherichia coli* detection as 10 g of the crashed eggshell from each governorate (Jenin and Tulkarm) were taken and mixed with 100 mL of triple sugar iron agar and then incubated for 24 h at 35ºC. 0.1 mL of the dilutions were spread into McConkey agar. After that, the Petri dishes were set at 35 ºC for 24h.

Statistical Analysis

The average, stranded deviation and coefficient of dispersion (CD) were calculated using excel 2013.

Results and Discussion

External egg quality and egg weight

The collected eggs were evaluated for their external quality appearance, cleanliness and eggshell abnormalities**.** Fig 1 shows the defects found in the collected eggs in both governorates (Tulkarm and Jenin), in total more than 40.0% of the collected samples have that defects in appearance, including dirty feces or blood, misshapen shells, cracks, stained eggs, fly marks and pimples

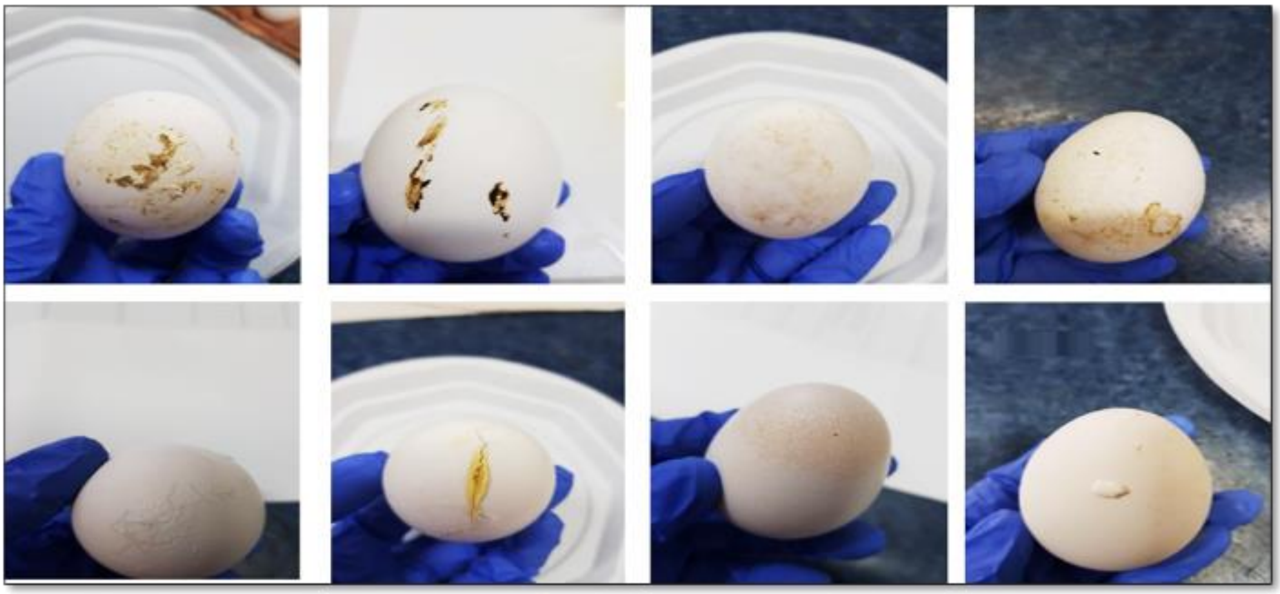

Figure (1): Eggs photo indicating some surface eggs abnormalities founded in both governorates (Tulkarm and Jenin) markets.

This high value of the external defect found in the table eggs in Jenin and Tulkarm could be due to a poor management system, diseases and an unsuitable reared system. Moreover, lack of knowledge shared by the farmer's about the correct way to control and clean the method for table eggs, although the absence of control over table eggs in the Palestinian market by the regulatory authorities for food products. In addition, the lack of egg processing companies in Palestine may contribute to marketing those eggs without preliminary treatment. Pavlovski *et al.* (2012), mentioned that the excess magnesium, sodium and potassium in the laying hen diet lead to an increase the water consumption, which can increase the number of dirty eggs. Roberts. (2019) explained that the increase in dirty table eggs results from floor-laid eggs or lack of separation of the egg from the hen's excreta. According to the commission regulation (EC) no 589/2008 and Roberts. (2019), the eggshell is expected to be clean, unwashed and unbroken.

