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Required Force for Penetrate the Duck Eggshell to Protect at Handling and Hatching

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ABSTRACT

The research aims to study the force required to break the shell of duck eggs, which helps to provide the conditions for the process of hatching eggs and circulation. The physical and mechanical properties hade been measured. The most important results were as follows: The arithmetic mean of the length and the longest diameter 56.19, 42.94 mm, the coefficient of shape, surface area and volume were 0.77, 18071.11 mm 2, 16.0 mm^3 , the thickness of the eggshell from the middle, top and bottom 0.23 mm, 0.23 mm 2, 0.21 mm, the minimum and maximum force required to break the egg and the occurrence of hatching, at top, middle, and bottom (0.05, 32.24 N), (0.11, 25.67 N), (0.05, 32.70 N), the standard deviation was 7.53, 6.52, and 8.02, respectively, the mean was 14.91, 12.23, and 14.73 N, respectively. The minimum and maximum distance that the surface advances was 0.015, and 9.0 mm to the center, and 13.8 mm to the bottom of the egg shell. The results of the ANOVA analysis showed that there were significant differences in the value of the compressive force depending on the area of breaking the egg. The least of them was in the middle, the area of fracture (collapse) when the egg hatched. It is preferable to use the largest pressure force (32.7 N) to break the egg to ensure the highest hatching rate inside the hatchery.

Keywords: Duck eggs, physical, mechanical, break.

INTRODUCTION

De Ketelaere *et al.* (2002) conducted research on the effects of several egg physical characteristics, including egg mass and volume, surface area, shell thickness, and mass, on the mechanical qualities of eggs. A popular method for determining the strength of an egg's shell is to compress it quasi-statically between two parallel steel plates.

Kemps *et al.* (2003) developed a different approach for determining the elastic modulus of eggshells is obtained by observing the laser vibrometer's vibration response to a clamped rectangular piece of eggshell. These authors' nondestructive loading approach has the benefit of enabling reproducible measurements to be taken on the same test specimen. However, it does not mention how resistant to breakage the eggshell is (fracture toughness).

Bain (2005) insisted on our understanding of eggshell architecture has been substantially improved by ultra-structural investigation of eggshells, which has also strengthened the idea that eggshell mechanical qualities cannot be determined by a straightforward thickness measurement. Rodriguez *et al.* (2002) implied that enhancement in eggshell quality would benefit the industry economically. Strength and colour of the shell are two factors that greatly influence how good an eggshell is. Eggs' mechanical characteristics are influenced by geometric factors including the shell's form and thickness as well as the material's basic characteristics. The shell's chemical composition and microstructure, both of which change as the shell strength increases, determine the material properties of the shell. Given that Ruiz and Lunam (2000) noted a direct correlation between shell thickness and strength, it stands to reason that altering the palisade layer's thickness without changing the structural arrangement of the palisade columns could have an impact on shell strength.

According to Rodriguez *et al*. (2002), geometric factors including the shape and thickness of the eggshell as well as the basic physical characteristics of the eggshell determine the mechanical properties of eggs. The eggshell's chemical composition and microstructure, both of which change with shell thickness, determine its physical characteristics.

According to Nys *et al*. (2004), the strength and colour of an eggshell are two factors that significantly influence its quality. Eggs' mechanical characteristics are influenced by geometric factors including the shell's form and thickness as well as the material's basic characteristics. The shell's chemical composition and microstructure, both of which change as the shell strength increases, determine the material properties of the shell.

In his study of the impact of drinking water calcium levels on the integrity of laying hens' shells, Coetzee (2002) showed that birds given an additional 200 mg of calcium per litre of water produced eggs with a mean shell strength of 42.6 N as opposed to those receiving unsupplemented water, whose eggs had a mean shell strength of 38.9 N.

According to USDA (2000) and FAO (2003), a number of factors affect an egg's size. Heat, stress, congestion, and inadequate nutrition are among causes that are dependent on the bird itself, while others are environmental, such as reduced egg masses. The egg producer places a high value on

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each of these factors. Egg size categorization, are divided into groups based on the minimum net mass. Jumbo (above 70 g), extra-large (65-70 g), giant (56-65 g), medium (49-56 g), small (42-49 g), and peewee are the different egg sizes (35–42 g). The most prevalent sizes are medium, big, and extra-large.

The influence of egg form on the mechanical behavior of eggs under a compression stress was examined by Altuntas and Sekeroglu in 2008. The physical characteristics and mechanical behavior of eggs as they relate to egg mass are not well understood on a technical level in the scientific community.

Kul and Seker(2004) abstracted that it has been aimed to determine the internal and external quality traits of the quail eggs as well as the phenotypic correlation between these traits. As a result, it has been considered that it was possible to use the egg mass in determining the eggshell mass, shell thickness and the shell ratio instead of using these traits that are the determinants of the eggshell quality of the quail eggs.

