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Evaluation of egg quality parameters of two Hungarian ostrich populations

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SUMMARY

The aim of our study was to evaluate the quality parameters, porosity and weight loss of eggs deriving from the two most significant ostrich farms in Hungary. Quality parameters included weight, length, width, shape index, egg volume, surface area, circumference and shell volume. The effect of storage conditions in both farms and the incubation technology on egg weight loss in farm "A" were also examined. The research objective was to impart a comprehensive knowledge on egg quality parameters of the main ostrich populations in Hungary and to compare the trios and the farms with each other and the international literature. We could reveal significant differences between trios in all egg quality traits. In conclusion, the shorter and the narrower the eggs were, the more spherical shape they had. Narrower eggs showed smaller surface area, volume, circumference and shell volume and vice versa. Eggs from farm "B" indicated significantly greater width, shape index, surface area, circumference and shell volume than farm "A". A significant difference was observed in weight loss during storage between the farms. Weight loss in farm "A" was a multiple of farm "B". In farm "B" there was a weak, positive correlation between storage period and weight loss (r=0.22, P≤0.05), in farm "A" it was not significant (P=0.52). There was no relationship between the initial egg weight and weight loss either in farm "A" or farm "B" (P=0,21, P=0,69). A slight positive correlation could be noted between egg porosity and weight loss (r=0.24, P≤0.05). Pores count presented here was less than the international results. Poultry eggs contain the most pores at the blunt end, less via the equator and the least at the pointed end. In ostrich egg we found more pores via the equator against the blunt end. To draw more precise conclusions, further investigation should be carried out on porosity. Considering the fact that the length of storage period and the weight loss during incubation are in strict correlation with hatchability, we intend to extend our research aims to these traits.

Keywords: *ostrich breeding in Hungary; egg production; egg quality parameters; egg storage; egg incubation*

INTRODUCTION

Egg quality parameters have been examined mostly in poultry species so far. Knowing egg shape index is necessary for testing shell stiffness (Nedomová et al., 2009) and is vital for the arithmetic simulation of egg response to mechanical and thermal effects (Perianu et al., 2010; Denys et al., 2003). Egg volume and surface area are the two main geometric calculations applied for the description of populations and for ecological-morphological evaluations. These parameters are also used to predict chick weight, hatchability, shell quality and egg internal value (Nedomová and Buchar, 2013). The length of storage period, weight loss during storage and incubation is relevant from the aspect of hatchability and chick quality. Longer storage period often occurs due to incubation management and the unpredictable market conditions. International literature states that storage period of more than 10 days significantly reduces hatchability and eggs stored for more than 17 days do not hatch (Deeming, 1996). Hassan et al. (2005) suggested that eggs stored for longer than 10 days had better hatchability, than those stored for 15–24 days, but storage period between 10–15 days did not differ from eggs stored either for 10 or 15 days. 15 days of storage significantly increased incubation period and chick weight. However, Nahm (2001) indicated that storage period did not significantly affected hatchability of eggs stored at 15.5 °C for 19 days. Weight loss during storage and incubation is known to be influenced by egg pores count, pores diameter and its distribution can be different in each part of the egg. In the paper we aimed to determine the correlation between egg surface area and weight loss and to define pores count at different parts of the egg depending on initial egg weight. Our purpose was to present egg quality parameters of the two significant ostrich farms in Hungary. Our indices were compared to the international results.

MATERIALS AND METHODS

The research was carried out at two Hungarian ostrich farms with an average 50 breeders. In farm "A" 16 females, from farm "B" 14 females took part in the investigations with a total egg number of 176. Company's names are hidden in the publication due to the protection of personal rights, instead we address them as "farm A" and "farm "B". After collection, workers cleaned and sanitized the eggs with a 1% cc. Virocid sol, then placed them in the storage room. In farm "A" the temperature and relative humidity were varying between 18–22 °C and 40–50%. In farm "B" storage temperature was constantly 16 °C with 40% relative humidity. Incubation temperature in farm "A" was 36.5 °C with relative humidity of between 20–50%. International papers indicate 35.5–37 °C incubation temperature with 25–50% relative humidity (Hassan et al., 2005; Nahm, 2001).

