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Research Article

The Effect of Egg Weight on Egg External Quality Characteristics and Hatching Performance in Pekin Ducks

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ABSTRACT

This study aimed to investigate the effect of different egg weights on egg external quality characteristics and hatching performance in Pekin ducks. A total of 800 eggs were divided into three weight categories: "light" (Lo; <76 g), "medium" (Me; 76-82 g), and "heavy" (Hi; >82 g). Parameters indicating egg external quality characteristics were calculated. Eggs were incubated and on the 25th day, transferred to the incubator for hatching. The mean egg weight for light, medium, and heavy categories were 70.25 g, 78.47 g, and 85.17 g, respectively (P<0.001). As egg weight increased, there was a significant decrease in shell thickness (P<0.001). The effect of different egg sizes on fertility was insignificant. The hatchability of fertile eggs was higher in the light and medium categories compared to the heavy category (P<0.05). Egg weight had a significant effect on early embryonic mortality rate (P<0.05) and chick hatch weight (P<0.001). In conclusion, different egg weights have varying effects on egg external quality parameters in Pekin ducks. Although heavy eggs produce chicks with higher weights, lighter or medium-weight eggs may be more advisable for incubation due to their better hatchability.

Keywords: Chick, Fertility, Shell, Incubation, Pekin duck, Egg weight

Introduction

Ducks are widely used as a source of food across the globe, especially in Europe and Asia, where their meat and eggs are frequently consumed. Compared to chicken meat, duck meat is considered to be tastier and more nutritious. Additionally, duck eggs are bigger and more nutrient-rich than chicken eggs. Duck meat is an important source of food for countries that are grappling with poverty and issues surrounding food security [1-3]. As the world's population continues to grow, the demand for protein is increasing. White meat is becoming more popular as a cheaper source of protein compared to red meat, resulting in an increase in both chicken meat and alternative poultry meat production. Duck breeding, with its short production period, is one of the alternatives to meet the demand for poultry meat in the industry [4,5]. Overall, integrated duck farming is a sustainable and profitable practice that has been an important part of traditional agriculture in Asia for centuries. With the increasing demand for protein and the need for sustainable agriculture practices, integrated duck farming could be a valuable model for other regions to consider [1,6].

According to the Turkish Statistical Institute, duck breeding in Türkiye has increased by 21.23% in the past decade. The total number of ducks in Türkiye is 432,457 as of 2022. Compared to other poultry types, ducks represent only 0.1% of the total poultry population [7].

Pekin ducks are a popular breed for meat production due to their fast growth rate, feed efficiency, and lower disease risk. They are easy to care for and feed, making them suitable for small-scale farmers and newcomers. Pekin ducks' tender meat and rich flavor make them sought after in high-end restaurants, offering farmers access to valuable markets. Overall, Pekin ducks contribute to job opportunities, economic growth, and increased production efficiency and profitability in the poultry industry [4,8]. Fertile egg supply, proper storage of hatching eggs, and optimal incubation conditions are crucial for the economic success of duck farming. Numerous studies have focused on these factors, including the appropriate weight and storage duration for hatching eggs, and the ideal hatching conditions for Pekin ducks [1,2,6].

Various factors, both genetic and non-genetic, can influence both fertility and hatching yield. These may include the farmer's management practices, the quality of the eggs, and the methods used during incubation [8–10] Fertility can be influenced by factors such as parent quality, male-to-female ratio, temperature, storage time, and housing systems. In Pekin ducks, the storage time of eggs before incubation can affect fertility, hatching yield, and early embryonic mortality [11,12]. Storing duck eggs for more than six days can decrease fertility [13]. Different external features such as weight, index (width/length), shell thickness, number of pores, surface quality, and resistance to breakage are commonly measured in studies [14-16]. The hatchability of low weight eggs can be higher than that of high weight eggs in better ratios [11,17]. In heavy eggs nutrient and energy reserves are greater [14]. Light weight eggs can have shorter incubation periods [18], and egg size can affect hatchability [11]. Proper incubation conditions such as humidity, temperature, egg turning, and ventilation are crucial for achieving high hatch rates in duck eggs. Providing suitable conditions for incubating duck eggs can result in a high hatch rate and increased production, but this balance is very delicate and subject to dynamic changes [10].

The aim of this study is to determine the effect of egg weight on egg external quality characteristics and hatchability performance, in Pekin ducks raised in the province of Kars, Türkiye.

