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Effects of Eggshell Thickness, Egg Weight and Shape Index on Hatch Window and Turkey Poults' Gender

Yumurta Kabuğu Kalınlığı, Yumurta Ağırlığı ve Şekil İndeksinin Çıkış Penceresi ve Hindi Civcivlerinin Cinsiyeti Üzerine Etkileri

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Abstract: The effects of eggshell thickness (EST), shape index (SI) and egg weight (EW) on the hatch window (HW), hatching time (HT), gender of hatched turkey poults hatched were investigated. Total of 150 commercial Hybrid Converter breed turkey hatching eggs obtained from a turkey meat producing integration were used. The effects of these parameters on HW and HT and gender were analyzed via ANOVA-GLM. The hatching window was 656th – 688th hours, and the procedure concluded during the 688th hour of incubation. The incubation was divided into three partitions as early (656 – 667h), midterm (668 – 676h) and late hatches (677 – 688h), with the final 32 hours of incubation divided into 7 partitions (7P) from 1 to 7 as (656 – 664h, 665 – 668h, 669 – 672h, 673 – 676h, 677 – 680h, 681 – 684h and 685 – 688h). A significant relation between EST and gender was found as eggs with thicker EST female chicks hatched more than males ($p<0.05$). There was no correlation between gender and EW and SI ($p>0.05$). Meanwhile, the number of hatches for 7P, EST, EW and SI were not found to affect the hatch window of turkey eggs ($p>0.05$).

Keywords: Eggshell thickness; hatch window; shape index; turkey; gender.

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Öz: Yumurta kabuk kalınlığı (EST), şekil indeksi (SI) ve yumurta ağırlığının (EW) kuluçka penceresi (HW), kuluçka süresi (HT), kuluçkadan çıkan hindi civcivlerinin cinsiyeti üzerine etkileri incelenmiştir. Bir hindi eti üretim entegrasyonundan elde edilen toplam 150 ticari Hybrid Converter cinsi hindi kuluçkalık yumurtası kullanıldı. Bu parametrelerin HW ve HT ve cinsiyet üzerindeki etkileri ANOVA-GLM ile analiz edildi. Kuluçka penceresi 656. – 688. saatlerdi ve prosedür, inkübasyonun 688. saatinde tamamlandı. Kuluçka erken (656 – 667 saat), ara dönem (668 – 676 saat) ve geç çıkım (677 – 688 saat) olarak üç bölüme ayrıldı ve son 32 saat kuluçka, 1'den 7'ye kadar 7 bölüme (7P) bölündü (656 – 664s, 665 – 668s, 669 – 672s, 673 – 676s, 677 – 680s, 681 – 684s ve 685 – 688s). Dişi civcivlerin erkeklere göre daha fazla yumurtadan çıkması nedeniyle EST ile cinsiyet arasında anlamlı bir ilişki bulunmuştur ($p<0.05$). Cinsiyet ile EW ve SI arasında korelasyon yoktu ($p>0.05$). Bu arada, 7P, EST, EW ve SI için çıkış sayısının hindi yumurtalarının çıkış penceresini etkilemediği bulundu ($p>0.05$).

Anahtar Kelimeler: Yumurta kabuk kalinliği, çikiş penceresi, şekil indeksi, hindi, cinsiyet

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INTRODUCTION

Poultry production is undertaken by heavily advanced integrated companies in industrialized countries. Sophisticated techniques are used in the poultry meat industry with great contemporary expertise and modern management strategies. High quality meat and maximum yield are required. Any contribution of knowledge or a new technique may contribute to the poultry industry with greater overall income.

The first step of the production chain is the hatchery, where the greatest part of total investment is made by companies, with a focus on hygiene and overall workflow. In hatcheries, some parameters are well-known as egg quality parameters affecting hatchability and as well hatchery performance, which primarily consist of egg weight (EW), egg shell color, eggshell thickness (EST), egg length, egg width, shape index (SI) and porosity (Narushin and Romanov, 2002; Yamak et al., 2015). Those hatchery performance parameters are known to be affected by genetic construct, breeder health conditions, breeder age and egg quality (Türkoğlu and Sarıca, 2014).

The most important aspects of the hatchery performance are known as hatchability, embryonic mortality, hatching time (HT), hatch window (HW) and overall chick quality (Elamin et al., 2014; Elibol and Türkoğlu, 2014; Bergoug et al., 2013; Türkoğlu and Sarıca, 2014).

The EST of turkey breeder eggs have been measured as 0.33 - 0.42 µm by some researchers (Christensen and Nestor, 1994; Akıncı et al., 1999) where broiler breeder eggs' EST was found to be around 0.33 – 0.40 µm (Yamak et al., 2015). It has been reported that eggshell thickness does not affect hatchability and mortality (Elamin et al., 2014) in broilers.