The following indices were examined:

- Initial egg weight (g)
- Length, width (cm)
- Shape index (%)

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- Egg volume (cm^3)
- Surface area (cm^2)
- Circumference (cm)
- Egg volume (cm^3)
- Porosity (pores count/cm^2)
- Weight loss during storage and incubation (g).

Initial egg weights on farm "B" were measured by workers. From farm "A" no initial weights have been measured, so the paper does not contain these data. Each quality index was calculated by the following formulas (Nedmová and Buchar, 2013), using length and width data taken by us with a two decimal accuracy caliper.

Shape index= (width/length) * 100
Volume= π/6 * length * width
Surface area= π * width^2
Circumference= π * width
Shell volume= surface are/length

Pores count was measured by the method of El-Safty (2012) using a 3-centimeter-wide and 11-centimeter-long plastic tape measure with four equidistant 1-square-centimeter cuts in it. The tape measure was placed on the outside egg surface at the equator and at the center of the blunt end, so we could count the number of pores at five points. The procedure was carried out by using a candling lamp and a magnifying glass. Egg weights for weight loss were measured with a calibrated digital scale of 5-gramm-accuracy. Sizes and weights were taken between 2020 May and September.

All data were evaluated by Microsoft Office Excel and SPSS 23.0. Trios on each farm and farms were compared applying univariate analysis. Egg weight loss was examined on eggs of various ages. We used correlation and regression analysis to determine the relationship between egg weight and egg surface area, egg weight and porosity, egg surface area and porosity, porosity and weight loss, egg age and weight loss, storage period and weight loss and time spent between weighing during incubation and weight loss.

RESULTS AND DISCUSSION

Average egg length was 15.21 cm, width showed 12.69 cm and shape index was 83.51%. Trio 1 had the shortest eggs (14.69 cm), trio 4 laid the longest ones (15.84 cm). The narrowest eggs were found in trios 1, 2, 3 and 5 (12.51, 12.65, 12.52 cm and 12.43 cm) and the widest ones were laid by trios 6, 7 and 8 (12.86, 13.00 and 13.07 cm). Expressing width in the ratio of length, eggs from trio 1 showed the most spherical shape (85.28%). The phenomenon can be explained simply, since the shortest and narrowest eggs were measured in trio 1, so in this case width stood the closest to the length. Eggs from trio 4 were the most egg-shaped with an index of 80.37%. *Table 1* and *Table 2* present the egg quality parameters of farm "A".

Table 1. **Egg length, width and shape index in farm "A"**

Trios	Length (cm)	Width (cm)	Shape index (%)
	Mean and standard error		
1 (n=14)	14.69±0.12^{d}	12.51±0.07^{a}	85.28±0.67^{b}
2 (n=14)	15.11±0.12^{ab}	12.65±0.07^{ab}	83.74±0.67^{abc}
3 (n=13)	14.95±0.13^{bd}	12.52±0.07^{ab}	83.81±0.73^{abc}
4 (n=10)	15.84±0.14^{e}	12.73±0.08^{bc}	80.37±0.80^{d}
5 (n=6)	15.02±0.20^{abd}	12.43±0.10^{a}	82.78±1.12^{abcd}
6 (n=9)	15.38±0.15^{ac}	12.86±0.08^{cd}	83.71±0.84^{abc}
7 (n=8)	15.74±0.15^{ce}	13.00±0.09^{d}	82.64±0.89^{acd}
8 (n=5)	15.32±0.20^{abc}	13.07±0.11^{d}	85.33±0.01^{abc}
Great mean (n=79)	**15.21±0.05**	**12.69±0.03**	**83,51±0.31**

^{a,b,c,d,e} p≤0.05 Different letters represent significant differences

Table 2. **Egg volume, surface area, circumference and shell volume of eggs in farm "A"**