Egg weight is one of the most critical parameters that must be considered because it is a good indicator of the length of the storage period. Fig 2**,** shows the egg weight distribution for all the results in both collection periods in Tulkarm and Jenin. The results indicated that the average egg weight is around 62.0 g in all periods. The coefficient of dispersion (CD) of the data round the average was 12.0% in Tulkarm in period one while 8.0% compared to Jenin and the same period of collection (Table 1). It is indicated that there is a high variation in the weight of the eggs collected in the Tulkarm due to the uncontrolled storage conditions of eggs in the markets. Additionally, this could also be due to the higher temperature weather in Tulkarm than in Jenin. Abo Omar and Aref. (2000), found that the average egg weight collected from Palestine supermarkets was (59.8 ± 0.34 g).

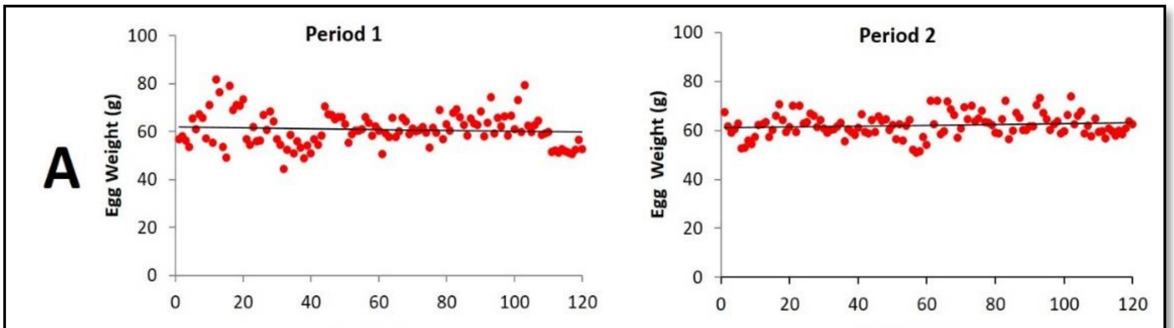

Figure (2): Retail table eggs weight in both governorates Tulkarm (A), Jenin (B) in two different collected periods.

Table (1): Average, standard deviations and coefficient of dispersion (CD) of the egg weight, Haugh unit, yolk index, yolk color and yolk pH in both governorates Tulkarm, Jenin in two different collected periods.

		Period 1		Period 2	
		Tulkarm	Jenin	Tulkarm	Jenin
Egg weight	**Average (g)**	61.9	62.91	62.1	62.99
	Standard deviation	7.3	5.05	4.7	5.84
	CD (%)	**12.0**	**8.0**	**8.0**	**9.0**
Haugh unit	**Average (g)**	49.99	56.61	59.2	61.33
	Standard deviation	14.3	15.87	11.4	11.18
	CD (%)	**29**	**28**	**19**	**18**
Yolk color	**Average**	8.2	8.30	7.8	7.88
	Standard deviation	1.1	1.31	1.0	1.03
	CD (%)	**14.0**	**16.0**	**13.0**	**13.0**
Yolk pH	**Average**	6.3	6.42	6.3	6.23
	Standard deviation	0.2	0.18	0.2	0.11
	CD (%)	**3.0**	**3.0**	**3.0**	**2.0**
Yolk index	**Average**	0.32	0.30	0.3	0.33
	Standard deviation	0.05	0.04	0.0	0.04
	CD (%)	**15.0**	**14.0**	**13.0**	**12.0**

Haugh unit (HU)

HU that was evaluated for the collected eggs led to understanding the fundamental qualitative changes during the storage of table eggs. However, increasing the storage time of the table eggs in the retail markets without refrigeration will decrease the height of dense albumen and the associated number of Haugh units. Moreover, studies have shown a relationship between ovomucin and albumen height, which changes with storage time (Drabik *et al.,* 2021).

