Comparison of hatching egg characteristics, embryo development, yolk absorption, hatch window, and hatchability of Pekin Duck eggs of different weights

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ABSTRACT This study was carried out to determine the hatching egg characteristics, embryo development and yolk absorption during incubation, hatch window, and hatchability of Pekin duck eggs of different weights. A total of 960 hatching eggs was obtained from a breeder flock 35 to 36 wk of age. The eggs were classed into 3 weight categories: "light" (L; <75 g), "medium" (M; 76 to 82 g), and "heavy" (H; >83 g). The albumen weight was the highest in the heavy eggs, whereas the yolk weight was higher in the medium and heavy eggs. Egg breaking strength was the highest with a value of 2.5 kg/cm^2 in light eggs, whereas the thinnest eggshell (0.3862 mm) was observed in heavy eggs. pH of albumen and yolk was similar and ranged from 8.8 to 8.9 and 5.9 to 6.0, respectively. On d 14 of incubation, yolk sac weight was found higher in the medium and heavy eggs. Additionally, the dry matter of the embryo and yolk sac differed among the egg weight groups during the incubation period. Interestingly, on d 25 of incubation, the embryo weight was higher in the light and heavy eggs (35.2 and 36.3 g, respectively) than in the medium eggs (29.8 g). These findings showed that embryo growth was affected by yolk absorption and dry matter accumulation. The hatchability of total and fertile eggs was lower for the heavy eggs than the light and medium eggs. The chick weight was 42.8, 48.4, and 54.9 g in light, medium, and heavy eggs, respectively. A percentage of 34.2, 36, and 31.6% of chicks from light, medium, and heavy eggs, hatched between 637 and 648 h, 39.6, 36.2, and 32.9% between 649 and 660 h, 26.2, 27.8, and 35.5% between 661 and 672 h of incubation, respectively. In conclusion, hatching egg quality, embryo development and yolk absorption during incubation, hatch window, and hatchability were affected by egg weight in Pekin ducks.

Key words: Pekin duck, incubation, yolk absorption, hatch window, dry matter

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INTRODUCTION

Recently, meat-type duck production, which has great value in Asian countries, has gained importance in other countries as a source of animal protein. Due to the rapid growth in the world population, there is a growing trend in meat-type duck production. In fact, global duck meat production increased by 94,7% in the last decade (Wen et al., 2015).

Ducks have a fast growth rate and can reach over 3 kg live weight in 42 to 45 days (Onbaşilar et al., 2011a). Additionally, duck meat is widely preferred by consumers for healthful nutrition and the prevention of some diseases, especially cardiovascular problems (Heo et al., 2015). White Pekin duck is one of the most popular meat-type duck strains and is produced in most countries, including China, Korea, England, and France (Heo et al., 2015; Wen et al., 2015).

Success in poultry production depends on breeder flock management and hatchability practices. In hatcheries, the essential goal is to maximize hatchability with a large number of high-quality and saleable chicks (Decuypere and Bruggemen, 2007). It is known that hatchability is an important economic parameter, and it is affected by many factors, including breeder age, egg quality, nutrition of the breeder flock, egg handling and storage, and incubation conditions (Kamanli et al., 2010; Weis et al., 2011), and one of the most important factors is egg weight (Ipek ve Sahan, 2002; Badowski et al., 2005; Onbaşilar et al., 2011b).

There is an increasing trend in egg weight as breeders age (Onbaşilar et al., 2011b). It is known that the complex relationship between egg weight and incubation parameters, e.g., hatching time, is influenced by egg size, egg quality, and hatch window (Tona et al., 2003; Careghi et al., 2005; Vieira et al., 2005; Romanini et al., 2013; Ipek and Sozcu, 2015). On the other hand, these factors also affect yolk absorption and embryo development and growth during the incubation process (Romanoff, 1960; Speake et al., 1998).