Trios	Volume (cm^3)	Surface area (cm^2)	Circumference (cm)	Shell volume (cm^3)
	Mean and standard error			
1 (n=14)	1205.16±19.91^{b}	492.18±5.14^{a}	39.31±0.20^{a}	33.54±0.44^{ab}
2 (n=14)	1265.61±19.91^{ac}	502.54±5.14^{ab}	39.73±0.20^{ab}	33.27±0.44^{a}
3 (n=13)	1229.35±21.50^{ab}	492.88±5.56^{a}	39.34±0.22^{a}	32.97±0.48^{a}
4 (n=10)	1325.02±23.55^{cd}	511.47±6.09^{bc}	40.08±0.24^{bc}	33.07±0.52^{a}
5 (n=6)	1214.15±33.31^{ab}	485.11±8.61^{a}	39.04±0.34^{a}	32.32±0.74^{a}
6 (n=9)	1331.55±24.83^{d}	519.65±6.42^{cd}	40.40±0.25^{cd}	33.83±0.55^{a}
7 (n=9)	1393.06±26.33^{d}	531.08±6.80^{d}	40.84±0.27^{d}	33.76±0.59^{ab}
8 (n=5)	1374.91±33.31^{d}	537.54±8.61^{d}	41.07±0.34^{d}	35.05±0.74^{b}
Great mean (n=79)	**1281.39±9.13**	**506.41±2.36**	**39.88±0.09**	**33.41±0.20**

^{a,b,c,d,e} p≤0.05 Different letters represent significant differences

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Average egg volume was 1281.39 cm^3. Trio 1, 3 and 5 had the smallest egg volume (1205.16, 1229.35 and 1214.15 cm^3) as these eggs were the narrowest of all. Eggs from trio 6, 7 and 8 indicated the greatest volume (1331.55, 1393.06 and 1374.91 cm^3). The result comes from the fact that these eggs were the widest, so multiplying width with the „π /6" quotient leads to the largest egg volume. Average surface area was 506.41 cm^2. The smallest surface area was calculated in trio 1, 3 and 5 (492.18, 492.88 and 485.11 cm^2), whereas eggs from trio 6, 7 and 8 had the largest surface area (519.65, 531.08 and 537.74 cm^2). Circumference on average was 39.88 cm. Differences were the same as in the previous cases. Trio 1, 3, 5 had the smallest egg circumference (39.31, 39.34 and 39.04 cm) and trio 8 indicated the largest one, 41.07 cm. Average shell volume showed 33.41 cm^3. Trios did not differ significantly, except for trio 8, having the greatest shell volume of 35.05 cm^3. *Table 3* and *Table 4* present the egg quality parameters of farm "B".

Table 3. **Egg weight, length, width and shape index in farm "B"**

Trios	Egg weight (g)	Length (cm)	Width (cm)	Shape index (%)
	Mean and standard error			
1 (n=10)	1375.10±28.86[a]	15.15±0.15[ab]	12.40±0.09[ab]	81.93±0.88[abe]
2 (n=13)	1359.08±25.31[a]	14.70±0.13[e]	12.48±0.08[ac]	85.05±0.77[d]
3 (n=13)	1392.46±25.31[a]	14.82±0.13[ae]	12.46±0.08[ab]	84.08±0.77[bd]
4 (n=19)	1465.42±20.94[b]	15.44±0.11[bc]	12.55±0.06[ac]	81.37±0.64[ace]
5 (n=10)	1557.30±28.86[c]	15.70±0.15[cd]	13.02±0.09[d]	83.00±0.88[abde]
6 (n=17)	1520.29±22.13[bc]	15.94±0.12[d]	12.68±0.07[c]	79.60±0.68[c]
7 (n=17)	1358.82±22.13[a]	15.12±0.12[a]	12.27±0.07[b]	81.19±0.68[ace]
Great mean (n=99)	**1432.64±9.44**	**15.29±0.05**	**12.54±0.03**	**82.09±0.29**