HU is a measure of egg quality depending on the egg's weight and the height of albumin in the same egg. Dependent on the following classification of HU (HU= 72 or more AA; HU= 71-60 A; HU= 59-31 B; HU= 30 or less C), the collected eggs were evaluated and classified as reported in (Fig. 3). The results indicated that the most collected eggs were in class B except the period two of the Jenin governorate showed that most eggs were in class A.

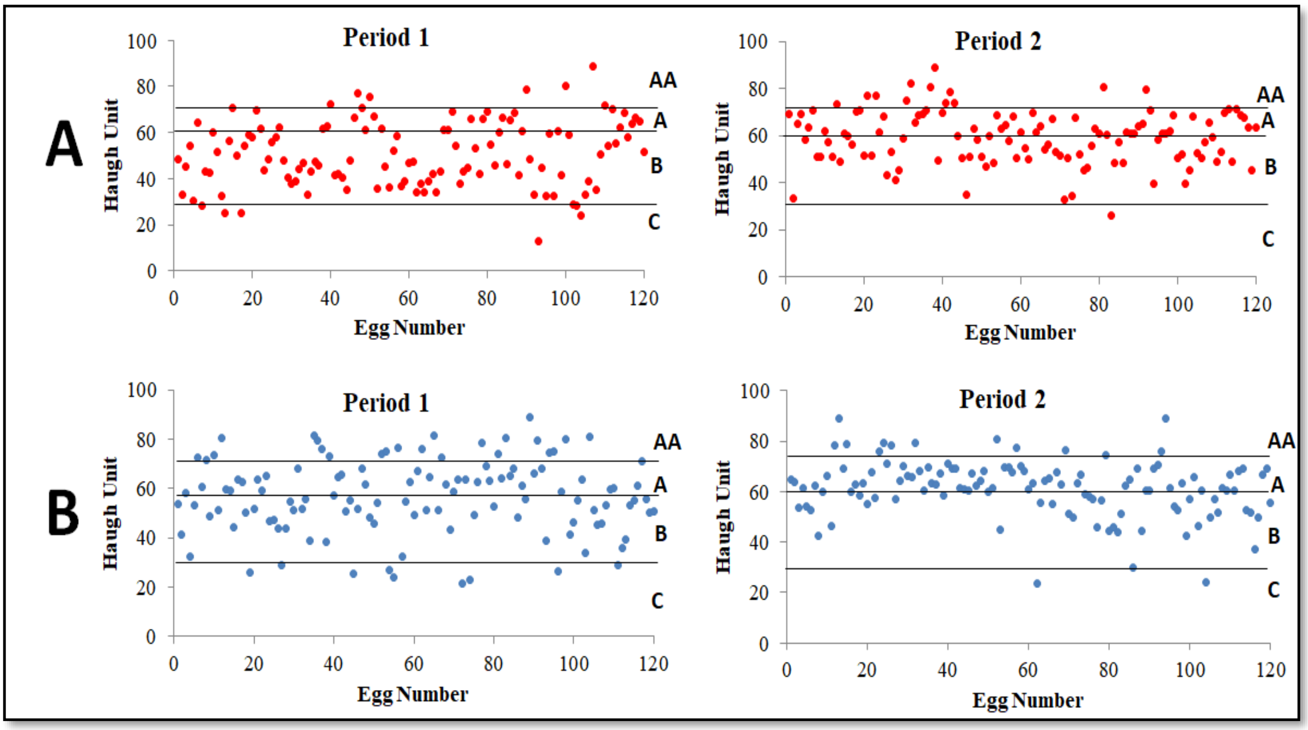

Figure (3): Haugh unit in both governorates Tulkarm (A), Jenin (B) in two different collected periods. AA: 72 or more, A: 71-60, B: 59-31, C: 30 or less.