The mechanical characteristics of the rupture force, specific deformation, rupture energy, and hardness were looked at byAltuntas and Ekerolu (2008).

Thus according Lin *et al.* (2009), an acoustic resonance-based system was created to detect eggshell cracks. It was done by analyzng the frequency response of eggshell that had been activated using a light method. Three pattern recognition algorithms—K-nearest neighbours, artificial neural network, and support vector machine—were looked at in order to create a reliable classification model. The outcomes demonstrated that, in comparison to k-nearest neighbours and artificial neural network models, the vector machine model is the most effective. With recognition rates of 95.1% in the calibration set and 97.1% in the prediction set, the best support vector machine model was discovered.

Berrueta *et al* (2007). attention was on the optimization of the acoustic system's parameters and on an analysis of the response signals' characteristic frequencies. The term "supervised pattern recognition" refers to methods where the category membership of samples used for classification is known in advance.

For the purpose of determining egg freshness, Dutta *et al.* (2003) developed an electronic nose (EN) system with four tin-oxide aroma sensors. They claimed that, depending on freshness, they could accurately divide the eggs into three groups with a 95% accuracy.

According to Casasent and Chen (2003), spectrum data can provide useful chemical, moisture, and other descriptions of an item's constituent parts, making visible/Near-infrared spectroscopy (VIS/NIRS) one of the most effective methods for quantitative and qualitative examination of foods.

Kemps *et al.* (2007) noticed that the egg business is experiencing difficulties due to intensive manufacturing with less workers. The amount of laying has increased, and their diets have improved. These elements have caused egg output to rise at a reduced price. However, this business needs accurate and trustworthy information about the egg in order to grade it exactly and to offer consumers quality that complies with their standards for egg quality.

According to Kemps *et al.* (2007), the egg industry is having trouble because of labor-intensive manufacturing. Laying populations have grown, and their diets have improved. These factors have led to an increase in egg production at a lower cost. However, in order to grade the egg precisely and provide customers with quality that meets their expectations for egg quality, this company needs reliable and accurate information about the egg.

The influence of egg form on the mechanical behavior of eggs under a compression stress was examined by Altuntas and Sekeroglu in 2008. The physical characteristics and mechanical behavior of eggs as they relate to egg mass are, however, not well understood on a technical level in the scientific community. Measures like rupture force, specific deformation, and rupture energy can be used to describe the physical characteristics of eggs as well as their resistance to damage from mechanical shock.

According to Kirmizibayrak and Altinel (2001), the egg size, egg mass, and shape index all have a significant impact on the total hatchability. The mass of an egg is one of the straightforward ways to gauge its physical features.

According to Anderson *et al.* (2004), the proportion of damaged eggs that are handled and transported has an impact on the egg shape index and shell thickness.

Our study had two main objectives. First, the test of hardness of duck shell to select suitable environment through hatching process and handling process by measuring required force to broke eggshell. The second one was to data analysis to improve eggshell quality goring handling process.

MATERIALS AND METHODS

In this work, 150 eggs with intact shells were collected from a farm within 2 days after lying. All egg sizes were used for the experiment.

The physical measurements

The physical measurements had been measured as external measurements of eggs.

Dimensions of egg samples were measured by caliper with accuracy of 0.01 mm.

External measurements of eggs were length, diameter, large end, and small end, and also, shell mass, and shell thickness wear measured.

Mass of samples was measured by sensitive digital scale with accuracy of two decimal digits of gm.

Egg volume measurement (V): The volume of the duck egg is measured by measuring the volume of the displaced water using the graduated cylinder.

Egg surface area measurement (S)

Egg surface area was calculated from the equation **(1)**

$$S = -7004.39 + 82.97\,L + 216.05\,W \quad \text{------------ (1)}$$

Where: (S): Egg surface area mm^2, (L): Egg length in mm, (D): Egg maximum diameter in mm, and(-7004.39), (82.97) and (216.05) are constants.

Egg shape index measurement

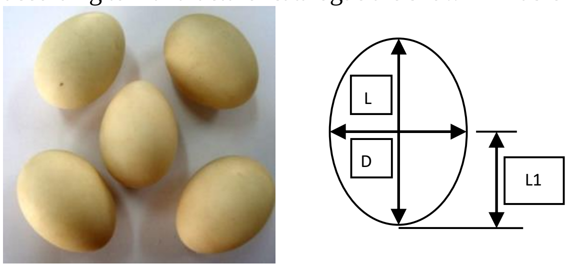
Shape Index (Sha-I) is estimated using the following equation (2), according to Anderson et. al (2004).