[a,b,c,d,e] $p \leq 0.05$ Different letters represent significant differences

Average egg weight was 1432.64 g. Eggs from trios 1, 2, 3 and 7 were the lightest, below 1400 g. Trio 4 had eggs of the medium weight category, between 1400 and 1500 g. The heaviest eggs were laid by the females of trios 5 and 6, above 1500 g. Average egg length was 15.29 cm. Trios 2 and 3 had the shortest eggs (14.70 and 14.82 cm) and trios 5 and 6 the longest ones (15.70 and 15.94 cm). Others showed values around the average. Average egg width was 12.54 cm. Trio 7 laid the narrowest (12.27 cm), trio 5 the widest (13.02 cm) eggs. Average egg shape index was 82.09%. Trio 2 and 3 had the most spherical eggs with indices 85.05% and 84.04%. A width/length percent ratio was the smallest in trio 6, 79.60%.

Table 4. **Egg volume, surface area, circumference and shell volume of eggs in farm "B"**

Trios	Volume (cm^3)	Surface area (cm^2)	Circumference (cm)	Shell volume (cm^3)
	Mean and standard error			
1 (n=10)	1221.12±24.60[ac]	483.42±7.01[ab]	38.97±0.28[ac]	31.92±0.49[bc]
2 (n=13)	1198.98±21.57[a]	489.53±6.15[b]	39.21±0.24[bc]	33.36±0.43[d]
3 (n=13)	1206.02±21.57[a]	487.89±6.15[ab]	39.14±0.24[ac]	32.91±0.43[bd]
4 (n=19)	1273.71±17.85[c]	494.70±5.09[bc]	39.41±0.20[bc]	32.08±0.36[bc]
5 (n=10)	1392.60±24.60[d]	532.41±7.01[d]	40.89±0.28[d]	33.96±0.49[d]
6 (n=17)	1345.64±18.87[d]	506.03±5.38[c]	39.85±0.21[b]	31.74±0.38[c]
7 (n=17)	1191.94±18.87[a]	473.10±5.38[a]	38.55±0.21[a]	31.30±0.38[c]
Great mean (n=99)	**1260.02±8.05**	**494.03±2.29**	**39.38±0.09**	**32.34±0.16**

[a,b,c,d,e] $p \leq 0.05$ Different letters represent significant differences

Average egg volume was 1260.02 cm^3. Eggs from trio 1, 2, 3 and 7 had the smallest egg volume (1198.98 cm^3, 1206.02 cm^3 and 1191.94 cm^3). Conversely, trio 5, 6 had the greatest egg volume (1392.60 cm^3 and 1345.64 cm^3). Surface area averaged at 494.03 cm^2. The smallest surface area was calculated in trio 1, 3, 7 (483.42 cm^2, 487.53 cm^2 and 473.10 cm^2), the greatest in trio 5 (532.41 cm^2). Average circumference was 39.38 cm. Trio 7 laid eggs with the smallest (38.55 cm) and trio 5 with the greatest (40.89 cm) circumference. Average shell volume was 32.34 cm^3. Trio 2, 3, and 5 had the smallest shell volume (33.36 cm, 32.91 cm and 33.96 cm). *Figure 1* demonstrates one-week weight loss of eggs deriving from farm "A".