According to the USDA Grading Manual, eggs declared excellent quality must have at least 72 Haugh Units (USDA, 2000). The average HU of the collected samples in each period and in both governorates, Tulkarm and Jenin were 49.9 ± 14.3; 56.6 ± 15.8 in period one, whereas in period two were 59.2 ± 11.4; 61.3 ± 11.1, respectively (Table 1). These results indicated that the table eggs in both governorates have lower quality than the USDA Grading Manual. The CD percentage was higher in period one compared to period two; this finding indicated that the eggs in the market have different storage times that lead to these high variations in the results. Ahmed *et al.* (2019) concluded that the HU value on the first day of storage at room temperature was 83.66; it decreases with increasing storage period until it reaches 60.59 after 28 days of storage. The weight decrease and the increase in egg whiteness could explain these results.

Yolk Color

One of the ways consumer's worldwide use to evaluate the quality of eggs is the yolk color. The color of the yolk depends on the feeding method provided to the chicken and the. Eggs have different yolk colors. Depending on the DSM Yolk Fan, the natural yolk color of the eggs in the market is 9-12. Lee *et al.* (2016) concluded a significant increase in the yolk color due to increased storage period and temperature. The results showed that the average yolk color score of all periods in both governorates is around 8 (Fig. 4). The highest CD was noticed in period one in both Tulkarm and Jenin, 14% and 16%, respectively, compared to period two, it was 13% in both governorates (Table 1). The results with higher CD percentages indicated variation in the concentration of carotenoid pigments in the hen feed. However, as the content of carotenoids in the hen feed increases, their engagement in the egg yolk rises in direct proportion (DSM, 2021).

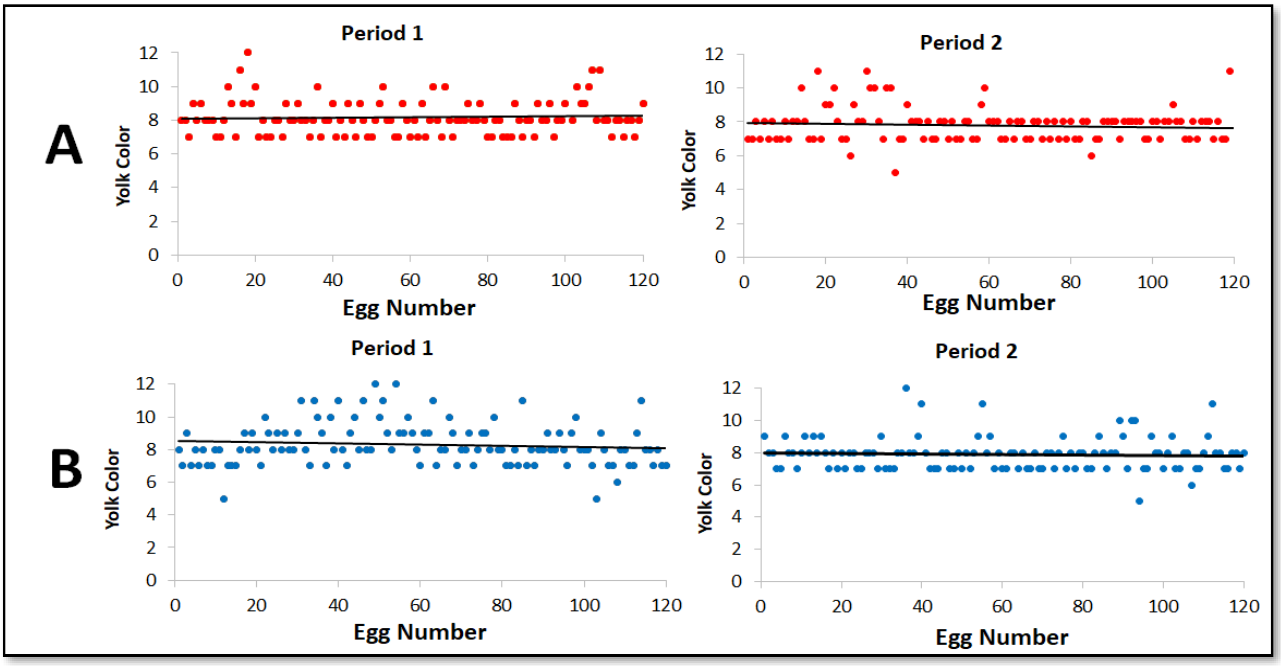

Figure (4): Yolk color in both governorates Tulkarm (A), Jenin (B) in two different collected periods.