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Little research has been performed regarding the effects of egg weight on parameters in Pekin ducks, including egg quality, embryo development, and hatchability (Kokoszynski et al., 2007; Onbaşilar et al., 2011b; Biesiada-Drzazga et al., 2014). Therefore, the objective of the present study was to compare the hatching egg exterior and interior characteristics, embryo development and yolk absorption during the incubation period, hatch window, and hatchability of Pekin duck eggs of 3 different weights (light, medium, and heavy eggs) of Pekin Ducks.

MATERIALS AND METHODS

The care and use of animals were in accordance with the laws and regulations of Turkey and were approved by the ethics committee of Uludag University (License Number 2015–10/05).

Hatching Egg Collection

The research was carried out at the research farm of the Department of Animal Science, Uludag University, Turkey. In this study, hatching eggs were obtained from a breeder flock at 35 to 36 wk of age. The breeder flock was reared under standard industry practices in the departmental farm of the faculty. The nests (with a size of 40/50/40 cm) were placed along the dark side of the barn. A total of 960 hatching eggs was collected and then classed into 3 weight categories: "light" (**L**; <75 g), "medium" (**M**; 76–82 g), and "heavy" (**H**; >83 g), by weighing with ± 0.1 precision.

Egg Quality Characteristics

Before incubation, 20 eggs per egg weight group were taken to determine egg quality measurements. The quality evaluation was performed 24 h after the egg was laid. The eggs were weighed, and then the shape index and eggshell breaking strength were measured, as reported by Yuan et al. (2013). After cracking the eggs, the yolk height and width, and the albumen height, width, and length were measured with a digital caliper (Mitutoyo, 300 mm, Neuss, Germany). The albumen weight was calculated from the difference between the egg weight and the total weight of the yolk and eggshell, and the yolk and albumen ratios were calculated (Card and Neshem, 1972; Pikul, 1998). The albumen and yolk pH were measured using a digital pH meter (Mettler Toledo, SevenCompact^{TM} pH/Ion S220, Greifensee, Switzerland).

After the removal of the egg content, the eggshell was dried at a temperature of 105 °C for 3 h in a drier (Nüve FN-500, Ankara, Turkey). Then, the eggshell was weighed to ± 0.01 precision and the eggshell ratio was calculated by comparing the egg weight. Eggshell thickness (mm) was measured using a digital micrometer at 3 points on the eggshell, including the blunt point, middle point, and pointed end (Kokoszynski et al., 2008).

Storage and Incubation

The eggs were stored at 18 to 20°C and 65% RH for 7 d and were then warmed to room temperature (21°C) for 8 h before setting. All eggs were numbered and weighed before incubation, and then they were incubated in a fully automated, ventilated, programmable incubator at 37.5°C and a RH of 55 to 60% during the first 24 d of incubation. The eggs from each weight group were randomly placed into incubator trays consisting of 60 eggs (n = 5 trays/egg weight group).

On d 25 of incubation, eggs were weighed to determine the weight loss during incubation, and all eggs were transferred to a hatcher. The hatcher was operated at 37.0°C and 72% relative humidity. Egg weight loss was calculated using the following formula:

$$\text{Egg weight loss (\%)} = ((\text{Egg weight before incubation} - \text{Egg weight at transfer}) / \text{Egg weight before incubation}) \times 100$$

Embryo Development and Yolk Absorption

A total of 15 eggs per egg weight group was randomly sampled on d 14 and 25 of incubation. The eggs were opened, and embryos from each treatment group were killed by cervical dislocation. The embryos were carefully separated from the yolk sac. Excessive embryonic fluid was dried off with absorbent paper, and the embryos were weighed for embryo weight and yolk sac weight to calculate the relative embryo and yolk sac weights (Willemsen et al., 2010; Ipek et al., 2014). On d 25 of incubation, the yolk-free body weight was calculated. The embryo length was measured from the tip of the beak to the tip of the middle toe by placing the embryo face down on a flat surface and straightening the right leg (Hill, 2001; Nangsuay et al., 2011). The shank length was measured from right knee joint to the tip of the middle toe (Willemsen et al., 2008). The yolk absorption was calculated according to Ipek et al. (2014):

$$\text{Relative embryo weight (\%)} = (\text{embryo weight/initial egg weight}) \times 100$$

$$\text{Relative body weight (\%)} = (\text{embryo body weight/initial egg weight}) \times 100$$

$$\text{Yolk absorption (g)} = \text{initial yolk weight} - \text{yolk sac or residual yolk weight (g)}$$

Table 1. Effect of egg weights on egg exterior and interior quality characteristics.