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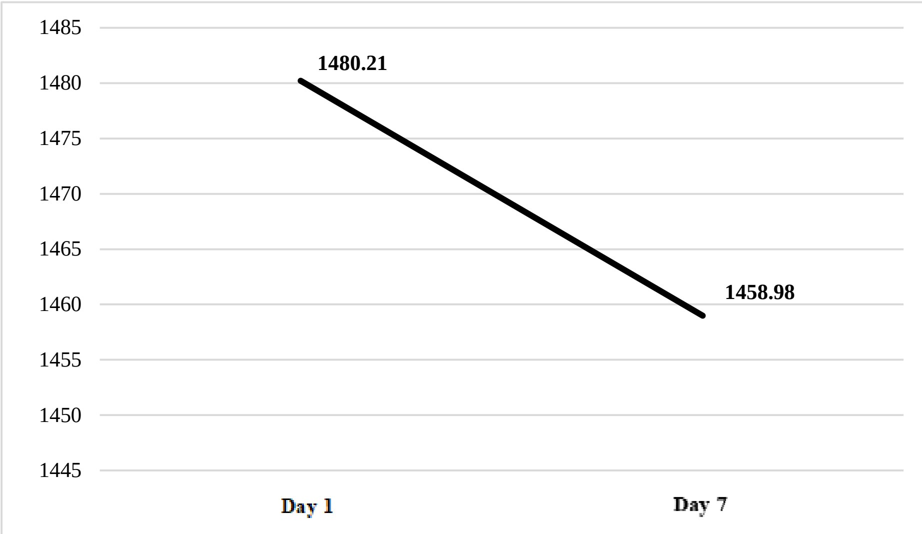
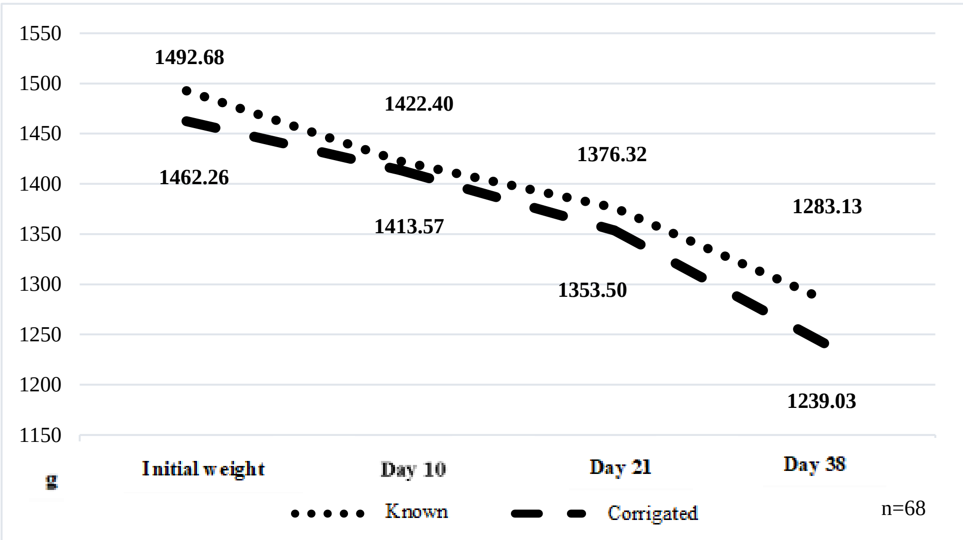
Figure 1. **One-week loss of eggs in farm „A"**



Weight on day 0 indicates the average egg weight at the moment of measurement, not the initial egg weight. The age at the measurement differed, as some eggs were set for the first day, some had been there for many days before weighing, but for not more than 7 days. Egg age was subjected to regression analysis to see if there was a relationship between the variables. Egg age had no significant effect on weight loss during storage (r=0.07, P=0.52). One-week egg weight loss was 21.23 g, indicating 3.03 g loss per day. *Figure 2* demonstrates weight loss during incubation in farm "A".

Figure 2. **Egg weight loss during incubation in farm „A"**



The age of eggs (r=0.49, P≤0.05) and the date of measure (the 10th, 21st and 38th day of incubation, r=0.53, P≤0.05) significantly influenced weight loss during incubation. The known curve (n=28) shows that in the first period of incubation eggs lost 70 g (4.71%) from their initial weight. In the next eleven days we could observe a 46-g-loss (3.24%), then in the second half a 93-g-loss (6.77%). During the 38 days of incubation total weight loss was 14.72%. From these results we drew the conclusion that embryo metabolism is the speediest in the first ten days of incubation, when firstly qualitative changes take place (the development of extra-embryonal membranes and apparatus - circulatory system, respiratory system, excretory system, digestive system and nervous system). From the second half, quantitative changes of the embryo (an increase in weight, length, width, depth and circumference) take priority over qualitative changes. For the curve below we had to adjust initial weight, since we had no data on it. The correction was made

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according to *Figure 1*. During storage, the average daily weight loss was 3.03 g. Eggs were set in the same condition, as it was mentioned in the chapter "Materials and methods". Similar storage conditions made it possible to correct weights measured four days before setting in the incubator to the onset of incubation considering the average daily 3.03 g loss. *Table 5* demonstrates egg surface area, pores count and one-week loss in three different weight groups.