Material and Methods

Ethical Statement

The care and use of the ducks in this study comply with the laws and regulations of Türkiye. Additionally, this study was conducted after obtaining approval from the Kafkas University Local Ethics Committee for Animal Experiments (KAÜ-HADYEK/2020-180), Kars, Türkiye.

Location

Kars province is located at coordinates 40°36'18"N and 43°5'48"E, at an altitude of 1760 meters above sea level. Kars province is located in the eastern region of Türkiye and shares a border with Armenia.

Hatching Egg Collection

The incubation eggs used in this study were obtained from a breeding flock that was 33-35 weeks old and had an average weight of 3.2-3.8 kg. The breeding flock was raised using standard industry practices in a poultry production unit. A total of 800 incubation eggs were included in the study. Prior to incubation, the eggs were stored at 17-19°C and 70% relative humidity for 3-7 days.

External Quality Characteristics of Eggs

The egg weights (EW) were weighed with a precision of ± 0.1 g immediately before placing them in the incubator. Then, the eggs were classified into three categories: "light" (<76 g), "medium" (76-82 g), and "heavy" (>82 g), by modifying the classification made by Ipek and Sozcu [15]. The length (L) and width (W) of the eggs were measured with a digital caliper with a precision of 0.01 mm. Geometric mean diameter (Dg), surface area (S), volume (V), shape index (SI), sphericity (Sp), elongation (E), and specific gravity (SG) were calculated using the following formulas [16,19,20]:

$$D_g\,(mm) = (LW^2)^{1/3}$$

$$S\,(mm^2) = \pi D_g^{\,2}$$

$$V\,(mm^3) = \pi/6\,(LW^2)$$

$$SI\,(\%) = (W/L) \times 100$$

$$Sp\,(mm) = [(LW^2)^{1/3}/L] \times 100$$

$$E\,(mm) = L/W$$

$$SG\,(g/cm^3) = (EW/V)$$

Shell weight (SW) was weighed with a precision of 0.1 g, and shell thickness (ST) was measured with an electronic digital micrometer with a precision of 0.001 mm from three different points (sharp end, blunt end, and equator) of each eggshell and their average was taken. Shell density (SD), shell volume (SV), shell specific gravity (SSG), and shell ratio (SR), pore number (PN) were calculated using the following formulas [19].

$$SD\,(g/cm) = (SW/S \times ST)$$

$$SV\,(cm^3) = ST \times S$$

$$SSG\,(g/cm^3) = SW/SV$$

$$SR\,(g) = (SW/W) \times 100$$

$$PN = 304 \times W^{0.767}$$

Incubation and Hatching

The eggs were incubated at 37.5°C and 62% humidity, with turning for the first 25 days. Starting from the 8th day of incubation, water was sprayed in the hatcher until the hatch. On the 25th day of incubation, all eggs were transferred to a hatcher that operated at 37.0°C and 72% relative humidity. The healthy chicks hatched on the 28th day of incubation were recorded.

The number of unhatched eggs was counted, opened, and macroscopically evaluated to determine fertility and the stage of embryonic death (early and late). The percentage of embryonic death was categorized as early and late. Fertility was calculated as the ratio of fertile eggs to total eggs. Sticky and dead embryos at the end of incubation were counted as dead in shell. The parameters obtained at the end of incubation were calculated using formulas reported in previous studies [15,21-23]. Hatching weight was determined by weighing each individual chick hatched from the eggs.

Statistical Analysis

This study utilized the SPSS software (version 26.0, Chicago, IL, USA) for statistical analysis. The Kolmogorov-Smirnov test was used to evaluate the distribution of the groups created based on egg sizes. Parametric tests were used since the data had a normal distribution. One-way ANOVA was used for multiple comparisons, while the Tukey HSD test was used for pairwise comparisons. Chi-Square Tests or Fisher's Exact Test were used to compare parameters with frequency data based on egg weights. Pearson correlation coefficients were calculated to determine the relationship between variables. Mean and standard error of mean (SEM) were used to present the results. Statistical significance was considered at a P-value of <0.05.