Characteristics	Light	Medium	Heavy	Probabilites
Egg weight (g)	70.6 ± 0.9[c]	78.6 ± 2.2[b]	86.4 ± 1.2[a]	<0.01
Exterior characteristics				
Egg shape index (%)	72.0 ± 3.5	73.6 ± 1.2	74.4 ± 4.9	NS
Egg breaking strength (kg/cm^2)	2.5 ± 0.1[a]	1.3 ± 0.4[b]	1.1 ± 0.5[b]	0.014
Eggshell thickness (mm)	0.4126 ± 0.009[a]	0.4115 ± 0.014[a]	0.3862 ± 0.010[b]	0.017
Eggshell weight (g)	7.0 ± 0.5	7.6 ± 0.6	7.7 ± 0.4	NS
Shell ratio (%)	9.9 ± 0.9	9.7 ± 0.7	8.9 ± 0.2	NS
Interior characteristics				
Albumen weight (g)	37.3 ± 1.8[b]	41.4 ± 2.5[b]	47.1 ± 0.7[a]	<0.01
Yolk weight (g)	26.3 ± 1.0[b]	29.6 ± 2.0[a]	31.6 ± 0.8[a]	0.006
Albumen ratio (%)	52.8 ± 0.4[a]	52.7 ± 1.4[b]	54.5 ± 0.5[a]	0.006
Yolk ratio (%)	37.3 ± 1.4	37.6 ± 1.8	36.6 ± 0.5	NS
pH				
Albumen	8.9 ± 0.04	8.9 ± 0.01	8.8 ± 0.21	NS
Yolk	5.9 ± 0.05	6.0 ± 0.18	5.9 ± 0.10	NS
Dry matter (%)				
Albumen	87.8 ± 1.0	87.4 ± 0.6	87.3 ± 0.2	NS
Yolk	44.5 ± 1.1	44.8 ± 1.2	45.2 ± 2.9	NS

[a–c]Means in the rows with different letters significantly ($P < 0.05$).
n: 20 eggs per each egg weight group.

Hatch Window and Hatching Process

The ideal incubation period is accepted to be 672 h, and the counting of hatched chicks and samplings was performed based on this ideal incubation period (Ipek and Sozcu, 2015). The chicks that hatched between 637 and 648 h, 649 and 660 h, and 661 and 672 h of incubation were counted, and the rates of chick hatching associated with these time intervals were calculated. In these intervals, the chicks were counted and then transferred to another hatching basket.

Incubation Results

At hatch, the chicks were classified as saleable (clean, dry, and without deformities) or culls (splayed legs, unhealed navels, etc; Tona et al., 2004; Molenaar et al., 2011). The percentage of saleable and cull chicks was expressed as a percentage of fertile eggs (Molenaar et al., 2011). Unhatched eggs were opened to macroscopically determine fertility and embryonic mortality (early, middle, late). Fertility was calculated as the ratio of total eggs at set to fertile eggs. Chick hatch weight was determined by individually weighing all chicks hatched.

Statistical Analyses

The data were subjected to analysis of variance (SAS, 1998) utilizing ANOVA procedures for balanced data. The parameters were analyzed using the general linear model (**GLM**) procedure. In the study, 5 replicate trays (60 eggs per tray) were used for each treatment group, and the trays were considered an experimental unit. Analyses for the percentage data were conducted after square root of the arc sine transformation of the data. Significant differences among treatment means were determined using Duncan's multiple range test. Data are presented as the means ± SE. In all cases, a difference was considered significant at $P \leq 0.05$.