Table 5. **Egg surface area, pores count and one-week loss of egg from the different weight categories**

Weight categories (g)	Egg surface area (cm^2)	Mean pores count (pores/cm^2)	Mean pores count via the equator (pores/cm^2)	Mean pores count at the centre of the aircell (pores/cm^2)	One-week weight loss (g)
	Mean and standard error				
≤ 1350 g (n=27)	456.01±4.29[a]	18.12±1.23	18.53±1.39	17.36±1.35	5.48±2.31
1351–1450 g (n=30)	488.99±4.02[b]	19.71±1.17	20.18±1.32	18.02±1.29	5.52±2.54
1451 g ≤ (n=24)	516.68±4.62[c]	18.25±1.30	19.18±1.47	14.54±1.44	5.48±3.07
Great mean (n=81)	**485.96±3.56**	**18.75±0.71**	**19.33±0.80[a]**	**16.77±0.79[b]**	**5.49±0.28**

[a,b,c,d,e] $p \leq 0.05$ Different letters represent significant differences

Eggs in the smallest weight category had the smallest surface area of 456.01 cm^2. Medium eggs showed greater (488.99 cm^2) and the largest eggs the greatest surface area (516.68 cm^2). Mean pores count did not significantly differ in each weight category (P=0.66), however, positive, medium relationship could be demonstrated between the porosity of the two examined areas (equator and the blunt end, r=0.39, P≤0.05). Pores count via the equator was 19 pores/cm^2, in the center of the blunt end we found 16 pores/cm^2 with a significant difference (P≤0.05). The result goes against our technical knowledge, since the literature states that the most pores can be detected in the blunt end, less via the equator and the least at the pointed end. In chicken egg this value is between 146–158, 134–143, and 97–108 pores/cm^2 and in goose 42–56, 36–44 and 29–37 pores/cm^2 can be observed in the three areas. Considering this correlation, we can assume that the larger the egg is, the less pores it is covered with and the greater the pore diameter is (Bogenfürst, 2017). In our research no relationship could be expressed between surface area and pores count (P=0.74). Eggs sent different, but not longer than seven days in the storage room. Time passed during storage was in a weak, positive correlation with weight loss (r=0.22, P≤0.05). Egg weight loss was 5 to 5.5 g regardless weight category. Initial egg weight and weight loss did not correlate (P=0.69). A weak positive relationship could be indicated between porosity and weight loss (r=0.24, P≤0.05).

