

Evaluation of Quality Parameters of White and Brown Eggs in Lebanon

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Abstract

The quality traits of fresh marketable chicken eggs collected during winter, autumn and summer periods from different local markets in Lebanon were evaluated in order to understand the reproductive fitness of the chicken and the correlation between collection dates. A total of 2000 brown and white eggs were analyzed and compared for their external quality parameters such as egg weight, length, width, size, shell thickness, specific gravity and for their internal quality traits such as Haugh unit, yolk diameter, yolk color, and yolk height. Results show that egg weight and size varied markedly and tended to be smaller during summer period. A significant difference was found between white and brown eggs in some quality traits such as egg weight, shell thickness, egg length, and yolk diameter parameters. Egg quality parameters were significantly reduced during summer season where eggs are exposed to high temperature conditions. For grading analysis, 80% of the total eggs were classified as A with a significant difference ($p < 0.05$) between white and brown egg and during collection dates. Overall, brown eggs graded better than white eggs in external quality cleanliness and shape. Based on our analysis, the results of this study show that Lebanese eggs are of good quality and suggest that proper egg handling and storage conditions should be applied especially at warm environmental conditions to improve egg quality during summer season.

Keywords

Brown and White Eggs, Egg Quality Control, Quality Parameters

[#]Deceased.

1. Introduction

Eggs are considered among the most widespread, popular and nutritious food and are less expensive than other equivalent animal protein sources [1] [2]. They play a vital role in many diets and are considered as a major source of essential nutrients. Specifically, they are an excellent source of high-quality and well balanced proteins as they contain all of the essential amino acids [3].

Eggs are one of the few foods used throughout the world and this character makes the egg industry an important section of the food industry that is primarily based on chicken eggs [4].

The global table egg and poultry meat consumption are increasing at a faster rate than that of beef and pork. Most of the increase in poultry production is taking place in developing countries, especially in Asia. This region now accounts for more than a quarter of current global poultry production. Between 2000 and 2010, world trade in eggs increased by around eight percent per year. Exports from Asia have grown by over nine percent per year from 204,000 tons in 2000 to 553,000 tons in 2011. Asia is currently home to 2230 million laying hens. By comparison, Europe is home to 609 million while North America has just 369 million. As the human population increases, the poultry industry continues to grow to meet the demand for poultry products in the market [4]. The economic increase for a poultry production is measured according to the total number of produced eggs [5]. However, the egg production depends on various factors such as age of the bird, season, breed, genetic basis, elevated environmental temperature, supplements, and housing, among others [6] [7].

According to Stadelaman (1977) [8], the evaluation of the egg characteristics is important factor for consumer preferences for better egg quality. The overall quality of the chicken egg is determined by the egg external and internal qualities. The appearance of the egg is important for consumer appeal. In fact, external quality is based on egg size, egg specific gravity, shell color, shell deformation, shell weight, and shell thickness. Interior egg quality is based on albumen quality, yolk quality, Haugh unit and the presence of blood or meat spots [9]. Moreover, external and internal quality traits of the eggs are significant in the poultry breeding for their influence on the yield features of the future generations and breeding performances [10]. The integrity of the egg external and internal structure is essential to maintain embryo survival, nutrients preservation, and prevention of microbial contamination [11].

In Lebanon, the poultry sector continues to grow. There are around 2000 farms in Lebanon producing 400 million table eggs per year. The mean annual total and per capita egg production growth rates in Lebanon for the last 12 years were around 1.0% and 1.9% [12]. The progress of poultry production in Lebanon is a result of diverse technological developments in nutrition and management techniques. However, this industry is greatly in need of improvements to enhance efficiency of production and quality of products through changes in management, feed nutritional value, cost and proper application safety regula-

tions. On the other hand, the geographical space for expanding the poultry industry to increase the production is diminishing every year. There are also several problems associated with marketing including but not limited to dirty eggs, unavailability of proper packaging materials, no standard packaging system for eggs and the absence of a standard grading system for eggs.

Moreover, egg quality parameters are greatly affected by weather conditions [13]. Lebanon has a Mediterranean type climate with an average annual temperature of 15°C. The weather is composed of four seasons; it is characterized by hot and dry summers from June to September. Autumn is warm and pleasant with moderate temperatures (20°C - 25°C). Winters are cold, rainy and temperatures are mostly above zero (December to mid-March). Therefore, there is a fluctuation in temperature during the year in particular during summer period specially that it witnesses recently an increase in temperature since 2010 exceeding sometimes 40°C in July/August. Furthermore, in local egg production operations, layers are mostly raised on floor litter and in semi-open housing, thus exposing the bird to extreme daily environmental and ambient condition fluctuations [12]. There is a lack of recent research work on quality parameters and grading of table eggs produced under different production dates in layer operations located in the Mediterranean region. To our knowledge, no reported studies were conducted on Lebanese eggs. Therefore, the objective of this study is to evaluate and compare the egg internal and external quality parameters of 2000 white and brown table eggs, produced by commercial laying hens kept in semi-open houses and raised on floor litter, in response to changes between different hot and cold seasons.