RESULTS AND DISCUSSION

The aim of the study was to compare the hatching egg characteristics, embryo development and yolk absorption during incubation period, hatch window, and hatchability of Pekin duck eggs of different weights. The effects of the egg weight on exterior and interior egg quality in Pekin ducks are presented in Table 1. The mean egg weight was found to be significantly different with values of 70.6, 78.6, and 86.4 g in the light, medium, and heavy egg groups, respectively ($P < 0.01$). The eggshell quality has importance for embryo nutrition and development during the incubation period and therefore affects hatchability (Sergeyeva, 1986). In this study, the egg shape index, eggshell weight, and eggshell rate were found to be similar among the egg weight groups ($P > 0.05$). Similar to our findings, previous studies stated that the egg weight did not affect the eggshell rate (Ulmer-Franco et al., 2010; Onbaşilar et al., 2014).

Because the eggshell assures nutrient availability to embryos, a thicker eggshell is required for hatching eggs (Sergeyeva, 1986), and it also prevents higher dehydration during incubation (Roque and Soares, 1994). In this study, egg breaking strength and eggshell thickness showed a decline as egg weight increased. Egg breaking strength was the highest in the light egg group, and had a value of 2.5 kg/cm^2, whereas the thinnest eggshells were observed in the heavy eggs and had a value of 0.3862 mm ($P < 0.05$). Similarly, Onbaşilar et al. (2014) found a decrease in eggshell thickness in heavier eggs due to an increase in the breeders' age.

Table 2. ffect of egg weights on embryo development and yolk absorption during the incubation period.

Parameters	Light	Medium	Heavy	Probabilities
14.day				
Egg sampling weight (g)	66.8 ± 0.8[c]	81.0 ± 0.2[b]	84.7 ± 0.6[a]	<0.01
Embryo weight (g)	4.7 ± 0.4	4.4 ± 0.5	5. 0 ± 0.5	NS
Relative embryo weight (%)	7.0 ± 0.7[a]	5.4 ± 0.6[b]	5.9 ± 0.6[b]	0.012
Yolk sac weight (g)	21.7 ± 2.6[b]	26.0 ± 0.2[a]	27.4 ± 0.5[a]	0.001
Relative yolk sac weight (%)	32.5 ± 3.5	32.1 ± 0.2	32.3 ± 0.3	NS
Body length (mm)	76.1 ± 4.2	76.0 ± 4.3	83.3 ± 3.9	NS
Shank length (mm)	14.1 ± 0.1[a]	10.5 ± 0.1[b]	14.2 ± 0.1[a]	0.003
Dry matter of embryo (%)	94.4 ± 0.7	95.2 ± 0.2	95.7 ± 1.3	NS
Dry matter of yolk sac (%)	53.9 ± 1.6[c]	64.9 ± 2.0[b]	76.9 ± 7.9[a]	<0.01
25.day				
Egg sampling weight (g)	72.8 ± 1.9 [c]	82.1 ± 0.7[b]	87.6 ± 1.5[a]	<0.01
Embryo weight (g)	35.2 ± 3.7[a]	29.8 ± 2.7[b]	36.3 ± 1.1[a]	0.019
Relative embryo weight (%)	48.4 ± 4.4[a]	36.3 ± 7.2[b]	41.4 ± 1.9[a,b]	0.042
Yolk sac weight (g)	14.3 ± 1.4[b]	16.3 ± 0.9[b]	19.5 ± 1.6[a]	0.001
Relative yolk sac weight (%)	19.6 ± 1.9	19.9 ± 0.9	22.3 ± 1.5	NS
Yolk free body weight	20.9 ± 3.2[a]	13.5 ± 1.9[b]	16.8 ± 1.6[a,b]	0.036
Body length (mm)	184.0 ± 8.1	179.3 ± 3.2	177.9 ± 4.8	NS
Shank length (mm)	44.0 ± 1.0[b]	47.0 ± 0.8[a]	46.3 ± 1.2[a]	0.006
Dry matter of embryo (%)	76.5 ± 3.6	79.1 ± 1.3	79.5 ± 2.2	NS
Dry matter of yolk sac (%)	47.7 ± 4.2	52.0 ± 6.1	47.1 ± 0.6	NS

[a–c]Means in the rows with different letters significantly ($P < 0.05$).
n: 20 eggs per each egg weight group.