The hatch window has been considered an essential criterion by hatcheries and academicians worldwide for decades and has been defined as the time passed from the first chick until the majority of the chicks hatch and incubation is completed by emptying the machine, also known as "take off" (Bergoug et al., 2013; Yamak et al., 2015).

It has been stated that shell thickness should be investigated with great care and samples should be selected carefully and measured correctly without destructing the eggshell. The measurement for the thinning of the eggshell during incubation is said to be incorrect if measured using improper methods. Thus, it has been suggested to measure the eggshell thicknesses with non-invasive methods to obtain better data for parameters like EST and embryonic development (Aslam et al., 2013; Orlowski et al., 2015). It has also been stated that the non-destructive measurement of the eggshell thickness is important for researchers and spectroscopy, and the ultrasonic thickness gauge was proposed to be enhanced for more consistent measurement (Narushin et al., 2004). An ultrasonic device for measuring the EST of hatching eggs was first built in 1972 where the device was able to measure the thickness of eggshell with an error of 1.1 µm and a handicap of being unable to measure eggshells thinner than 25 µm. The equipment considered imprecise and inadequate to obtain healthy measurements in a practical manner. For decades, the only equipment used was the Vernier calipers which could only measure the thickness after breaking the egg shell (Gould, 1972).

With industrial evaluation, deviation of measurements is below 1 µm and all EST can be measured (Orka Tech. Ltd., Israel). The device has also gotten smaller and lighter in weight from around 4.500 kg to 0.250 kg enabling mobility as well as wellbeing The device has reached ± 0.1 µm of accuracy as reported by researchers (Yamak et al., 2016).

Research has shown that EST can be measured using the specific gravity method (Hamilton, 1982), however this method is impractical for industrial organizations and is only suitable for academic verification of non-destructive equipment (NDE) or a new method, where a the Vernier caliper can be more practically used to correct the data gathered by a NDE post-hatching or by breaking the egg. It has been reported by researchers that the thickness and porosity of the eggshell has an effect on incubation results and non-destructive methods should be used to measure the eggs and, that breeding should be based on the data gathered in order to achieve better success in breeding (Saylam and Sarıca, 1999). It was also reported by researchers that breeding for egg weight loss and eggshell quality should improve breeding results and hatchery performance (Türkyilmaz, 2005).

As far as we know, there is no data from previous experiments relating EST with the gender of the hatched poults. This experiment was primarily designed to understand if the gender of the hatchlings differ according to EST and if eggs with thinner EST hatch earlier in the incubators.

Data to be obtained will be important for hatchery performance as well as providing an opportunity to prevent some of the male birds from being culled in breeder and layer industries where they are considered useless if a relation is found between EST and gender. According to researchers (Karautwald-Junghans et al., 2018), there will be a potential in ovo sexing procedure in the near future, which will make it feasible to arrange the eggs in distinct compartments or trolleys for easier and healthier takeoffs, as well as to obtain more females and less males. It has been stated that EST does not affect hatchability and mortality (Elamin et al., 2014). This experimental data is the first to show how the pre-incubation EST affects HW and hatched chick gendermeasured by a non-destructive method for turkey hatching eggs.

MATERIAL AND METHOD

The study was conducted at Bolca Hindi's (turkey production integration) hatchery located in Bolu (northern Turkey) with 150 turkey eggs obtained from the same integration. The eggs originated from Canada and they were collected from the same turkey breeder flock of Hybrid Converter EU genotype on the same day at the age of 46 weeks.

The eggs were weighed using a laboratory (1/1000) precision scale (Radwag AS 220.R2, Poland). Egg length (EL) and egg width (EWd) were measured by a digital (1/100) precision Vernier caliper (Mitutoyo 500-181-30, Japan) and Shape Index (SI) values were calculated via the formula of SI = (EWd / EL) * 100 and were recorded as data. All the eggs were numbered individually to ensure the accuracy of hatching time and hatch window data. The eggs were later handled to measure the egg shell thickness (EST) data where a non-destructive ultrasonic egg shell thickness gauge was emplyed (Orka Tech. Ltd., Israel) to measure the EST values. The EST data were recorded three times and the mean values were taken as the EST value. The instrument is useful to measure the unhatched eggs' shell thicknesses with an accuracy of ± 0.1 μm. EST measurements were performed at the blunt side of the eggs. The precision of the equipment was formerly tested in 100 table eggs by first measuring with the gauge and then breaking and measuring the exact same point of the egg by Vernier caliper, so it can be concluded that the gauge works with 0.1 μm accuracy.