Shape Index = [Egg maximum diameter "D" / Egg length "L"] × 100. -------- (2)

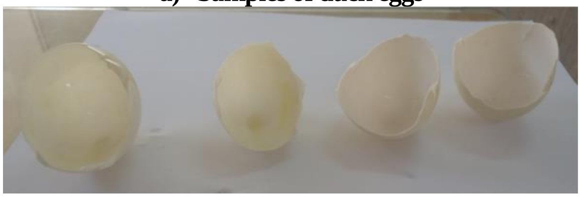
Experimental system

The impacting point was placed randomly in the intact eggshell, for each egg, in three positions (top, mid and bottom) breaking force and eggshell thickness were measured. Duck eggshells and diagram of breaking test setup of samples was used, it was illustrated in Figure (1).

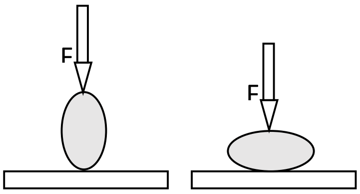
Bench top testing setup (Figure 1d, 1e) (Tinius Olsen-model H5ks-USA) using to determine the mechanical properties of the egg such as stress-strain behavior and egg firmness. The device has three main components, which are stable up and stationary bottom of the platform, a driving unit (AC electric motor and electronic variator) and the data acquisition (dynamometer, amplifier and display recorder) system. Technical specifications for bench top testing setup according to manufacturer catalogue are shown in Table (1) .



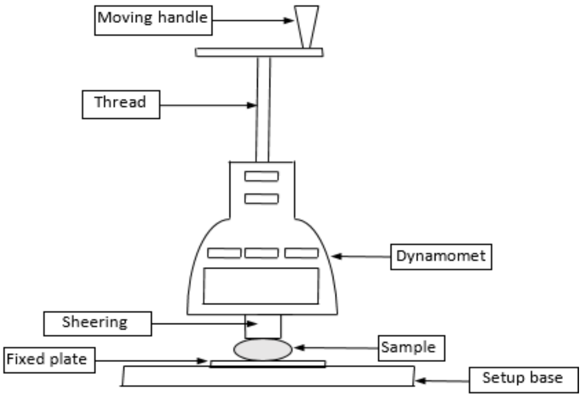
a) Samples of duck eggs



b) Samples of duck eggshell



c) Position of duck eggshell samples during breaking test



d) Diagram of breaking test setup of duck eggshell samples

e) Bench top materials testing setup.

Figure 1. Duck eggshells and breaking test

Table 1. Technical specifications for bench top testing setup.

Model (h5k)	Unit	
Capacity	kg	500
Maximum sample diameter	mm	200
Maximum crosshead travel	mm	750
Testing speed range	mm/min	0.001 to 500 up to 5kN

Eggs were placed horizontally between two flat parallel steel plates and compressed at a speed of 1.0 mm/min. The accuracy of the force sensor was ± 0·001 N. A maximum force of 10 N was exerted. The setup was used single side penetration shaft in eggshell with height 9 mm and diameter 6.36 mm, while the penetration shaft with cone height and diameter were used of 9.95 and 3.69 mm, respectively. The measurement was repeated on three equidistant places at the equator of the egg. The average value of the three measurements was used in the statistical analysis.

Statistical analysis

Descriptive analysis method had been used to describe and summarize the basic characteristics of the data to estimate how the data is distributed and develop some relationships between the variables {break force and Extension (pending distance of duck eggshell)}and know the values in which the data is concentrated.

Using ANOVA (analysis of variance) in one way to study the presence of significant differences between the average distance of the weapon advance to the sample in the first three cases are at top, middle and bottom of the egg - at the level of significance 5%.

RESULTS AND DISCUSSION

Physical properties of Duck eggshell:

Figures (2, 3 and 4) show that the frequency percentage distribution of physical properties of duck and eggshell, which important to specify quality of duck eggs and very important during handling process and hatching eggs during incubation process. Figure (2) shows the curves of the middle and top thickness distribution of the duck eggshell are the same, but it is not necessary the same value on the same egg.

The data presented in Table (2) indicate the results analysis of some physical properties measured for duck eggs, which were collected through 9 separate samples, and it was found that for the characteristics of the egg length and the maximum egg diameter, its minimum reached 53.36, 41.41 mm and the maximum 61.62, 44.25 mm and the values of the standard were 2.768, 0.963 mm for both the length attribute and the maximum egg diameter respectively, which indicates that there is no dispersion in the data and that most of the data falls around its arithmetic mean of 56.19 and 42.94 mm, respectively. Also, it was found that the minimum value of the adjective value is the longest distance from the diameter to the bottom which amounted to 17.59 mm, while the maximum reached 31.96 mm, and the values of standard deviation was 5,482. Relatively large value shows the existence of figures after anomalies of this character far removed from the middle of arithmetical 24.17 mm.