Internal quality traits of the eggs are significant for poultry breeding due to their influence on the yield properties of the future progenies and the quality and growth of the chicks (McDaniel et al., 1978). Albumen has a vital function during embryonic development via defending the embryo against pathogens and providing nutrients to the embryo (Walsh, 1993; Benton and Brake, 1994). On the other hand, the yolk has vital importance for embryo development and is the only source of lipids for embryo tissue growth (Speake et al., 1998). The quantity of yolk and albumen is altered depending on changes in egg weight. In this study, the albumen and yolk weight increased with increasing egg weight ($P < 0.01$), and the lowest albumen rate was observed in the heavy eggs (52.7%, $P < 0.01$). On the other hand, the yolk rate was found to be similar among the egg weight groups ($P > 0.05$).

The egg quality has vital importance for subsequent embryo development and poult quality at hatch. Therefore, preserving egg quality until the setting process results in successful incubation practices. One of the most important interior egg quality characteristics is the pH value of the albumen and yolk, and these correlate with embryo development during the incubation period. An albumen pH between 8.2 and 8.8 is optimal for embryo development (Walsh, 1993). The yolk pH is approximately 6.0 in newly laid eggs. In this study, the pH of the albumen and yolk was found to be similar for the egg weight groups, ranging from 8.8 to 8.9 and 5.9 and 6.0, respectively ($P > 0.05$). On the other hand, egg weight did not affect the dry matter content of the albumen (range from 87.3 to 87.8%) or yolk (range from 44.5 to 45.2%) in the study.

Embryo development is affected by several factors, including breeder age, egg weight, egg composition, and incubation conditions. Egg weight affects egg content and yolk absorption and, therefore, embryo development during the incubation period. Mortola and Al Awam (2010) reported that embryo development is different in small and large eggs after d11 of incubation. Additionally, Gous (2010) concluded that insufficient yolk absorption of embryos in smaller eggs causes a deficiency in growth and development during the incubation period.

In this study, embryo development was determined by yolk absorption, embryo body and shank length, and dry matter of the embryo and yolk sac during the incubation period (Table 2). The effects of the different egg weights on embryo development in Pekin ducks are presented in Table 1. On d 14 of incubation, it was found that egg weight significantly affected the relative embryo weight, yolk sac weight, dry matter of the yolk sac, and shank length ($P < 0.05$). The highest relative embryo weight and the lowest yolk sac weight and yolk sac dry matter were observed in embryos from light eggs (7.0%, 21.7 g, 53.9%, respectively).

Interestingly on transfer d, the embryo weight was interestingly found to be the lowest in the medium eggs (29.8 g) compared with the light and heavy ones (35.2 and 36.3 g, respectively, Table 2). Similarly, the lowest relative embyo weight was observed in medium eggs, with a value of 36.3% ($P < 0.05$). The yolk sac weight was greater in light and medium eggs than in heavy ones; it was found to be 14.3, 16.3, and 19.5 g in light, medium, and heavy eggs, respectively ($P < 0.01$). On the other hand, the yolk-free body weight was significanty different with values of 20.9, 13.5, and 16.8 g in light, medium, and heavy eggs, respectively.

Some researchers have concluded that a lower percentage of yolk weight in small eggs than in larger eggs from breeder flocks of the same age may be a restricting factor for embryo development (Noble and Cocchi,

Table 3. The effect of egg weights on incubation results.