The measured eggs were finally placed in the incubator of the company (Petersime PM-13, Belgium) with a capacity for 14200 turkey eggs. The standard procedure of the hatcher was carried out with no interference to the hatcher program and there has not been any manipulation to the machine controls and hatched poults until hatching was complete. The temperature applied during the first 24 days of incubation was 37.5˚C and relative humidity was 56.0%. For the last 4 days of incubation, the temperature was lowered to 37.0˚C and relative humidity was raised to 60.0%. At day 14 of the incubation period, candling was undergone and unfertile eggs were removed from the experiment. At day 24 of incubation, the eggs were transferred from trays to hatch baskets which were formerly divided into individual compartments by hand made plastic barriers, allowing airflow throughout the machine for the eggs to be individually observed at hatching, and having the same amount of space for each egg.

During the final 32 hours of the incubation process starting at 656 hours to 688 hours, the baskets were taken out every 4 hours, hatched poults' numbers were recorded, and baskets were immediately placed into their former places to avoid cooling the eggs. As a secondary precaution to keep the eggs warm, 250 watt infrared lamps (General Electric IR 250) were set up above the hatch inspection table.

The statistical analyses were carried out from the data collected every 4 hours and the findings are shown in Table 1. Additionally, the data were analyzed as if the hatch is uniformly divided into three parts homogeneously as early (656-667 hours), midterm (668-676 hours) and late (677-688 hours of incubation) hatches by a 3 interval period test and the findings are shown in Table 2.

After the hatching period ended, hatched poults were sexed by expert sexors and the findings were recorded individually.

After assuring the homogeneity of the gathered data by a homogeneity test (Skewness and Kurtosis), statistical analyses were carried out with the ANOVA method (Kocabaş et al., 2013) using SPSS v. 22.0 software program (SPSS, 2013) where the detailed analyses were made by the Shapiro-Wilk test. The effects of EL, EWd, SI, and EST on HW and gender of the hatched poults were analyzed using a general linear model as seen in Formula 1., where these means were compared using Tukey's test per gender with an error margin of 5%. In the text and tables, the findings were recorded as means ± standard error of the means (M ± SEM).

Formula 1. The statistical model undertaken in the research.

$$Yijkl = \mu + \alpha i + \beta j + \Omega k + eijk \qquad (1)$$

Yijkl: independent variable, μ: Population mean, αi: Effect of EST (Thin, Medium, Thick), βj: Effect of EW (Light, Medium, Heavy), Ωk: Effect of SI (Low, Medium, High), eijk: error.

RESULTS AND DISCUSSION

The primary goal of the research was to see if the hatch window of turkey eggs was affected by sorting the eggs in accordance with their shell thicknesses. From the findings of the research, no significant effect of EST on hatch window was found as seen in Table 1 and 2 (p>0.05). These data are in line with findings of another study (Elamin et al., 2014).

Table 1. The effect of EW, EST and SI on 7 partitioned HW of hatched turkey poults.
Çizelge 1. Kabuk Kalınlığının Çıkış Gücüne Etkilerinde Çıkış Penceresinin 7 parçalı olma durumu.

	Egg Weight, g			Egg Shell Thickness, µm			Egg Shape Index		
Hours	M		SEM	M		SEM	M		SEM
656 – 664	98.570	±	2.130	48.290	±	2.070	69.662	±	0.652
665 – 668	99.710	±	2.050	49.800	±	1.240	70.734	±	0.627
669 – 672	96.880	±	1.330	48.400	±	0.746	71.015	±	0.512
673 – 676	98.090	±	1.130	48.439	±	0.511	70.077	±	0.423
677 – 680	95.980	±	1.220	48.333	±	0.564	71.474	±	0.427
681 – 684	98.660	±	1.610	48.950	±	0.922	70.870	±	0.576
685 – 688	97.270	±	2.440	45.000	±	0.949	72.280	±	1.490
p Value		0.758			0.452			0.637	

EST was found to be in relation with gender in the experiment where female turkey poults hatched mainly from thicker shelled eggs and males from thinner shelled eggs (p<0.01) as seen in Table 3. As there is no evident data reported in former research about this view, this issue is promising for pre-sexing (in ovo sexing) the poults before placing them in the machine. More extensive work should be carried out in this way of look, additionally regarding layers and breeders. This is important as males of layers and breeders cannot grow economically or provide a satisfactory meat yield, resulting in them being culled and sent to grinders which emerges an issue of welfare and is relevant as an uneconomical act as well, as told by researchers (Krautwald-Junghans et al., 2018). Further experiments on this subject may provide new data and by sorting eggs regarding EST and other related parameters, some part of the male birds may be saved from culling after hatching and their eggs may be transferred to the pastry industry or others for a more esteemed and humane industry.