The raw yolk color score based on the DSM color yolk color fan is 7, and more than that is due to the pigment present in the feed. Increasing the canthaxanthin from the feed changes the yolk color to a more orange-red color (DSM, 2021).

Yolk pH

The results indicated that most eggs in both governorates at different collection periods were in the normal range of the yolk pH, which is between 6.3 to 6.6. Some eggs have a higher pH value than 6.6, especially in the collection period 1 in both governorates (Fig. 5).

However, Lee et al. (2016) concluded that yolk pH significantly increased with increasing storage period and temperature; this rising in yolk pH value could be due to some components that passage from egg albumen to yolk through the yolk membrane when the storage time and temperature increased (Heath, 1977; Ahn et al., 1999). The CD percentage indicated that the variation between samples in all collection periods in both governorates was 3%, except for period two in Jenin was 2% (Table 1).

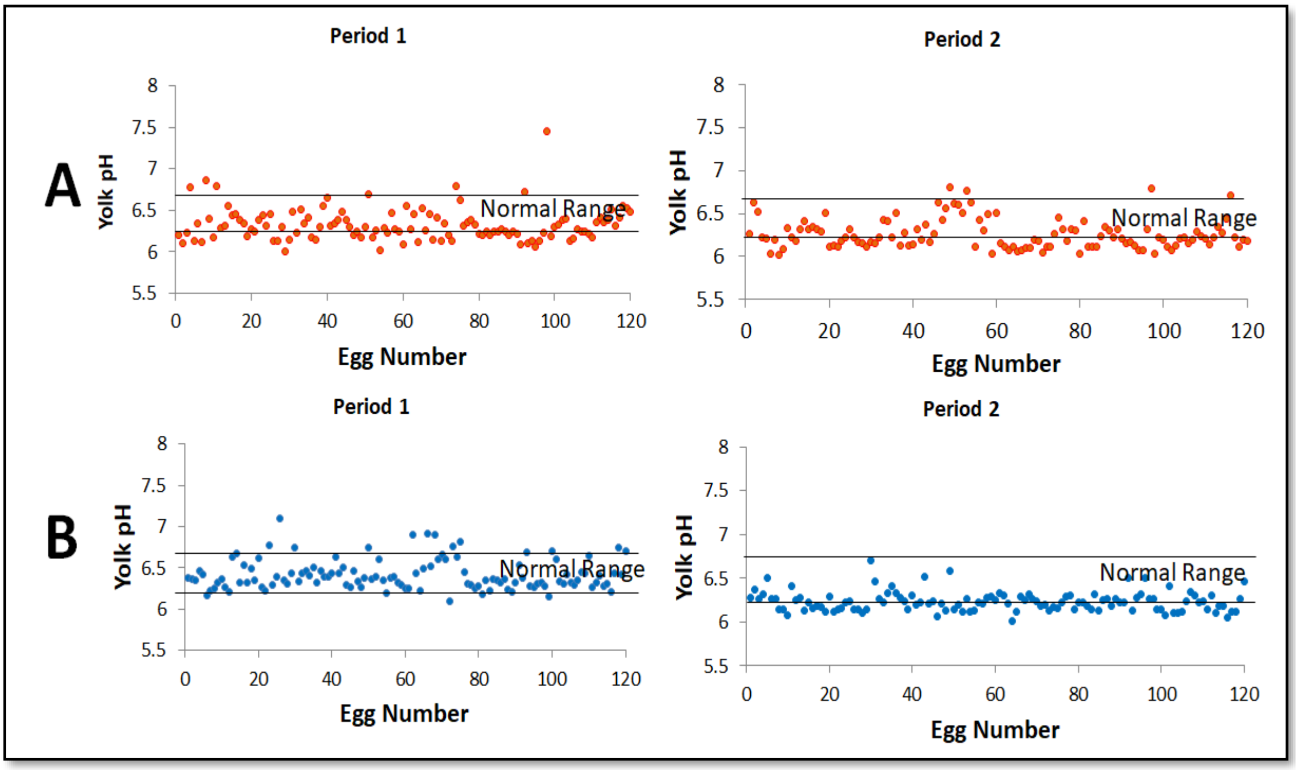

Figure (5): Yolk pH in both governorates Tulkarm (A), Jenin (B) in two different collected periods.

Yolk Index

The yolk index is defined as the ratio of the yolk height to the yolk's diameter and indicates the egg's freshness. Eggs with a yolk index higher than 0.38 are rated very fresh. Those ranging from 0.28 to 0.38 fresh and those less than 0.28 are considered normal. The yolk index decreases during the longer storage period. The results indicated that most of the collected eggs in both periods and governorates were in the fresh area, as shown in (Fig 6). Moreover, the results show up that there is a significantly higher number of eggs that is very fresh area in both periods in Tulkarm compared to Jenin; this may be due to the higher number of layers in Tulakrm 365,637 respect to Jenin 51,372, which helps the farmer to provide the supermarkets and mini markets with very fresh eggs daily (PCBS: Livestock Survey 2013 - Palestine). Eke et al. (2013), showed that by increasing the storage time, the yolk index decreases rapidly in the ambient temperature compared to the refrigerated temperature. Decline the yolk height will significantly redact the yolk index. The yolk height change due to the elasticity of the vitelline membrane, which significantly reduces due to reducing the strength during the storage time. The decrease in yolk index value was caused by osmotic pressure, so there was a process of transferring water existed in the egg white into the egg yolk (Akyurek and Okur, 2009; Demirel and Kirikci, 2009).