Parameters	Light	Medium	Heavy	Probabilities
Number of eggs	300	300	300	–
Average egg weight (g)	71.4 ± 0.9[c]	79.5 ± 0.6[b]	86.4 ± 1.0[a]	<0.01
Egg weight at transfer (g)	65.0 ± 1.3[c]	71.8 ± 0.7[b]	78.3 ± 0.8[a]	<0.01
Egg weight loss (%)	8.9 ± 0.7	9.6 ± 0.6	9.4 ± 0.7	NS
Fertility (%)	88.1 ± 5.8	89.6 ± 1.4	88.4± 1.0	NS
Hatchability of fertile eggs (%)	84.7 ± 5.3[a]	86.5 ± 3.4[a]	72.7 ± 2.7[b]	0.002
Hatchability of total eggs (%)	77.1 ± 6.3[a]	77.8 ± 5.0[a]	65.2 ± 3.1[b]	0.010
Early-term TEM* (%)	5.3 ± 1.6[b]	4.4 ± 2.7[b]	8.0 ± 2.9[a]	0.016
Mid TEM* (%)	2.3 ± 0.9[a]	0.00 ± 0.00[b]	0.00 ± 0.00[b]	0.022
Late TEM* (%)	4.3 ± 1.6[b]	3.4 ± 3.4[b]	10.3 ± 3.0[a]	<0.01
Contaminate egg ratio (%)	1.9 ± 1.1	1.5 ± 2.5	1.00 ± 1.5	NS
Cull chick (%)	1.5 ± 2.8[b]	4.2 ± 0.6[a,b]	8.0 ± 1.6[a]	0.015
Chick hatching weight (g)	42.8 ± 1.9[c]	48.4 ± 1.7[b]	54.9 ± 2.1[a]	<0.01
Chick/egg weight ratio (%)	59.9 ± 2.6	60.9 ± 2.0	63.5 ± 2.2	NS

[a–c]Means in the rows with different letters significantly ($P < 0.05$).
*TEM: term embronic mortalities.
n: 5 trays per each egg weight group.

1990; Gous, 2010). Thus, Lourens et al. (2006) concluded that embryos in large eggs had more nutrients for gaining body weight than embryos in small eggs. In the current study, relative yolk sac weight was found to be similar across egg weight groups during incubation. Therefore, differences in embryo development could be attributed to embryo nutrient utilization of yolk sac dry matter content, utilization of solid content, and accumulation of dry matter in the embryo. Yolk absorption and yolk nutrient utilization are different terms. The dry matter of the yolk sac was found to be the lowest in embryos from light eggs on d 14 of incubation ($P < 0.05$). These findings could suggest that embryos in light eggs had a higher dry matter utilization than the other groups.

Shank length together with body length are accepted as an indicator of embryo growth during the incubation period and are performance indicators during the post-hatch period (Wolanski et al., 2006). In this study, egg weight affected shank length based on embryonic age. Whereas shank length was found to be higher for embryos in light and heavy eggs on d 14 of incubation, it was found to be higher for embryos in medium and heavy eggs with values of 47.0 and 46.3 mm, respectively, than light ones on d 25 of incubation (44.0 mm; $P < 0.01$). These findings suggested that shank length should be considered to evaluate development and poult quality.

The effects of different egg weights on hatchability in Pekin ducks are shown in Table 3. Egg weight loss was found to be similar among the treatment groups, between 8.9 and 9.6%. The hatchability of fertile eggs and the hatchability of total eggs were found to be higher in light and medium eggs than in heavy eggs ($P < 0.01$). Similarly, Weis et al. (2011) reported a higher hatchability of total eggs for small (70.0 to 76.9 g) and medium (77.0 to 83.9 g) eggs (76.0 vs. 76.81%) than large eggs (70.97%) in Muscovy ducks. Additionally, they found a decline in the hatchability of fertile eggs among the large eggs. Similar to these results, in many studies, it has been found that larger eggs tend to have the poorest hatchability (Wilson, 1991; Gonzales et al., 1999). These findings suggest that an ideal egg weight could range between 70 and 80 g for optimum hatchability in Pekin ducks.