Table 2. The effect of EW, EST and SI on 3 periods HW of hatched turkey poults.
Çizelge 2. Kabuk kalinliğinin çikiş gücüne ve şekil indeksine 3 çikiş dilimine göre etkileri.

	Egg Weight, g			Egg Shell Thickness, µm			Egg Shape Index		
Period	**M**		**SEM**	**M**		**SEM**	**M**		**SEM**
Early	97.580	±	1.020	48.568	±	0.644	70.721	±	0.381
Midterm	97.150	±	0.832	48.392	±	0.376	71.254	±	0.301
Late	98.380	±	1.360	48.160	±	0.820	71.152	±	0.546
p Value	0.736			0.909			0.578		

The means and standard deviations of EST, EW and SI were found to be 48.29 ± 5.64 µm, 98.57 ± 5.64 g and 69.66 ± 1.73, respectively. These findings are given in Table 1 and 2. The findings are in line with other studies' findings stating that the EST values are between 0.38 - 0.57 µm (Akinci et al. 1999; Aslam et al., 2013, Christensen and Nestor, 1994; Elamin et al., 2015; Narushin et al., 2004; Yamak et al., 2015; Yamak et al., 2016).

As the controls were made at 4-hour periods, the data obtained concerning EW, EST, EWD, EL and SI affecting the HW are shown in Table 1. As can be seen, no significant relation has been discovered between the HW and the traits rinsed on ($p>0.05$). Our findings are comparable to those of other studies (Yamak et al., 2015; Yamak et al., 2016). The periods of a standard hatch window are described as 3 parts; early, midterm and late (Yamak et al., 2015). Controls of eggs in the machine were done every 4 hours during the last 32 hours of incubation. The collected data concerning EW, EST, EWD, EL and SI in terms of early (656 – 667 hours), midterm (668 – 676 hours) and late hatch (677 – 688 hours) periods affecting the HW are shown in Table 2. As seen, no significant relation has been discovered between the HW and the traits focused on in the research ($p>0.05$). Thus, it can be concluded that the hatch window cannot be altered by the criteria of interest in this experiment.

Gender has not been observed be related with EW and SI ($p>0.05$).

Table 3. The effect of EW, EST, and SI on gender of hatched turkey poults.
Çizelge 3. Yumurta ağirliği, kabuk kalinliği ve şekil indeksinin yumurtadan çikan hindi palazlarinin cinsiyeti üzerine etkileri.

	Egg Weight, g			Egg Shell Thickness, µm			Egg Shape Index		
Gender	**M**		**SEM**	**M**		**SEM**	**M**		**SEM**
Male	97.928	±	0.732	47.638^{b}	±	0.407	71.224	±	0.283
Female	96.873	±	0.960	49.482^{a}	±	0.428	70.899	±	0.340
p Value	0.376			0.003			0.464		

^{ab} The superscript lowercase letters indicate there is a statistically important difference between the treatment groups ($p<0.01$).

EST was found to be correlated with gender. According to the findings of the experiment, female turkey poults hatched more than males from thicker shelled turkey eggs ($p<0.05$) as seen in Table 3. This may generate an idea and pioneer a series of research on the subject if the ratio of poults to hatch can be altered prior to placement in incubators.

CONCLUSION

From the findings of the experiment, it can be concluded that not placing turkey eggs with 46.26 µm (females hatched having the thinnest eggshell value) or less EST into the incubators would have resulted in 31.25% of males (as males hatched from eggs from less than this EST was 31.25%) not been set on the machine. Therefore, approximately 1/3 of male birds should have completed recovery from culling and their eggs should be evaluated in other industries such as pastry. This is a simple calculation from the data of the research presented to show that there can be a promising numerical relation between EST and predetermination of gender of turkey hatching eggs where more extensive analyses, more repetitions and more detailed work should be undertaken.

Further experiments should be undertaken taking into consideration EST together with other parameters such as weight, shape index, etc. As more data is obtained and structured economically, automatic sorting and in ovo sexing device for egg sorting by EST should be manufactured in the near future for use by modern hatcheries. Thus, great amounts of capital may be conserved, and the poultry industry may thrive economically and become a more humane, welfare-conscious profession.

CONFLICT OF INTEREST

The author reports that there are no conflicts of interest.

DECLARATION OF AUTHOR CONTRIBUTION

The author reports there are no conflicts of interest and the work was overtaken by himself.

DECLARATION OF ETHICS COMMITTEE

The study was approved by Bolu Abant İzzet Baysal University Animal Research Ethics Committee, in 04.03.2015, verdict number 2015/10.

All actions were taken under the legislation and allowances of the local ethical regulations.

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