The data presented in Table (2) indicate the results of the analysis of some of the calculated physical properties of duck eggs, which were collected through 9 separate samples, and with regard to the shape index, surface area, and volume of the egg, it was found that the minimum limit for it was 0.71, 16714.662 mm^2, and 44 mm^3 Respectively, while the maximum reached 0.79, 20408.00 mm^2, and 60.0 mm^3 on the tip, and the standard deviation values were 0.030, 1335.763, and 4.690 respectively, and it indicates that the data is not widely dispersed in the data of this attribute and its occurrence around its arithmetic mean, 077, 18071.11 mm^2 and 16.0 mm^3, respectively.

With regard to the characteristics of the duck egg shell, which was tested, the results shown in Table (2) also indicated that for the egg shell thickness attribute in the middle, top and bottom of the egg, it was found that their minimum value was of 0.10, 0.10, and 0.10 mm, while the maximum value reached to 0.30, 0.30, 0.30 mm respectively, and the standard deviation values were 0.061, 0.061, 0.058 respectively, and it indicates that the data is not dispersed and its presence is around its mean of 0.23, 0.23, and 0. 21 mm, respectively, for these characteristics.

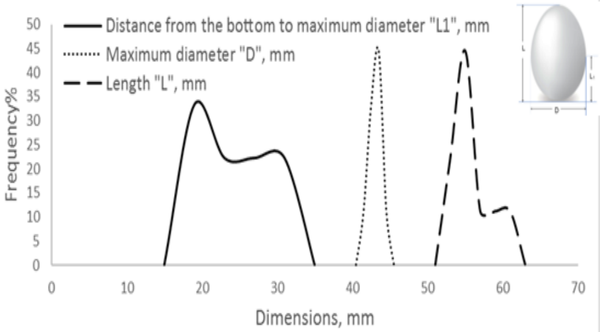


Figure 2. Frequency percentage distribution of egg duck dimensions.

In general, the results show that there is great stability in the physical properties of duck eggs and shell characteristics such as, the egg length and the maximum egg diameter which followed also with the shape index, surface area, and volume of the egg,

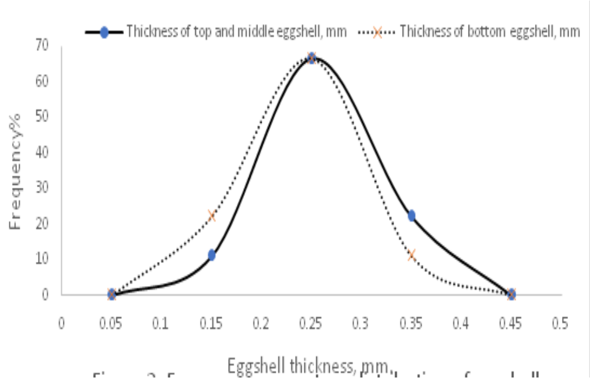


Figure 3. Frequency percentage distribution of eggshell duck thickness.

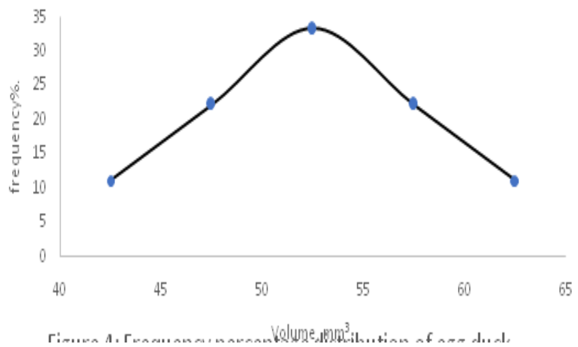


Figure 4. Frequency percentage distribution of egg duck volume.

Table 2. Statistical analysis of Physical properties of Duck egg.

Sample No.	Length, mm	Maximum diameter, mm	Maximum distance of diameter from the bottom, mm	Shape index	Egg surface area, mm2	Volume, mm3	Thickness of middle eggshell, mm	Thickness of top eggshell, mm	Thickness of bottom eggshell, mm
Min	53.36	41.41	17.59	0.71	16714.56	44.00	0.10	0.10	0.10
Max	61.62	44.25	31.96	0.79	20408.00	60.00	0.30	0.30	0.30
Rang	8.26	2.84	14.37	0.08	3693.44	16.00	0.20	0.20	0.20
Aver.	56.19	42.94	24.17	0.77	18071.11	52.17	0.23	0.23	0.21
S.D	2.768	0.963	5.482	0.030	1335.763	4.690	0.061	0.061	0.058
S^2	7.660	0.927	30.052	0.001	1784262.86	22.000	0.004	0.004	0.003
Aver.S^2	0.851	0.103	3.339	0.000	198251.429	2.444	0.000	0.000	0.000
S.E.	0.9226	0.3210	1.8273	0.0102	445.2543	1.5635	0.0204	0.0204	0.0194
C.V.	1.6417	0.7476	7.5596	1.3269	2.4639	2.9971	8.7482	8.7482	9.4595

Relationship between break force and Extension (pending distance of duck eggshell) in different position of egg

The results shown in figure (2) indicate to the relationship step of progress blade towards egg and required break force in top, mid and low positions of egg.