2. Materials and Methods

The present study was carried out to evaluate the quality traits of chicken eggs collected from three local markets in Lebanon during summer autumn and winter seasons; 2000 brown and white eggs were analyzed and compared for their external and internal quality parameters.

2.1. Sampling

A total of 2000 table eggs were collected from three different supermarkets during summer, autumn and winter seasons respectively in 2015. Different cartons of fresh brown and white table eggs were collected for 16 times every two weeks during these periods. Eggs of each carton were weighed and after calculating the average weight of 30 eggs, 15 eggs were chosen with a weight value close to the mean and studied for further analysis of external and internal quality traits following the USDA standards of measurements [14]. Each essay was performed in triplicates.

2.2. Egg Weight

Egg weight was measured by placing an unbroken egg on a scale and recording

the value. The individual eggs were weighed on a digital balance (Ohaus EX45 Explorer) to the nearest of 0.01 g accuracy. According to USDA (2000) [14], egg weights were divided into six size categories. The minimum weight requirements in the United States for these categories are jumbo (68.6 g), extra-large (61.5 g), large (54.4 g), medium (47.3 g), small (40.3 g) and peewee (no minimum requirement).

2.3. Specific Gravity

The specific gravity (SG) was determined using the saline flotation method of Hurnik (1977) [15] and a hydrometer was used to evaluate the density from 1060 to 1100. Briefly, eggs were immersed sequentially into series of saline solution of ascending SG. The saline solutions were placed in a plastic containers with 4.5 l of water and with an increasing amount of sodium chloride (NaCl) from score 0 to 8. A low score have a low amount of NaCl. The increasing of the specific gravity indicates freshness and excellent egg shell quality.

2.4. Haugh Unit

The Haugh unit is considered a typical measure for albumen quality and is calculated by Haugh (1937) [16] by using the following equation:

$$HU = 100 \log \left(\frac{H - G \cdot 0.5(30W^{0.37} - 100)}{100 + 1.9} \right)$$

where HU = Haugh Unit, H = Albumen height in cm, G = 32.2 and W = egg weight in grams. In general, a higher HU value is a good indicator of the quality of eggs, where the minimum acceptable level is 60 HU [17].

2.5. Eggshell Thickness

Eggshell thickness is an important factor for the determination of egg quality and consumer preferences. It must be resistant to forces and should withstand manipulating techniques [2]. The eggshell thickness was measured at the equator in the middle part of the egg using a digital micrometer after removing the internal membranes of the eggshell.

2.6. Egg Yolk Color

The egg yolk color was determined using a yolk color fan having tabs from 1 to 15 (1155, Roche & Company Ltd., Switzerland). Depending on the feed composition provided to the laying hen, yolk color can vary from a very pale yellow to deep orange [18].

2.7. Evaluation of Internal and External Egg Size

An egg-shape factor meter was used to indicate the length, the width and the size of the egg. The egg was fixed at the frame of the egg shape meter with its round side up. Shell color was not considered as a factor in judging quality.

For albumen and yolk height, a tripod micrometer (S-6428, B.C. Ames Com-

pany, USA) was set on the glass surface. Then the zero reading was checked and adjusted by lowering the measuring rod until the point touched the surface of the glass on which the broken out egg will be placed. The point was retracted upwards to its full extent. The egg was weighted first and then broken on to the flat glass surface. The above micrometer was placed over the egg and the point was lowered until just touched the albumen which height was determined. The thicker is the albumen; the better is the quality of the egg, with heights of 8 to 10 mm being considered of superior interior quality [19]. Then the tripod micrometer was again placed over the egg and the point was lowered until just touched the yolk. The diameter of the yolk was detected by using a ruler graduation placed below the glass on the mirror.

2.8. Internal and External Egg Grading

All eggs must be clean to pass external grading requirements, but a small amount of staining is permitted in Grade B [14]. All eggs must have unbroken shells. Egg shells with cracks or markedly unsound, or flawed are classified as restricted eggs. The ideal eggshell shape is oval with one end larger than the other. Abnormal shells, permitted for Grade B eggs, may be decidedly misshapen or faulty in texture with ridges, thin spots or rough areas.