We did not have data on initial egg weight from farm "A", so we only examined this parameter in case of farm "B". *Table 3* showed that in farm "B" the average initial egg weight was 1432.64 g. Our result was higher than the 1321 g observed by Mushi et al. (2007), but it was similar to the 1455 g of Brand et al. (2003). Regarding climate conditions, Benoît et al. (2014) declared that egg weight in wet environment was 1370 g and showed 1200 g in drought. In farm "A" the average egg length was 15.21 and 12.69 cm (*Table 1*) and in farm "B" these traits showed 15.29 and 12.54 cm (*Table 4*). On the basis of length there was no significant difference between farms (P=0.39), however, eggs differed in width (P≤0.05). Cooper et al. (2001) found ostrich egg length and width to be 15.24 cm and 12.70 cm, respectively. Egg shape index in farm "A" was 83.51% (*Table 1*), in farm "B" showed 82.09% (*Table 3*). There was a significant difference between farms in this parameter (P≤0.05). Nedomová and Buchar (2013) claimed that the average egg length, width and shape index were 14.66 cm, 12.56 cm and 82.49%. Elsayed (2009), Koutinhouin et al. (2014), Benoît et al. (2014) and Selvan et al. (2014) stated that egg shape was 80%, 83.5%, 82.49% and 82.86%, respectively. Average egg volume in farm „A" was 1281.39 cm^3 (*Table 2*), in farm „B" it was observed 1260.02 cm^3 (*Table 2*). There was no significant difference between farms (P=0.16). Moreki et al. (2016) had 1116.12 cm^3 for average egg volume in his research. This value is less than the one we found. In farm "A" the average egg surface area was 506.41 cm^2 (*Table 2*) and in farm "B" showed 494.03 cm^2 (*Table 4*). There was a significant difference between farms (P≤0.05). Nedomová and Buchar (2013) calculated egg surface 464.97 cm^2. Their result was less than ours. Average egg circumference in farm "A" was 39.88 cm (*Table 2*), in farm "B" showed 39.38 cm (*Table 4*). There was a significant difference between farms in this parameter (P≤0.05). Elobeid et al. (2010) had 40.35 cm for circumference, which is slightly greater than that we found in Hungary. The average 33.41 cm^3 shell volume in farm "A" (*Table 2*) was significantly larger (P≤0.05) than the 32.34 cm^3 in farm "B" (*Table 4*). One-week weight loss of eggs in farm "A" was observed 21.23 g (*Figure 1*) being a multiple of 5 to 5.5 g found in farm "B" (*Table 5*). We assume that the cause of the great weight loss in farm "A" was the higher and inconstant temperature and relative humidity. Weight loss during incubation was only examined in farm "A", so farms were not compared regarding this trait. Weight loss during the 38 days of incubation was 14.72% in total. Gonzalez et al. (1999) measured 13.20% weight loss in medium-sized eggs. Hassan et al. (2005) declared 12.48% loss during 38 days in eggs stored for 5–10

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days and weighed 1515 g. Nahm (2001) claimed that hatchability is negatively affected only if 20% weight loss is observed during incubation. Also El-Safty (2012) examined weight categories presented in *Table 5*. He stated that surface area of eggs in the smallest weight category showed 543.30 cm^2, in the medium and the largest category the surfaces were 572.30 and 598.80 cm^2. There were significant differences between the categories. El-Safty (2012) did not find relationship between egg surface and porosity, nor in pores count/cm^2 and there was no difference between categories based on weight loss. He counted 26.9, 25.4 and 27.1 pores/cm^2 in small, medium and large eggs. Our results were closer to the 22 pores/cm^2 observed by Cloete et al. (2006). El-Safty (2012) stated that egg weight did not affect porosity significantly and the average pores count was in a medium, positive correlation with weight loss only in medium-sized eggs. Medium-sized eggs lost more water compared to small and large eggs. However, we found no difference in weight loss between eggs in each weight category.

CONCLUSIONS

In conclusion, we can summarize that except for egg length, a significant difference could be observed in all traits between trios. Narrower eggs showed smaller surface area, volume, circumference and shell volume and vice versa. Eggs from farm "A" indicated significantly greater width, shape index, surface area, circumference and shell volume than farm "A". Weight loss in farm "A" was a multiple of farm "B", presumably due to the inappropriate storage conditions. In farm "B" there was a weak, positive correlation between storage period and egg weight loss ($r=0.22$, $P \leq 0.05$). There was no relationship between initial egg weight and weight loss. We could demonstrate a weak, positive correlation between egg porosity and weight loss ($r=0.24$, $P \leq 0.05$*)*. Pores count presented here was less than the international results. Poultry eggs contain the most pores on the blunt end, less via the equator and the least on the pointed end. In ostrich egg we found more pores via the equator against the blunt egg. To draw more precise conclusions further investigation should be carried out on porosity. Considering the fact that the length of storage period and the weight loss during incubation are in strict correlation with hatchability, we intend to extend our research aims to these traits.

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