Previous research showed that embryonic mortalities increased with increasing egg weight (Vieira and Moran, 1998; Leeson and Summers, 2000; Elibol and Brake, 2003; Tona et al., 2004; Joseph and Moran, 2005). Similarly, in our study, early- and late-term embryonic mortalities were found to be highest in heavy eggs and had values of 8 and 10.3%, respectively ($P < 0.01$). However, mid-term embryonic mortalities were the highest in light eggs, with a value of 2.3% ($P < 0.01$). This could be related to the egg contaminate ratio, because the egg contaminate ratio was relatively higher in light eggs than medium and heavy eggs.

The number of healthy and saleable chicks has gained increasing importance for hatcheries and producers, because it has been accepted as an indicator of live performance (Tona et al., 2003; Meijerhof, 2009). In this study, the cull chick rate was found to be the highest for heavy eggs ($P < 0.05$). The cull chick rate was 1.5, 4.2, and 8.0% for light, medium, and heavy eggs, respectively. On the other hand, the chick hatching weight ranged from 42.8 g to 54.9 g among the egg weight groups ($P < 0.01$). The chick/egg weight ratio was similar among the groups. This ratio was 59.9 to 63.5% in Pekin ducks and was previously reported to be an average of 72 to 73% for broiler chicks (Campos and Santos, 2003; Vieira et al., 2005; Almeida et al., 2008).

The difference in hatching times between the first and last hatched chicks is called the hatch window (Romanini et al., 2013; Ipek and Sozcu, 2015). Decuypere et al. (2001) found a difference for broilers in the hatch window of 24 h to 48 h. In practice, many chicks hatch earlier, and therefore they remain without food and water for the time from hatching to the time of placement in the broiler house (Noy and Sklan, 1997; Dibner et al., 1998; Careghi et al., 2005).

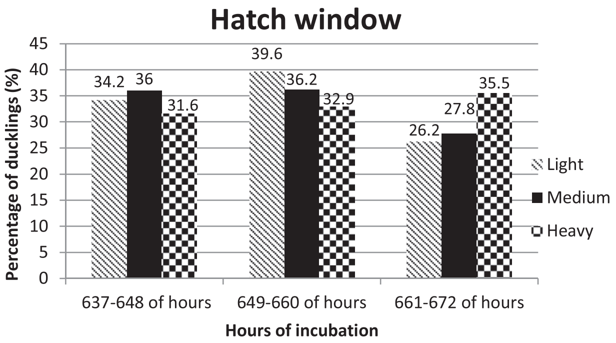

Figure 1. Hatch window (%) in different egg weight groups.

The hatch windows for different egg weights are presented in Figure 1. Analysis of the hatch window showed that 34.2, 36, and 31.6% of the chicks from light, medium, and heavy eggs, respectively, hatched between 637 and 648 h; 39.6, 36.2, and 32.9% of the chicks from light, medium, and heavy eggs, respectively, hatched between 649 h and 660 h; and 26.2, 27.8, and 35.5% of the chicks from light, medium, and heavy eggs, respectively, hatched between 661 h and 672 hours. These findings are consistent with those of Vieira et al. (2005), who concluded that the time required for the hatching process was greater for heavy eggs than for lighter eggs. These results are important for chick handling and post-hatch early feeding management in practical procedures.

In conclusion, the first condition of successful and profitable poultry production depends on hatchery management, quality, and healthy poult production. Egg quality, embryo development, incubation results, and hatch window are affected by variations in egg weight as a natural progression of breeders' age. It is known that embryo development during the incubation and hatching processes is crucially important for optimum live performance and therefore profitability. Knowing the relationships among egg weight and egg quality, embryo development, and incubation for Pekin ducks may improve hatchability and the number of saleable and quality chicks, and may inform the management of hatchery practices.

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