Grading the interior of the egg (albumen and yolk) and candling the air cell were also conducted. In this process, eggs are passed over a bright light which shows up internal defects and previously undetected cracked or weak shells [20]. The internal defects often detectable by candling include blood and meat spots, enlarged air cell and very thin whites [14]. The small size of the air cell is a good indicator of good quality. According to USDA (2000) [14], air cell grading AA indicated the air cell may not exceed 1/8 inch in depth and is about the size of a dime. Grade A eggs may have air cells over 3/16 inch in depth. However, there is no limit on air cell size for Grade B eggs.

For the albumen, the following grading are used: Grade AA if it is clear and firm, Grade A for clean and reasonably firm, Grade B for weak and watery small blood and meat spots present. Grading yolk was also determined, the Grade AA outlines slightly free from defects, Grade A if it is fairly well defined and Grade B if it is plainly visible enlarged and flattened with visible spots development without blood.

3. Results and Discussion

3.1. Egg Weight

Egg weight is one of the essential phenotypic parameters that affect egg quality and reproductive fitness of the hens [21]. Our study showed that egg weight was variable according to egg type and collection dates. Results in **Table 1** showed that the average egg weight for brown and white eggs were 61.2 ± 0.451 g and 59.7 ± 0.451 g respectively. Brown eggs were significantly heavier ($p = 0.0145 < 0.05$) than white eggs. These results are in agreement with those reported by Vits

Table 1. Egg weight and quality parameters of white and brown table eggs.

Egg shell color		Egg weight (g)	Specific gravity	Haugh unit score	Shell thickness (mm)	Yolk color score
White		59.7 ^b	1.078 ^a	63.39 ^a	0.471 ^b	9.81 ^a
Brown		61.2 ^a	1.077 ^a	63.26 ^a	0.510 ^a	10.23 ^a
SEM ¹		0.451	0.008	0.130	0.0067	0.157
Collection date						
Summer season	17-06-2015	59.42 ^{ab}	1.076 ^d	61.43 ^b	0.44 ^b	9.16 ^d
	1-07-2015	59.86 ^b	1.078 ^a	60.00 ^c	0.45 ^{ab}	10.48 ^{bc}
	15-07-2015	59.35 ^{ab}	1.075 ^{de}	54.01 ^c	0.46 ^b	10.08 ^c
	29-07-2015	59.74 ^{ab}	1.074 ^{dec}	61.21 ^b	0.47 ^{ab}	8.32 ^d
	12-08-2015	59.34 ^{ab}	1.077 ^d	53.80 ^c	0.46 ^b	10.17 ^d
	26-08-2015	59.75 ^b	1.077 ^a	60.30 ^c	0.44 ^{ab}	9.48 ^{bc}
	9-9-2015	59.34 ^{ab}	1.076 ^{de}	61.33 ^b	0.47 ^b	10.12 ^c
	23-09-2015	59.75 ^{ab}	1.075 ^{dec}	62.10 ^b	0.47 ^{ab}	9.32 ^d
Autumn/winter seasons	7-10-2015	61.73 ^a	1.082 ^a	68.38 ^a	0.54 ^a	11.13 ^{ab}
	21-10-2015	61.98 ^a	1.081 ^{abc}	70.52 ^a	0.54 ^a	11.85 ^a
	4-11-2015	60.64 ^{ab}	1.082 ^{ab}	69.72 ^a	0.55 ^a	11.42 ^a
	18-11-2015	61.90 ^a	1.080 ^{abc}	63.00 ^b	0.50 ^{ab}	7.28 ^e
	2-12-2015	61.83 ^a	1.082 ^a	68.38 ^a	0.54 ^a	11.13 ^{ab}
	16-12-2015	61.98 ^a	1.082 ^{abc}	69.82 ^a	0.55 ^a	11.75 ^a
	30-12-2015	61.74 ^{ab}	1.081 ^{ab}	70.32 ^a	0.54 ^a	11.32 ^a
	13-01-2016	61.80 ^a	1.080 ^{abc}	64.01 ^b	0.51 ^{ab}	9.45 ^e
SEM ¹		0.907214	0.001175	2.576679	0.103861	0.293011
P > F						
Egg shell color		0.0145	0.8617	0.8076	0.003	0.012
Collection date		0.0167	0.0021	0.0027	0.002	0.0001
ESC × CD		0.3229	0.2869	0.1741	0.1986	0.2271

^{a,b,c,d,e}Least square means along the same column with different superscripts for each independent variable are significantly different ($p < 0.05$). ¹Pooled standard error of the least square means.

et al. (2005) [22] that colored feather hen lay bigger eggs than white feather hens. These authors assume that genotype has a direct influence on egg weight and characteristics.