From the results in figure (2), the large step progress towards the egg was during the press towards in bottom position of egg, which was ranged between 0.02 to 13.80 mm, with average 6.90 mm, this extension resulted in the largest required break force in towards in bottom position of egg, which was ranged between 0.05 to 32.70 with average 14.73. Meanwhile, the lowest step progress towards the egg was during the press towards in middle position of egg, which was ranged between 0.02 to 9.0 mm, with average 4.50 mm, this extension resulted in the lowest required break force in towards in middle position of egg, which was ranged between 0.11 to 25.76 with average 12.23. But, the values of step progress towards the egg during the press towards in top position of egg were intermediate the step progress values of towards bottom and middle of egg, which was ranged between 0.02 to 12.80 mm, with average 6.40 mm, this extension resulted in the required break force in towards in top position of egg, that also, intermediate the break force values of towards bottom and middle positions of egg, which was ranged between 0.05 to 32.24 with average 14.91 N. That is mean; it shall be to design the incubator of duck eggs incubation under environment conditions of temperature degree and relative humidity, which allow by the pressing on egg by high break force (32.70), which was towards bottom position of egg. The average change of break force over time is depicted in Figure (5).

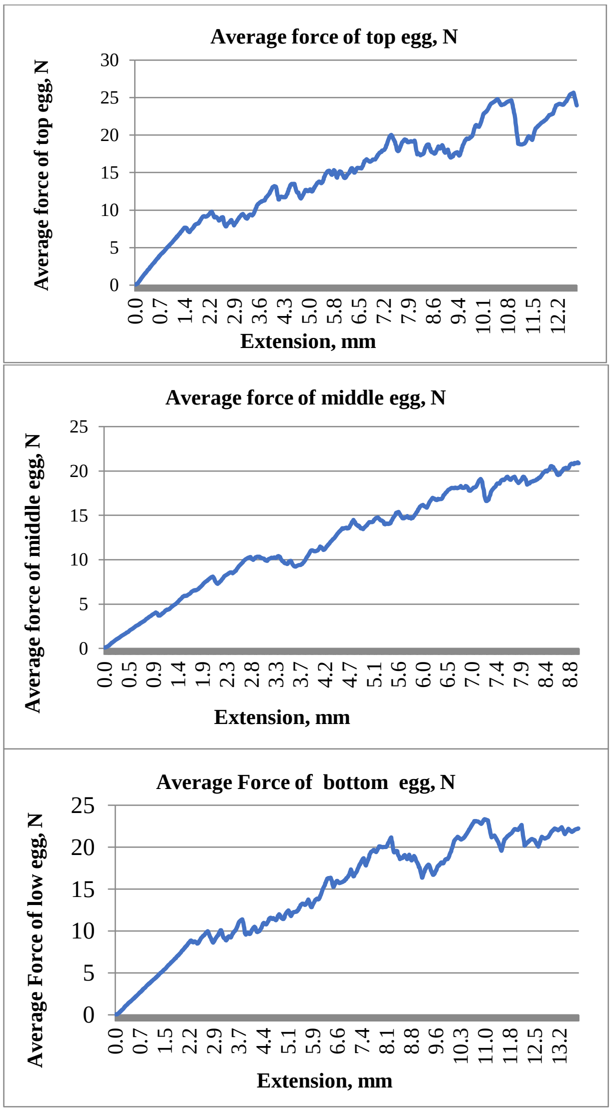


Figure 5. Relation between break force and Extension in different position of egg.

Relation between the break force and extension on the top of duck eggshell

Table (3) shows all break forces which were affected on tops of duck eggshell samples, it showed significant differences in terms of break forces, with extension tops of duck eggshell having the minimum value 0.05 N at extension distance of 0.02 mm and the maximum value 32.24 N at extension distance of 12.80 mm, therefore the average value 14.91 N at extension distance of 6.40 mm. According the pervious date, the data analysis showed that the standard deviation of break force on top duck eggshell was 7.53 at 3.70 of extension distance, and the variation of break force on top duck eggshell was 57.64 at 13.69 of extension distance, the standard error of break force on top duck eggshell was 0.26 at 0.1266 of extension distance, coefficient of variance of break force on top duck eggshell was 1.74 at 1.9791 of extension distance. Nine samples of duck eggs have been tested and numbered from N1 to N9.