Results

The external quality characteristics of eggs classified as light, medium, and heavy are given in *Table 1*. The average weight of eggs in the light, medium, and heavy groups were 70.25 g, 78.47 g, and 85.17 g, respectively, and the differences were statistically significant (P<0.001). The external quality characteristics of the eggs were also found to be significantly different among the groups (P<0.001). Specifically, the shape index was lower in the light and medium groups compared to the heavy group, with a statistically significant difference (P<0.001).

The shell characteristics of eggs with different weights are given in *Table 2*. The shell weight, shell density, shell

Table 1. *External quality characteristics of eggs of different weights*

Parameters	**Light**	**Medium**	**Heavy**	**Total**
n	445	205	150	800
Weight (g)	70.25±0.16^{c}	78.47±0.13^{b}	85.17±0.20^{a}	75.15±0.23
Width (mm)	45.27±0.11^{c}	46.61±0.06^{b}	48.29±0.07^{a}	46.18±0.08
Length (mm)	62.44±0.12^{b}	63.24±0.15^{a}	63.64±0.18^{a}	62.87±0.08
Geometric diameter (mm)	50.36±0.07^{c}	51.59±0.06^{b}	52.94±0.07^{a}	51.16±0.06
Surface area (cm^2)	79.74±0.23^{c}	83.63±0.19^{b}	88.06±0.24^{a}	82.30±0.18
Volume (cm^3)	67.05±0.32^{c}	71.95±0.25^{b}	77.73±0.31^{a}	70.31±0.25
Shape index (%)	72.70±0.32^{b}	73.79±0.21^{b}	75.98±0.26^{a}	73.59±0.20
Elongation	1.38±0.004^{a}	1.36±0.004^{b}	1.32±0.005^{c}	1.36±0.003
Sphericity (%)	80.79±0.22^{c}	81.64±0.15^{b}	83.25±0.19^{a}	81.47±0.14
Specific gravity (g/cm^3)	1.05±0.003^{b}	1.09±0.004^{a}	1.10±0.003^{a}	1.07±0.002

$^{a-c}$ Different letters in the same line are statistically different (P<0.001)

Table 2. *Shell characteristics of eggs of different weights*

Parameters	**Light**	**Medium**	**Heavy**	**Total**
n	445	205	150	800
Shell weight (g)	5.95±0.02^{c}	6.73±0.01^{b}	7.38±0.02^{a}	6.42±0.02
Shell thickness (mm)	0.388±0.003^{a}	0.375±0.005^{b}	0.358±0.008^{c}	0.379±0.005
Shell density (g/cm^3)	2.90±0.01^{b}	2.99±0.01^{a}	2.98±0.01^{a}	2.94±0.01
Shell volume (cm^3)	30.92±0.09	31.22±0.08	31.28±0.11	31.07±0.06
Shell specific gravity (g/cm^3)	0.19±0.001^{c}	0.21±0.001^{b}	0.23±0.001^{a}	0.21±0.001
Shell ratio (g)	8.47±0.002^{c}	8.56±0.003^{b}	8.65±0.003^{a}	8.53±0.003
Number of pores	7794.1±13.59	8482.1±10.31^{b}	9029.6±16.48^{a}	8202.1±19.37

$^{a-c}$ Different letters in the same line are statistically different (P<0.001)

***Table 3.** Hatchability results according to egg weights*

Parameters	Light	Medium	Heavy	P	Total
n	445	205	150	-	800
Fertility (%)	82.9	83.4	81.3	NS	82.8
Hatchability of fertile eggs (%)	88.1[a]	89.5[a]	79.5[b]	*	86.9
Hatchability of total eggs (%)	73.0[a]	74.6[a]	64.7[b]	*	71.9
Early embryonic death (%)	1.9[b]	2.9[ab]	6.6[a]	*	3.0
Late embryonic death (%)	6.2	4.6	7.3	NS	6.0
Dead in shell (%)	3.5	2.9	6.6	NS	3.9
EED / Total death (%)	15.9	27.8	32.0	NS	23.0
LED / Total death (%)	54.5	44.4	36.0	NS	47.1
Dead in shell / Total deaths (%)	29.5	27.8	32.0	NS	29.9
Chick hatching weight (g)	43.61 ± 3.95[c]	47.22 ± 4.78[b]	52.12 ± 4.35[a]	***	46.01 ± 5.29
Chick / Egg weight (%)	62.00 ± 5.49	61.14 ± 6.62	62.14 ± 5.47	NS	61.79 ± 5.81