Concerning egg weight measured during different collection dates, our results show that egg mass was significantly reduced ($p = 0.0167 < 0.05$) especially during summer season. These results are in accordance with Bozkurt and Tekerli, (2009) [13] who reported that several quality traits of eggs are affected by hen age and production season. The same researchers found that eggs became smaller with thinner shells in seasons with high temperatures. In fact, high ambient

temperatures lead to the depression of feed consumption and reduced layer performance and body weight [23]. Moreover Davilo (2000) [24] showed that egg mass is reduced in hot summer; the extremely high temperatures reduced layer appetite, resulting in decrease in their entire nutrient requirement and thus they produced smaller eggs.

Furthermore, in our study, eggs were collected from laying hens kept in semi-open houses and raised on floor litter which allow them to be more exposed and affected by environmental variation. A subsequent study found that eggs from the conventional cages have significantly higher egg weight compared with the other systems used [25].

3.2. Specific Gravity

High egg specific gravity is an indicator of freshness and good quality eggs; it is also used to assess shell quality as the hen ages or during periods of stress [26]. In our study, **Table 1** showed that there is no significant difference ($p > 0.05$) for white (1.078 ± 0.008) and brown eggs (1.077 ± 0.008). However, a decrease in specific gravity occurs when birds were submitted to heat stress especially during summer period where it was significantly reduced to a value of 1.074 ($p = 0.0021 < 0.05$). Our results are in accordance with those previously stated by Mashaly *et al.* (2204) [27] showing that exposure to stress and high temperature may affect the specific gravity. Hen age may also be a limiting factor influencing shell thickness [28] [29].

Moreover, specific gravity was also found to be affected by storage time and temperature [30]. Eggs can lose quality and reduction in shell thickness can occur at room temperature more than in the refrigerator [26]. Therefore, retailers should have adequate refrigerated holding space, avoid storage of eggs close to strong-smelling foods and display eggs away from sunlight.

3.3. Haugh Unit

A higher value of Haugh unit is a good indicator of a better egg quality which is classified according to the USDA standards. Our results showed that no significant differences were observed between brown and white egg ($p > 0.05$) (**Table 1**) with values of 63.39 ± 0.130 and 63.26 ± 0.130 respectively. Lower values of Haugh units that were below the minimum acceptable limit ($53.80 < 60$) were detected during summer season. This result may be explained by the exposure of eggs to air, storage conditions in markets, including high temperature, humidity, presence of CO₂ and duration of storage. These factors are of prime importance for egg quality at retail. More specifically, storage time and temperature appear to be the most crucial factors affecting albumen quality or Haugh unit (HU). Morais *et al.* (1997) and Akter *et al.* (2014) [26] [31] have demonstrated that Haugh unit of eggs stored at room temperature was reduced significantly ($p < 0.05$) compared to refrigeration. Akter *et al.* (2014) [26] showed that the reduction in Haugh unit is due to decrease in thick albumen height. In fact, storage

time and high temperature cause the breakdown of the ovomucin-lysozyme complex, increasing the pH of eggs which is related to the deterioration of albumen or Haugh Unit [31]. Haugh value unit was also reported to be decreased with age [29].

3.4. Egg Shell Thickness

Egg shell thickness were detected with significant differences between brown (0.510 ± 0.006 mm) and white eggs (0.471 ± 0.006 mm) ($p = 0.003 < 0.05$) (Table 1). This may be due to the reduction in feed intake and egg weight between brown and white layers. Egg shell thickness was also significantly reduced ($p = 0.002 < 0.05$) by collection date especially when submitted to heat stress during summer period (Table 1). In fact, egg shell thickness was affected by the birds' nutrient intake such as calcium, vitamins and salt content in water [9]. Moreover, the previous research conducted by Samiullah *et al.* (2014) [29] indicated that hen age and season influence egg shell thickness. Chronological factors had also an impact on the quantity of special membrane fibers involved in conserving eggshell resistance. During exposure to warm environmental temperature, a condition termed “respiratory alkalosis” occurs to hens, due to the increase of breathing rate by panting to cool themselves. Therefore, the blood had less carbon dioxide, an alkaline pH. This acid-base unbalance causes a reduction in calcium in eggshell resulting in soft-shelled eggs. Moreover, respiratory alkalosis is responsible for increased carbonate loss through the kidney leading to a competition between kidney and uterus for carbonate ion, and consequently causing poor eggshell thickness [32].