Relation between the break force and extension on the middle of duck eggshell:

Table (4) shows all break forces which were affected on middles of duck eggshell samples, it showed significant differences in terms of break forces, with middles of duck eggshell having the minimum value 0.11 N at extension distance of 0.01 mm and the maximum value 25.76 N at extension distance of 9.0 mm, therefore the average value 12.23 N at extension distance of 4.50 mm. According the this result, the data analysis showed that the standard deviation of break force on middle duck eggshell was 6.52 at 2.60 of extension distance, and the variation of break force on middle duck eggshell was 46.88 at 6.784 of extension distance, the standard error of break force on middle duck eggshell was 0.27 at 0.1062 of extension distance, coefficient of variance of break force on middle duck eggshell was 2.17 at 2.3609 of extension distance. Twelve samples of duck eggs have been tested and numbered from N1 to N12.

Table 3. Statically analysis of extension and penetrate force in the top duck eggshell

	Extension mm	Force N1	Force N2	Force N3	Force N4	Force N5	Force N6	Force N7	Force N8	Force N9	General Average
Average	6.40	16.32	17.59	14.27	11.60	16.31	15.68	11.53	14.00	16.90	14.91
Min	0.02	0.04	0.05	0.04	0.04	0.05	0.04	0.04	0.08	0.05	0.05
Max	12.80	30.00	34.90	27.92	27.52	41.00	28.40	26.48	37.92	36.00	32.24
Range	12.78	29.96	34.85	27.88	27.48	40.95	28.36	26.44	37.84	35.95	32.19
Std	3.70	7.30	8.01	6.95	6.26	8.82	6.85	6.33	9.08	8.16	7.53
Variation(s2)	13.690	53.292	64.157	48.252	39.184	77.765	46.987	40.033	82.491	66.560	57.64
V.of Mean	0.0160	0.0624	0.0751	0.0565	0.0459	0.0911	0.0550	0.0469	0.0966	0.0779	0.07
S.E.	0.1266	0.2498	0.2741	0.2377	0.2142	0.3018	0.2346	0.2165	0.3108	0.2792	0.26
C.V	1.9791	1.5303	1.5581	1.6662	1.8462	1.8503	1.4963	1.8771	2.2193	1.6522	1.74

Table 4. Statically analysis of extension and penetrate force in the middle duck eggshell

	Extension mm	Force N1	Force N2	Force N3	Force N4	Force N5	Force N6	Force N7	Force N8	Force N9	Force N10	Force N11	Force N12	General mean
Mean	4.500	10.106	12.787	10.519	10.445	10.440	13.325	8.598	15.005	10.596	11.869	21.018	12.088	12.23
Min	0.00	0.04	0.05	0.05	0.04	0.04	0.04	0.03	0.04	0.04	0.76	0.15	0.04	0.11
Max	9.00	21.32	28.35	31.60	21.84	21.92	25.16	16.08	32.68	18.40	23.52	42.68	25.52	25.76
Range	9.00	21.28	28.30	31.55	21.80	21.88	25.12	16.05	32.64	18.36	22.76	42.53	25.48	25.65
Std	2.60	6.26	6.35	8.40	5.27	5.15	6.54	4.57	7.03	4.87	5.18	12.60	5.97	6.52
Variation	6.784	39.249	40.338	70.577	27.768	26.546	42.790	20.846	49.439	23.711	26.862	158.795	35.653	46.88
V.of Mean	0.0113	0.0653	0.0671	0.1174	0.0462	0.0442	0.0712	0.0347	0.0823	0.0395	0.0447	0.2642	0.0593	0.08
S.E.	0.1062	0.2556	0.2591	0.3427	0.2149	0.2102	0.2668	0.1862	0.2868	0.1986	0.2114	0.5140	0.2436	0.27
C.V	2.3609	2.5288	2.0261	3.2577	2.0578	2.0130	2.0024	2.1662	1.9115	1.8746	1.7813	2.4456	2.0149	2.17

Relation between the break force and extension on the bottom of duck eggshell:

Table (5) shows all break forces which were affected on bottoms of duck eggshell samples, it showed significant differences in terms of break forces, with bottoms of duck eggshell having the minimum value 0.05 N at extension distance of 0.02 mm and the maximum value 32.70 N at extension distance of 13.80 mm, therefore the average value 14.73 N at extension distance of 6.90 mm. According to date in table 5, the data analysis showed that the standard deviation of break force on bottom duck eggshell was 8.02 at 3.99 of extension distance, and the variation of break force on bottom duck eggshell was 64.99 at 15.922 of extension distance, the standard error of break force on bottom duck eggshell was 0.26 at 0.1315 of extension distance, coefficient of variance of break force on bottom duck eggshell was 1.81 at 1.9055 of extension distance. Nine samples of duck eggs have been tested and numbered from N1 to N9.