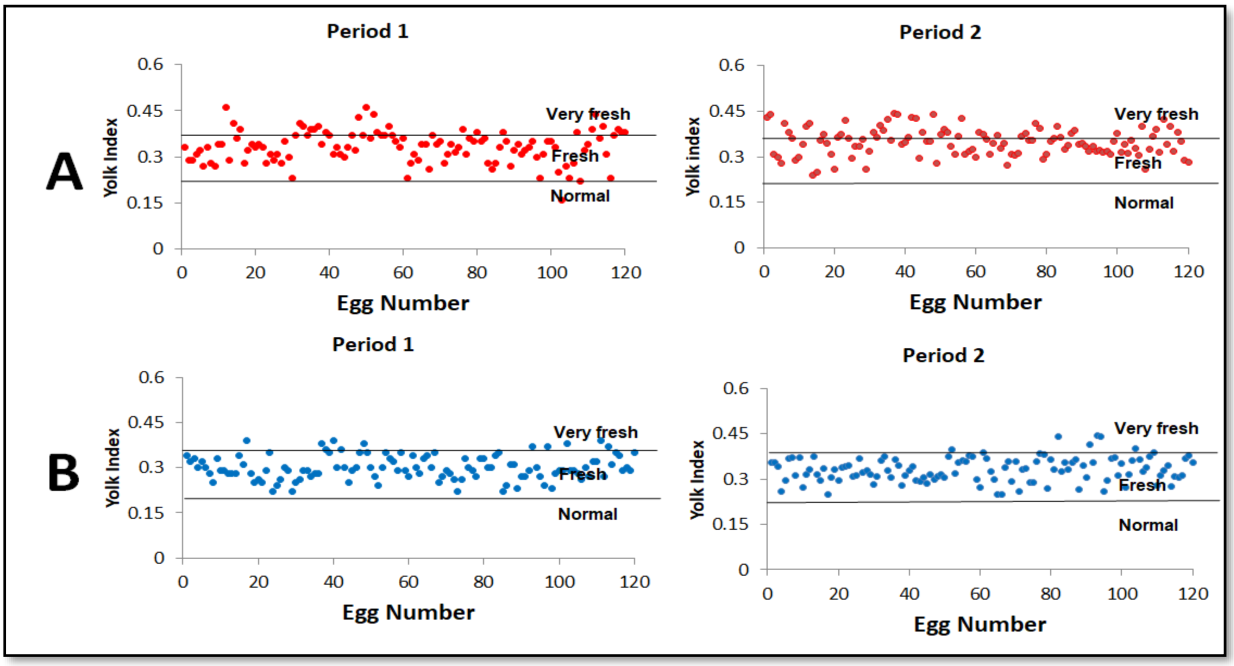

Figure (6). Yolk index in both governorates Tulkarm (A), Jenin (B) in two different collected periods.

The CD percentage was higher in Tulkarm governorates during collection period one; it reached 15%, while the lowest CD in Jenin governorates was 12%, as reported in Table 1. The results showed some eggs in the normal area in Tulkarm governorates during the collection period one, which explained the higher CD value (Fig. 6).

Eggshell microbial

Escherichia coli (*E*-coli) and *Salmonella enteritidis* were evaluated in the egg shells, and the results are reported in (Table 2). The result showed that the eggshells collected from Tulkarm governorate samples were contaminated with *Salmonella* and did not contain *E.*coli. However, the eggshells collected from Jenin governorate contained *E.*coli while absence of *Salmonella.*

The presence of *Salmonella enteritidis* and *E.*coli on eggshell surfaces is the potential to spread into other foods in consumer's kitchen and their hands (Pasquali *et al.,* 2015). The scientific opinion from EFSA (2014), concluded that the effective way to minimize any risk during storage is to keep the eggs refrigerated both at retail and the household. Regarding egg spoilage, *Salmonella enteritidis*, and *E.*coli strongly depend on the hygienic conditions of egg production and egg handling practices, including storage times and temperatures. According to many studies, the *Salmonella enteritidis* was the most common microbial found in eggs (Gantois *et al.,* 2006; Delmas, *et al.,* 2006). The presence of *Salmonella enteritidis* in the table egg surfaces can be explained by many reasons, which are; a) the farm's system that accumulates hen feces below the hen nest or the laying hen's cages (Kouam *et al.,* 2017); b) inefficient cleaning and sanitation system in the hen farms (Kouam *et al.,* 2017); c) absence of the integrated pests management system that increase the contamination levels and transmit the infection from one production round to the next; d) absence of *Salmonella* vaccination neglect the laying hens unprotected against Salmonella (Gantois *et al.,* 2006).