3.5. Yolk Color

Yolk color score, as shown in Table 1, a significant difference between brown (10.23 ± 0.157) and white (9.81 ± 0.157) eggs. By referring to literature, the primary determinant of yolk color is the xanthophyll (plant pigment) content of the diet consumed [33]. Yolk color is thus affected by feeding. Grains and green feeds produce dark yellow to orange colored yolks. Rations high in green grasses, silage, and cottonseed meal cause the yolks to acquire a reddish or olive color. Off-flavors may be due to feed formulated with a poor-quality fish meal or other contaminants in the feed.

3.6. Evaluation of Egg Size

The variation of egg size is due to egg length and width. Table 2 lists the internal and external dimensions of white and brown table eggs. Results showed that there is a significant difference between white (5.67 ± 0.021 cm) and brown (5.58 ± 0.021 cm) egg length ($p = 0.0111 < 0.05$) and a variation between collection dates ($p = 0.0012 < 0.05$) whereas it was reduced during summer season. However, there is no significant difference between brown (4.47 ± 0.078 cm) and white egg width (4.45 ± 0.078 cm) with $p = 0.3187 > 0.05$ as well as between

Table 2. Internal and external dimensions of white and brown eggs.

Egg shell color	Egg length (cm)	Egg width (cm)	Yolk height (mm)	Yolk diameter (cm)	Albumen height (mm)	
White	5.67 ^a	4.45 ^a	14.96 ^a	2.80 ^a	4.45 ^a	
Brown	5.58 ^b	4.47 ^a	14.87 ^a	2.92 ^b	4.55 ^a	
SEM ¹	0.021	0.078	0.18	0.015	0.125	
Collection date						
Summer season	17-06-2015	5.62 ^{ab}	4.35 ^b	13.48 ^d	3.12 ^a	4.22 ^{ab}
	1-07-2015	5.53 ^{bc}	4.33 ^b	14.41 ^c	2.83 ^{abc}	3.72 ^b
	15-07-2015	5.58 ^{ab}	4.38 ^b	14.76 ^c	2.95 ^{ab}	4.34 ^{ab}
	29-07-2015	5.43 ^c	4.35 ^b	13.31 ^d	2.32 ^a	4.41 ^{ab}
	12-08-2015	5.61 ^{ab}	4.35 ^b	13.47 ^d	3.13 ^a	4.22 ^{ab}
	26-08-2015	5.52 ^{bc}	4.31 ^b	14.42 ^c	2.84 ^{abc}	3.72 ^b
	9-9-2015	5.56 ^{ab}	4.38 ^b	14.77 ^c	2.95 ^{ab}	4.35 ^{ab}
	23-09-2015	5.42 ^c	4.35 ^b	13.32 ^d	2.32 ^a	4.41 ^{ab}
Autumn/winter seasons	7-10-2015	5.71 ^a	4.42 ^b	15.94 ^{ab}	2.85 ^c	4.80 ^a
	21-10-2015	5.71 ^a	4.86 ^b	16.43 ^a	2.91 ^b	4.84 ^a
	4-11-2015	5.64 ^a	4.34 ^b	15.23 ^{bc}	2.85 ^c	4.91 ^a
	18-11-2015	5.63 ^{ab}	4.32 ^b	14.94 ^{bc}	2.91 ^{bc}	4.51 ^a
	2-12-2015	5.70 ^a	4.41 ^b	15.96 ^{ab}	2.86 ^c	4.81 ^a
	16-12-2015	5.71 ^a	4.85 ^b	16.47 ^a	2.90 ^b	4.86 ^a
	30-12-2015	5.63 ^a	4.32 ^b	15.22 ^{bc}	2.86 ^c	4.93 ^a
	13-01-2016	5.64 ^{ab}	4.31 ^b	14.93 ^{bc}	2.90 ^{bc}	4.51 ^a
SEM ¹	0.044366	0.159413	0.380694	0.029843	0.249023	
P > F						
Egg shell color	0.0111	0.3187	0.7478	0.0348	0.6023	
Collection date	0.0012	0.2130	0.0002	0.0063	0.0314	
ESC × CD	0.0735	0.3441	0.2358	0.9675	0.5598	

^{a,b,c,d,e}Least square means along the same column with different superscripts for each independent variable are significantly different ($p < 0.05$). ¹Pooled standard error of the least square means.

collection date ($p = 0.2130 > 0.05$). According to the literature, egg size is influenced by different factors such as breed, genetics, age of laying hen, nutrition, production practices, climatic conditions, physiological stress, the season and the various housing system [6] [34]. The stressful behavioral responses of birds may also affect egg sizes. Indeed, elevated respiratory rate and restlessness, resulting in loss of body fluids (dehydration) which cause a reduction in egg size and obtaining of small brown and white eggs all the summer season. During storage, water from egg is lost through evaporation, and the rate of evaporation is influenced by the length of storage, temperature, humidity, the surface and

porosity of the shell [26]. Moreover, Walsh *et al.* (1995) [35] concluded that the prevention of water loss from the egg is an important requirement for successful long-term storage.