[a-c] Different letters in the same line are statistically different. *: P≤0.05, ***: P<0.001, NS: Not significant, EED: Early embryonic death, LED: Late embryonic death

***Table 4.** Pearson correlation coefficients between external egg quality, shell characteristics, and hatching weight*

Parameters	Shell weight (g)	Shell thickness (mm)	Shell density (g/cm³)	Shell volume (cm³)	Shell specific gravity (g/cm³)	Shell ratio (g)	Number of pores	Hatch weight (g)	Chick / Egg (%)
Weight (g)	0.940**	-0.760**	0.492**	0.285**	0.872**	0.908**	0.794**	0.586**	-0.173**
Width (mm)	0.561**	-0.443**	-0.202**	0.771**	0.247**	0.558**	0.457**	0.279**	-0.096*
Length (mm)	0.261**	-0.158**	-0.032	0.209**	0.106**	0.263**	0.192**	0.215**	0.028
Geometric diameter (mm)	0.704**	-0.533**	-0.166**	0.818**	0.337**	0.702**	0.564**	0.405**	-0.090*
Surface area (cm²)	0.681**	-0.518**	-0.191**	0.830**	0.312**	0.678**	0.546**	0.387**	-0.087*
Volume (cm³)	0.653**	-0.499**	-0.217**	0.841**	0.284**	0.650**	0.524**	0.366**	-0.083*
Shape index (%)	0.210**	-0.194**	-0.192**	0.486**	0.053	0.208**	0.183**	0.064	-0.079
Elongation	-0.315**	0.273**	0.006	-0.325**	-0.220**	-0.310**	-0.269**	-0.130**	0.093*
Sphericity (%)	0.233**	-0.211**	-0.159**	0.461**	0.085*	0.229**	0.201**	0.076	-0.082*
Specific gravity (g/cm³)	0.358**	-0.269**	0.871**	-0.667**	0.680**	0.363**	0.274**	0.147**	-0.109**
Hatching weight (g)	0.501**	-0.535**	0.171**	0.113**	0.521**	0.583**	0.578**	-	0.694**

* Correlation is significant at the 0.05 level (2-tailed). **: Correlation is significant at the 0.01 level (2-tailed)

specific gravity, and pore count increased proportionally with egg weight (P<0.001). As egg weight increased, the shell thickness decreased (P<0.001). There was no statistical difference between the groups in terms of shell volume. The shell ratio was determined as 8.47 g, 8.56 g, and 8.65 g for light, medium, and heavy eggs, respectively (P<0.001).

Table 3 displays the hatchability results of Pekin ducks categorized by different egg weights. The fertility of eggs was not significantly affected by their weight. Nevertheless, the hatchability rate was higher in the light and medium weight categories compared to the heavy weight group ($P<0.05$). The overall hatchability rate of light, medium, and heavy eggs was 73.0%, 74.6%, and 64.7%, respectively ($P=0.05$). Early embryonic mortality rate was affected by egg weight ($P<0.05$), but late embryonic mortality or dead in shell was not. The light eggs had a significantly lower rate of early embryonic mortality (1.9%) than the heavy eggs (6.6%) ($P<0.05$). The hatching weight of the chicks was also affected by the egg weight, and the average hatching weight obtained from light, medium and heavy eggs was 43.61±3.95 g, 47.22±4.78 g and 52.12 ± 4.35 g, respectively ($P<0.001$).

Table 4 shows the Pearson correlation coefficients between external quality and shell characteristics of eggs and hatch weight in Pekin ducks. The results revealed that egg weight had a strong positive correlation with shell weight ($r = 0.940$, $P<0.01$), but a strong negative correlation with shell thickness ($r = -0.760$, $P<0.01$). Additionally, there was a strong positive correlation between hatch weight and egg weight ($r = 0.586$, $P<0.01$), while a strong negative correlation was found between hatch weight and shell thickness ($r = -0.535$, $P<0.01$).

Discussion

The proportion of the goose population in Kars province's poultry is significant and ranks first. In terms of poultry population by species, Kars province's ranking is as follows: Chicken, goose, turkey, and duck [24,25]. However, due to the increasing demand for poultry meat, there is a growing trend towards different poultry species. One of the most important indicators of this is the increasing popularity of duck farming as an alternative to goose farming [4]. During the literature review, no study investigating the influence of various egg sizes on the external quality and shell characteristics of eggs as well as hatchability performance in Pekin ducks raised in Kars and its surrounding areas was found.