The highest average value of break value was (14.91 N) at extension distance of 6.40 mm on top duck eggshell sample, while the lowest value was (12.23 N) at extension distance of 4.50 mm on middle duck eggshell sample. The average value of break force for bottom duck eggshell of (14.73 N) at extension distance of 6.90 mm was intermediate between top and middle duck eggshell samples.

The ordering of the strains by pressing toward the middle, top, and bottom positions of the egg and step progress blade corresponds to the ordering of the strains from weakest to highest in terms of break force stiffness. Given the extremely strong correlation between these two variables, this was to be expected (break force and step progress blade towards of egg). A strong correlation was found between break force and step progress of blade towards the eggs during measurements the compression on eggs in different positions. So, the break force was related to the genetic strains of laying, this work is required to determine which variable or combination of variables gives the best results in terms of shell quality in relation to resistance to breaking under practical conditions.

In contrast to all other factors, dynamic stiffness or break force offers a comprehensive measurement of an egg's strength and enables a quick evaluation of shell strength. This is as a result of the analysis of the egg's overall response to dynamic impact. Due to the dynamic nature of the forces applied to eggs under practical circumstances, dynamic stiffness or break force may be of particular importance for evaluating shell strength. In order to achieve the ultimate goal of any selection for shell strength, it should be determined whether selection on dynamic stiffness or break force results in a lower percentage of eggshell breaking in actual use.

Table 5. Statically analysis of extension and penetrate force in the bottom duck eggshell

	Extension mm	Force N1	Force N2	Force N3	Force N4	Force N5	Force N6	Force N7	Force N8	Force N9	General Average
Mean	6.900	16.823	16.077	12.580	13.691	16.771	16.028	14.461	11.448	14.663	14.73
Min	0.02	0.10	0.05	0.04	0.04	0.08	0.04	0.04	0.04	0.04	0.05
Max	13.80	39.75	36.85	25.00	30.84	32.00	33.52	30.24	30.00	36.08	32.7
Range	13.79	39.65	36.80	24.96	30.80	31.92	33.48	30.20	29.96	36.04	32.65
Std	3.99	9.12	8.69	6.61	7.07	8.47	7.75	7.46	8.44	8.59	8.02
Variation(s2)	15.922	83.188	75.459	43.721	50.032	71.803	60.061	55.664	71.199	73.805	64.99
V.of Mean	0.0173	0.0903	0.0819	0.0475	0.0543	0.0780	0.0652	0.0604	0.0773	0.0801	0.07
S.E.	0.1315	0.3005	0.2862	0.2179	0.2331	0.2792	0.2554	0.2458	0.2780	0.2831	0.26
C.V	1.9055	1.7864	1.7804	1.7319	1.7024	1.6648	1.5933	1.7001	2.4288	1.9306	1.81

The results shown in table (6) indicate that the minimum and maximum strength required to break the egg and the occurrence of hatching and measured in three places, namely the top of the egg shell and the middle of the shell, then the bottom of the egg shell shows that it reached (0.05 and 32.24), (0.11 and 25.67), (0.05 and 32.70), respectively. The standard divisions values for each of them was 7.53, 6.52, and 8.02, respectively, and the average values were 14.91, 12.23, and 14.73, respectively, meaning that the amount of dispersion in the data in the case of the force needed to break the egg shell from the top is lower than the other two cases

Table 6. Average of statically analysis of extension and penetrate force in the duck eggshell types.

Eggshell types	Average	Min.	Max.	Range	S.td	Variation (s2)	Mean of variation	S.E.	C.V.
Top of Eggshell	14.91	0.05	32.24	32.19	7.53	57.64	0.07	0.26	1.26
Mid of Eggshell	12.23	0.11	25.67	25.65	6.52	46.88	0.08	0.27	2.17
Bottom of Eggshell	14.73	0.05	32.70	32.65	8.02	64.99	0.07	0.26	1.81

The results shown in Table (7) show that the minimum distance the blade advances from the egg shell is 0.015 mm, and the maximum value is about 9.0 mm in the case of approaching the middle of the egg shell and about 13.8 mm in the event of approaching the bottom of the egg shell. The results of ANOVA came to clarify the significance of the differences between the distance of progress of the blade towards the egg shell in the case of approaching the top, middle or bottom, where the value of p-value was significant at the level of 1%, 5%

And by doing LSD analysis, it was found that there were significant differences between the three cases of the distance of the breakage blade towards the egg, meaning that the force required to break the egg varies according to the breakage side.

Table 7. the results of ANOVA to show the differences between the distances of the blade's advance towards the egg shell in different positions.