Concerning yolk and albumen dimensions, results show that there is no significant difference for yolk height between white (14.96 ± 0.18 mm) and brown egg (14.87 ± 0.18 mm) ($p = 0.7478 > 0.05$) as well as for albumen height for white (4.45 ± 0.125 mm) and for brown eggs (4.55 ± 0.125 mm) ($p = 0.6013 > 0.05$). Moreover, as a comparison between collection date, the experiment showed that there is a significant difference for yolk ($p = 0.0002 < 0.05$) and for albumen ($p = 0.0314 < 0.05$) heights. A significant difference was also found between white and brown yolk diameter ($p = 0.0348 < 0.05$) as well as between collection dates ($p = 0.0063 < 0.05$).

In fact, albumen and yolk height are influenced by layer's nutrition, environment and housing. The heat stress appeared to have almost direct effect [30]. As the egg gets stored for a longer time, the yolk absorbs water from the egg white, increasing its diameter and gives the yolk a flattened shape. This produces also an enlargement and a weakness of the membrane [26]. Our results are in accordance with what was previously stated by these authors, since albumen and yolk were decreased in height and the yolk diameter was increased during summer periods. Moreover, excluding disease, the hen age is also an important factor affecting albumen and yolk quality of eggs; yolk volume were increased and the quality decreases with bird age [36]. However, Williams (1992) [36] showed that an induced pause in egg production (induced molt) has been shown to improve the albumen quality of eggs.

3.7. External and Internal Grading

The white and brown egg external and internal grading is presented in **Table 3** and **Table 4** respectively. As shown in **Table 3**, egg shell is major grading A for white ($63.39\% \pm 0.07\%$) and brown eggs ($56.57\% \pm 0.07\%$) with a significant difference ($p < 0.05$) between egg shell color and during collection dates. An egg-shell grading AA was observed for brown eggs with high percentage ($36.7\% \pm 0.06\%$) compared to white eggs ($23.9\% \pm 0.06\%$). The exterior of the egg was inspected for cleanliness, soundness, texture, and shape. The eggs must be clean and have unbroken shells. Ideally, they also have an oval shape with one end slightly larger than the other. They include shell thickness, gross cracks, hairline cracks, star cracks, misshapen egg, pimples, and sand paper. The complexity of structure of the shell gives rise to differences in breakage in eggs. Although egg shells with an abnormal texture (ridges, thin spots, rough areas) are not permitted, they were given a Grade B [14].

In our study, the presence of some defects in egg shell grading may be frequently a result of bird age, but may also be caused by other factors diseases such as infectious laryngotracheitis [34] and avian encephalomyelitis along with other external quality attributes such as dirtiness. Many findings about egg dirtiness

Table 3. External grading of white and brown table eggs.