Table (2): *Escherichia coli* (*E*-coli) and *Salmonella Enteritidis**.

	Tulkarm	Jenin
***Escherichia coli* (*E*-coli)**	-	+
Salmonella Enteritidis	+	-

* + Presence, - Absence

Conclusion

The reported results clearly indicated a higher variation in the egg quality parameter in both governorates. According to the Haugh unit, most retail table eggs in both governorate's markets are classified as B. Moreover, the eggs in both sources were not subjected to any grading system. However, the surface of retail table eggs containing many defects in appearance, including dirt with feces or blood, misshapen shell, cracks, stained eggs, fly marks, and pimples. Only slightly dirty eggs can be gently rubbed with an egg brush, paper towel, sanding sponge, or plastic scourer, using a gentle rubbing motion. Muddy or feces-covered eggs that cannot be easily removed using this method should be separated from clean eggs and disposed of. Different sterilization methods can be used, such as UV or pasteurization. Moreover, the best way to market the eggs is to store them under optimum temperatures that will keep them without deterioration in quality. *Salmonella* and *E-coli* isolated from the shell egg surface constitute a big challenge to the egg industry and public health. The results indicated an excellent opportunity to invest in the eggs industry sector to clean, grade the table eggs and produce different egg products. Moreover, regulatory and public health authorities must conduct workshops in conjunction with egg producers and sellers to develop effective control strategies against pathogenic microorganisms in the laying hen's egg sector and improve egg quality.

Conflict of interest: The authors declare no conflict of interest.

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