In a study conducted on Pekin ducks, the average weights of light, medium, and heavy eggs were determined as 70.6, 78.6, and 86.4 g, respectively [15]. In another study, the average weights of light, medium, and heavy eggs in Pekin ducks were determined as 76.64, 81.08, and 85.93 g, respectively [26]. In our study, the average weights of light, medium, and heavy eggs were 70.25, 78.47, and 85.17 g, respectively. The weight averages obtained from the classified eggs in the studies are similar to our study. The average width and length of our eggs were 46.18 and 62.87 mm, respectively, and the obtained data are close to the sizes of Pekin duck eggs observed by Galic et al. [16], and Balkan and Biricik [27].

In our study, the mean values for geometric diameter, surface area, volume, shape index, elongation, and specific gravity were 51.16 mm, 82.30 cm^2, 70.31 cm^3, 73.59%, 1.36, and 1.07 g/cm^3, respectively. The geometric diameter of Pekin ducks was reported as 50.41 mm [16], the surface area as 79.86-81.23 cm^2 [16,27,28], the volume as 66.38-70.19 cm^3 [27,28], the shape index as 69.69-75% [16,28-30], the elongation as 1.40-1.43 [27,28], and the specific gravity as 1.01-1.06 g/cm^3 [14,29]. The reported egg quality characteristics in previous studies were found to be close to the values obtained in our study. However, different values may be determined by using eggs with different weights or sizes in these studies. Since most studies did not classify eggs according to their weight in Pekin ducks, the general averages of our study were compared with the data from previous studies. In a study conducted on Pekin ducks with different egg weights [15], the shape index of light, medium, and heavy eggs was 72.0%, 73.6%, and 74.4%, respectively, and there was no statistically significant difference. In our study, the shape index of light, medium, and heavy eggs was 72.70%, 73.79%, and 75.98%, respectively, and there was a significant statistical difference ($P<0.001$). In the study conducted by İpek and Sözcü [15], the weight of eggs did not have a significant effect on the shape index, but in our study, despite finding similar values, the weight of eggs had a statistically significant effect on the shape index. Heavy eggs had a higher shape index than both light and medium eggs ($P<0.001$). Egg length in our study may be one of the most important factors affecting the shape index. The length of heavy eggs was close to that of the other groups. Therefore, the shape index may have been higher in the heavy group.

Shell thickness in ducks can vary between 0.36-0.42 mm on average [2]. In Pekin ducks, the shell thickness and weight are between 0.34-0.51 mm and 6.03-9.97 g, respectively [16,27-29,31]. Moreover, in Pekin ducks, the shell thickness of light, medium and heavy eggs were determined as 39.3, 38.8 and 37.9 µm, respectively [17]. In our study, shell weight increased parallel to egg weight ($r = 0.940$, $P<0.01$). Shell weight was 5.95, 6.73, and 7.38 g (general average 6.42 g) for light, medium, and heavy eggs, respectively, and there was a significant difference ($P<0.001$). Shell thickness decreased as egg weight increased. The strongest indicator of this was the strong negative correlation between shell thickness and egg weight ($r = -0.760$, $P<0.01$). In one study, shell weight increased numerically with increasing egg weight [15]. In a study conducted on Pekin ducks [17], there was a statistically significant difference in shell thickness among groups created based on egg weight. In another study, the egg weight increases, the shell thickness decreases in a similar way [15]. A thicker eggshell for incubation eggs prevents higher dehydration during incubation [32,33]. In Pekin ducks, as the egg weight increased, the egg breaking strength and eggshell thickness decreased. The egg breaking force was found to be the highest in the light egg group, and the thinnest eggshell was observed in the heavy egg group [15]. The thickness of the eggshell may decrease in heavier eggs as the breeding age increases [17]. The shell density of Pekin ducks has been determined as 3.17 g/cm^3 [16] and the shell ratio as 8.5-13% [15,28] in previous studies. However, in our study, the shell density was lower than the reported study, and the shell ratio was within the range reported in previous studies. These findings contribute to our understanding of the intricate relationship between egg weight and eggshell characteristics in Pekin ducks. Further investigations should be conducted to explore the underlying mechanisms behind these observations and to develop strategies for optimizing egg quality and hatching performance in duck farming practices.