Egg shell color	Egg shell grading (%)			Air cell grading (%)			
	AA	A	B	AA	A	B	
White	23.90 ^b	63.39 ^a	12.71 ^a	13.86 ^b	63.75 ^a	22.39 ^a	
Brown	36.70 ^a	56.57 ^b	6.76 ^b	17.77 ^a	62.14 ^a	20.09 ^a	
SEM ¹	0.06	0.07	0.14	0.15	0.30	0.58	
Collection date							
Summer season	17-06-2015	28.66 ^b	66.68 ^a	4.66 ^{bc}	6.67 ^{bc}	57.17 ^{bc}	42.16 ^a
	1-07-2015	29.98 ^{ab}	65.57 ^a	5.45 ^{bc}	15.68 ^{abc}	75.00 ^{ab}	9.32 ^b
	15-07-2015	18.82 ^c	78.17 ^a	3.01 ^{bc}	8.93 ^{bc}	85.76 ^a	5.31 ^b
	29-07-2015	30.01 ^{ab}	64.49 ^a	5.50 ^{bc}	0.00	55.4 ^{bc}	44.6 ^a
	12-08-2015	28.76 ^b	66.70 ^a	4.54 ^{bc}	6.75 ^{bc}	57.17 ^{bc}	42.16 ^a
	26-08-2015	29.16 ^{ab}	65.57 ^a	5.26 ^{bc}	15.67 ^{abc}	75.00 ^{ab}	9.32 ^b
	9-9-2015	18.71 ^c	78.21 ^a	3.08 ^{bc}	8.73 ^{bc}	85.76 ^a	5.31 ^b
	23-09-2015	30.02 ^{ab}	64.39 ^a	5.49 ^{bc}	6.73 ^{bc}	55.67 ^{bc}	37.6 ^a
Autumn/winter seasons	7-10-2015	26.82 ^b	57.33 ^a	15.85 ^b	19.42 ^{abc}	64.75 ^{ab}	15.83 ^b
	21-10-2015	37.59 ^a	27.90 ^b	34.51 ^a	32.00 ^a	34.33 ^c	33.67 ^a
	4-11-2015	35.5 ^a	54.50 ^a	10.00 ^{bc}	27.83 ^{ab}	67.42 ^{ab}	4.75 ^b
	18-11-2015	35.66 ^a	64.33 ^a	7.30 ^b	17.95 ^{abc}	67.78 ^{ab}	14.27 ^b
	2-12-2015	26.85 ^b	58.35 ^a	12.80 ^b	20.35 ^{abc}	66.72 ^{ab}	12.93 ^b
	16-12-2015	38.72 ^a	27.84 ^b	33.44 ^a	33.54 ^a	33.56 ^c	32.90 ^a
	30-12-2015	35.62 ^a	53.29 ^a	11.09 ^{bc}	28.91 ^{ab}	68.47 ^{ab}	2.62 ^b
	13-01-2016	35.66 ^a	64.33 ^a	7.3 ^b	16.85 ^{abc}	68.78 ^{ab}	14.37 ^b
SEM ¹	0.068	0.0736	0.0429	0.064	0.083	0.051	
P > F							
Egg shell color	0.0098	0.01955	0.0463	0.4166	0.7715	0.5852	
Collection date	0.5938	0.0037	0.0001	0.0338	0.0075	<0.0001	
ESC × CD	0.9485	0.6742	0.4223	0.7063	0.6554	0.8172	

^{a,b,c,d,e}Least square means along the same column with different superscripts for each independent variable are significantly different ($p < 0.05$). ¹Pooled standard error of the least square means.

were reported. Usually, hens raised on floor have been found to produce a higher percentage of dirty eggs than those in cages that have been implicated in the production of rough or “sandpaper” eggshells [34]. The production of eggs with calcium deposits on the shell (or pimples) is thought to be hereditary, or may be due to changes in the lighting program and poor shed. There are more dirty eggs in furnished cages than in conventional cages. However, nest box design has an effect on the percentage of dirty eggs [37].

Concerning air cell grading, 63.75% ± 0.30% and 62.14% ± 0.30% were classi-

fied as Grade A for white and brown eggs respectively with no significant difference ($p > 0.05$), but a significant difference between collection dates was observed due to heat stress. Increasing in the size of the air cell is resulting from contraction due to evaporation of water from the egg. The rapidity which this takes place is due to many factors, such as age, shell texture, temperature and humidity [38].

By referring to **Table 4**, albumen was graded A for both white and brown eggs with high percentages ($76.54\% \pm 0.034\%$) and ($71.50\% \pm 0.034\%$) respectively

Table 4. Internal grading of white and brown table eggs.