One-way ANOVA	Extension of Top		Extension of Middle		Extension of Bottom	
	Min.	Max.	Min.	Max.	Min.	Max.
Descriptive	0.15	12.795	0.15	9.000	0.15	13.800
Sig.	0.000					
F	85.357					

The results of ANOVA analysis showed that when comparing the force needed to break the egg at constant levels of the pressure blade on the nine samples in three cases, which are pressure from the top of the egg and pressure from the middle and then pressure from the bottom of the egg, the results show that the average strength in the case of pressure from the egg top reached 39.698 While in the case of pressure at the center of the egg reached 33.402 and in the case of pressure from the bottom of the egg the average pressure strength reached 40.853 , as the value of P-Value shows that there are significant differences between each case and this means that the pressure strength needed to break the egg varies according to the area of the egg breaking.

Therefore, it is preferable to use the greatest pressure force needed to break the egg to ensure the highest hatching rate inside the hatchery.

Table 8. ANOVA analysis to compare the force needed to break an egg at fixed levels of the pressure blade on different samples

One-way ANOVA		Sum of squares	df	Mean square	F	Sig.
Top	Between groups	33822.944	852	39.698	980204.722	0.001
	Within groups	0.000	1.00	0.000		
	Total	33822.944	853			
Middle	Between groups	20007.608	599	33.402	401438.412	0.001
	Within groups	0.000	1.00	0.000		
	Total	20007.608	600			
Bottom	Between groups	37543.849	919	40.853	2269607.606	0.001
	Within groups	0.000	1.00	0.000		
	Total	37543.849	920			

CONCLUSION

- In general, there is great stability in the physical properties of duck eggs and shell characteristics such as, the egg length and the maximum egg diameter which followed also with the shape index, surface area, and volume of the egg,
- For thickness of eggshell, it indicates that the data is not dispersed and its presence is around its mean of 0.23, 0.23, and 0.21 mm, respectively.
- To design the incubator of duck eggs incubation under environment conditions of temperature degree and relative humidity, the high break force (32.70) , which was towards bottom position of egg.
- The ordering of the strains from weakest to strongest in terms of break force stiffness, a strong correlation was found between break force and step progress of blade towards the eggs in different positions.
- The results clarify the significance differences between the distance of progress of the blade towards approaching the top, middle or bottom, the value of p-value was significant at the level of 1%, 5% meaning that the force required to break the egg varies according to the breakage side.
- Therefore, it is preferable to use the greatest pressure force needed to break the egg to ensure the highest hatching rate inside the hatchery.

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القوة المطلوبة لاختراق قشر بيض البط لحمايته عند التداول والفقس

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الملخص

يهدف البحث إلي دراسة القوة اللازمة لكسر قشرة بيض البط مما يساعد على توفير الظروف الخاصة بعملية فقس البيض والتداول، وقد تم قياس الخصائص الطبيعية والميكانيكية والتى ترتبط بالتأثير فى قوة قشرة.استخدم طريقة التحليل الوصفى للبيانات ، وكانت أهم النتائج كالتالى: الوسط الحسابي لطول البيضة وأطول مسافة من القطر الى القاع 56.19، 42.94 مم ، الوسط الحسابي لمعاامل الشكل والمساحة السطحية وحجم البيضه 0.77 ، 18071.11 مم^2، 16.0 مم^3 الوسط الحسابي لسمك قشرة البيضه من ناحية وسط وقمه وقاع البيضة 0.23 مم ، 0.23 مم^2، 0.21 مم^3، الحد الادنى والاقصى للقوة اللازمة لكسر البيضة وحدوث الفقس والمقاسة عند ثلاث مواضع وهم قمة قشرة البيضة ووسط القشرة ثم قاع قشرة البيضة (0.05، 32.24 نيوتن)، (0.11، 25.67 نيوتن)، (0.05، 32.70 نيوتن) ، الانحراف المعيارى لكل منهم 7.53، 6.52، 8.02 على الترتيب، وان المتوسط بلغ 14.91، 12.23، 14.73 نيوتن على الترتيب . الحد الادنى للمسافة التى يتقدم بها السطح من قشرة البيضة تبلغ 0.015 مم ويبلغ الحد الاقصى 9.0 مم فى حالة الاقتراب من وسط قشرة البيضة ، 13.8 مم فى حالة الاقتراب من قاع قشرة البيضة. نتائج تحليل ANOVAتبين أن هناك فروق معنوية في قيمة قوة الضغط اللازمة لكسر البيضة تبعا لمنطقة كسر البيضة.وأقلها عند الوسط منطقة الكسر (الأنهيار) عند فقس البيضة. يفضل استخدام أكبر قوة ضغط (32.7 نيوتن) لكسر البيضة لضمان الحصول على أعلى نسبة فقس داخل المفرخ.