Different factors such as fertility, breeder quality, male-to-female ratio, temperature, storage time, and housing systems can affect egg production and quality in duck breeds. Moreover, ovulation, egg formation and development stages, and sperm quality are also crucial for fertility. Although there may be variations among duck breeds, these factors can still have an impact [11,34-36]. Hatchability and early embryo mortality of Pekin duck eggs are significantly affected by pre-incubation storage time. Moreover, there may be a decrease in fertility of duck eggs that are stored for more than six days from laying to incubation [10,11]. Embryonic deaths are more common in the first and last third of incubation. The survival of the embryo is not only dependent on pre-incubation and incubation environmental conditions. In particular, factors related to the genotype of the parents can have a positive or negative impact on the life of the duckling inside the egg. Chromosomal abnormalities and lethal genes acquired from the mother and father can cause high rates of early embryonic deaths [11,37]. Fertility rate in Pekin ducks can vary between 80.96% and 95.4% [8,31,38]. In this study, the overall fertility rate was 82.5%, which was within the range reported in previous studies. There was no statistically significant difference in terms of fertility rate, late and total embryonic mortality rate among light, medium, and heavy eggs. The hatchability of fertile eggs in the light and medium groups was higher than that in the heavy group ($P<0.05$). The hatchability of total eggs was lowest in the heavy eggs ($P=0.05$). Furthermore, statistically higher embryonic mortality was observed in the heavy eggs compared to the light eggs ($P<0.05$). Similar to our study, İpek and Sözcü [15] found that different egg weights did not have a significant effect on fertility. They also observed that in eggs classified as heavy, the hatching rate of fertile eggs, the hatching rate of total eggs, and the early embryonic mortality rate were lower than those of light and medium eggs. Another study on Pekin ducks found that different egg weights did not have a significant effect on fertility, early or late embryonic mortality rate, or hatchability of fertile or total eggs [17].

There is a strong positive relationship between egg weight and the weight of the chick that hatches from it. The percentage of chick weight relative to egg weight is fairly consistent across species [39]. Our study showed that hatching weight of chicks varied between 43.61 and 52.12 g, and there was a statistically significant difference among the groups ($P<0.001$). As the egg weight increased, the hatching weight of the chick also increased and a strong positive correlation was determined ($r = 0.586$, $P<0.01$). However, different egg weights did not affect the chick/egg weight ratio. In a study conducted in Pekin ducks, different weights of eggs have been found to affect the hatching weight of the chicks [17]. Similar to our study, in Pekin ducks, the hatching weight of chicks ranged from 42.8 to 54.9 g, and different egg sizes had an effect on hatching weight. However, there was no difference between groups in terms of chick/egg weight ratio [15]. There are many factors that affect chick hatching weight. Egg size and the age of the breeder are among the most influential factors. As the breeder's age increases, the egg size obtained can also vary. In this context, in a study conducted on Pekin ducks, the hatching weights of eggs obtained from breeders of different ages were statistically different. Age had a statistically significant effect on egg weight [31]. In our study, we also used breeders at 33-35 weeks of age, which limited the use of a large number of heavy eggs. However, the classification of eggs according to weight directly affected the chick hatching weights.

In conclusion, there are significant statistical differences in many external quality characteristics of eggs of different sizes in Pekin ducks raised in Kars and its surrounding areas. As egg weight increases, shell thickness decreases. In addition, different weights of eggs did not affect fertility, but fertilized and total egg hatchability had the worst results in heavy eggs. One of the most important handicaps of heavy eggs is the occurrence of early embryonic mortality. Despite this, the hatching weight of chicks from the heavy egg group was higher than that of other groups. Considering the hatchability, light or medium weight eggs can be selected for incubation.

Availability of Data and Materials

Datasets analyzed during the current study are available in the author (B. Boğa Kuru) on reasonable request.

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Ethical Approval

This study was conducted after obtaining approval from the Kafkas University Local Ethics Committee for Animal Experiments (KAÜ-HADYEK/2020-180), Kars, Türkiye.

Competing Interest

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of paper.

Author Contributions

BBK and TK: Study design, data collection, draft writing. MMC and SAI: Contribution to study design, pre-editing of manuscript. BBK, TK, and SAI: Statistical analysis, article editing. BBK and TK: Article writing and editing, supervision. All authors have read, reviewed, and approved the final draft.

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