Egg shell color		Albumen grading (%)			Yolk grading (%)		
		AA	A	B	AA	A	B
White		18.53 ^b	76.54 ^a	4.93 ^a	4.90 ^a	73.39 ^a	21.72 ^a
Brown		25.72 ^a	71.50 ^b	2.78 ^a	5.48 ^a	70.56 ^a	23.96 ^a
SEM ¹		0.034	0.0343	0.017	0.015	0.021	0.0231
Collection date							
Summer season	17-06-2015	7.98 ^c	84.90 ^{ab}	7.20 ^{ab}	0.00	51.97 ^d	48.03 ^a
	1-07-2015	8.95 ^{bc}	85.67 ^a	5.38 ^{ab}	3.26 ^b	77.32 ^{abc}	19.42 ^{ab}
	15-07-2015	12.45 ^{bc}	83.05 ^b	4.50 ^{ab}	2.80 ^b	85.98 ^a	11.22 ^c
	29-07-2015	21.2 ^{bc}	73.6 ^{ab}	5.2 ^{ab}	0.00	56.91 ^d	43.09 ^a
	12-08-2015	8.75 ^c	83.71 ^{ab}	7.54 ^{ab}	0.00	53.77 ^d	46.67 ^a
	26-08-2015	8.15 ^{bc}	84.68 ^a	7.17 ^{ab}	0.00	55.72 ^d	44.28 ^a
	9-9-2015	13.48 ^{bc}	83.17 ^b	3.35 ^{ab}	3.1 ^b	84.96 ^a	11.94 ^c
	23-09-2015	20.5 ^{bc}	74.8 ^{ab}	4.70 ^{ab}	4.26 ^b	76.75 ^{abc}	18.99 ^{ab}
Autumn/winter seasons	7-10-2015	32.35 ^b	63.25 ^{bc}	4.44 ^{ab}	7.80 ^{ab}	71.09 ^c	21.11 ^{ab}
	21-10-2015	54.32 ^a	43.68 ^c	2.00 ^b	16.68 ^a	73.73 ^{bc}	9.59 ^c
	4-11-2015	21.50 ^{bc}	67.30 ^{ab}	11.20 ^a	5.35 ^b	84.45 ^{ab}	10.20 ^c
	18-11-2015	15.85 ^{bc}	81.72 ^{ab}	2.43 ^b	9.60 ^{ab}	73.43 ^{bc}	16.97 ^b
	2-12-2015	33.39 ^b	61.65 ^{bc}	4.96 ^{ab}	7.91 ^{ab}	72.87 ^c	19.22 ^{ab}
	16-12-2015	54.92 ^a	43.72 ^c	1.36 ^b	17.69 ^a	72.65 ^{bc}	9.66 ^c
	30-12-2015	21.46 ^{bc}	68.76 ^{ab}	9.78 ^a	5.48 ^b	83.55 ^{ab}	10.97 ^c
	13-01-2016	14.65 ^{bc}	82.77 ^{ab}	2.58 ^b	9.75 ^{ab}	72.74 ^{bc}	17.51 ^b
SEM ¹		6.6	6.7	2.4	2.7	4.2	4.77
P > F							
Egg shell color		0.2735	0.02086	0.6031	0.6948	0.3354	0.5518
Collection date		0.0003	0.0019	0.1083	0.0035	0.0001	<0.0001
ESC × CD		0.2722	0.391	0.5545	0.0961	0.1780	0.4961

^{a,b,c,d,e} Least square means along the same column with different superscripts for each independent variable are significantly different ($p < 0.05$). ¹Pooled standard error of the least square means.

and the difference was significant ($p < 0.05$) between white and brown eggs. A high percentage of the yolk ($73.39\% \pm 0.021\%$) and ($70.56\% \pm 0.021\%$) was grading A for white and brown eggs respectively with no significant difference ($p > 0.05$). However, highly significant differences were observed ($p < 0.05$) between collection dates for albumen and yolk grading during collection dates especially during summer period. In fact, at higher temperatures, the loss of CO_2 is faster and the albumen quality deteriorates faster [39]. Moreover, as the egg ages, carbon dioxide is lost through the shell; the contents of the egg become more alkaline, causing the albumen to become transparent and increasingly watery [7]. Therefore, in order to maintain the internal egg quality, the storage of eggs at a low temperature and a humidity of 50% - 60% may reduce the rate of albumen degeneration. Moreover, egg albumen and yolk quality may be maintained for longer time depending also on the hen's age and health. The use of medications, the weather conditions and hereditary factors may contribute also to the internal egg quality [7].

4. Conclusions

The availability and accessibility of nutritionally balanced edible foods in a safe consumable form are essential for the survival, wellbeing and people health in a community. In this study, the quality parameters of 2000 eggs were evaluated for the first time in the Lebanese markets during summer, autumn and winter seasons.

Some quality parameters showed significant difference between white and brown eggs such as egg weight, eggshell thickness, egg length and yolk diameter. However, all quality parameters studied in our report except egg width showed that significant differences were found between cold and hot periods where eggs are exposed to severe environmental conditions and high temperatures.

Moreover, grading analysis showed that 80% of the total eggs were classified as A. Brown eggs graded merely better than white eggs concerning external quality cleanliness and shape.

Therefore the results of this study suggest that the eggs collected from Lebanese market are of good quality. However, proper egg handling and storage conditions such as low temperature storage may be implemented especially under severe climatic conditions in order to increase the proportion of desirable quality eggs including better hygiene practices.

Moreover, egg producers can expect possible changes in table egg grades in each season of the year, thus taking the necessary management and feed steps to optimize sales profit under the existing environmental conditions.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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