

MAIN EGG CHARACTERISTICS IN THE PEKING DUCK (*Anas platyrhynchos f. dom.*)

Pekin Ördeğinde (*Anas platyrhynchos f. dom.*) Başlıca Yumurta Özellikleri

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Abstract

Main egg characteristics of the unincubated Peking duck eggs (*Anas platyrhynchos f. dom.*) such as egg mass, egg elongation, eggshell thickness, eggshell mass, eggshell proportion in egg content, egg density, egg volume, total pore number, content mass, water proportion in egg content, albumin mass, albumin proportion in egg mass, water proportion in albumin content, yolk mass, yolk proportion in egg mass, yolk proportion in egg content, water proportion in yolk were investigated. The findings were compared with those of reported in literature concerning the eggs of domestic duck and other forms of domestic duck and mallard, and with values estimated from equations given for the precocial bird species. We observed that, while some of our obtained values for main egg characteristics of the Peking duck eggs were similar to both values of Domestic duck / Mallard and the predicted values from equations for precocial species, the other values different considerably. The reason of these differentiations may be genetically or environmental conditions.

Key Words: Peking duck, *Anas platyrhynchos*, egg, eggshell

Özet

Kuluçkaya bırakılmamış Pekin ördeği (*Anas platyrhynchos f. dom.*) yumurtasına ait, kütle, elongasyon, kabuk kalınlığı, kabuk kütlesi, kabuk oranı, yoğunluk, hacim, kabuk gözenek sayısı, su oranı albümin oranı gibi bazı özellikler araştırıldı. Pekin ördeği ve diğer *Anas platyrhynchos* formları yumurtalarına ilişkin bazı parametrelerin, bu çalışmada saptanan, bağıntılardan beklenen ve daha önceki çalışmalarda gözlenen değerleri karşılaştırıldı. Bazı değerlerde benzerlik görülürken, bazıları oldukça farklılık gösterdi. Bu farklılıkların genetik ya da çevresel koşullardan kaynaklanmış olabileceği ileri sürüldü.

Anahtar kelimeler: Pekin ördeği, *Anas platyrhynchos*, yumurta, yumurta kabuğu.

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1. Introduction

Avian embryos develop within confines of the eggshell from a fertilized ovum to a functional hatching bird (Vleck et al. 1980; Nys et al. 2004). At the time of egg-laying, an avian egg contains all of the nutrients needed for embryonic development with exception of oxygen, which is supplied by diffusion through the pores in the shell (Vleck and Vleck 1987; Nys et al. 2004). The thickness of the eggshell and its structural components and features of the porous system vary among different species; however, the main structure of the eggshell is basically similar in all birds (Nys et al. 2004). The principal macronutrients in eggs are lipids and proteins. Proteins and lipids are used in the biosynthesis of the tissues of the developing embryo, and lipids are also used as the primary source of energy for biochemical work (Ricklefs 1977). A hatchling is the outcome of embryonic development, and its size and maturity and energy reserves depend on the amount of energy within the egg at laying. These special characteristics make avian eggs excellent for the study of energy metabolism and growth (Vleck and Vleck 1987).

The determination of properties, such as dimension, mass, volume, density, proportions of components, and eggshell structure of avian eggs provides to constitute the general patterns of avian developmental and energetic, thus providing useful insight into the relationship between different developmental strategies and their evolutionary significance (Vleck and Vleck 1987).

Peking duck originates from mallard *Anas platyrhynchos* and evolved in China during last centuries. Although Peking duck has been well known all over the world; e.g. since 1873 in America (Marks and Krebs 1968; Selçuk and Aykurt 1986), they were directly imported from China to Turkey at 1984, and it has rapidly become widespread (Kelten 1987). Data obtained from eggs of several forms of *A. platyrhynchos*, such as those of Peking duck, can be used for comparisons with a regard to many aspects, such as developmental physiology, evolution and domestication effects.

In this study, main egg characteristics, such as size and mass and proportions of content and shell thickness and pore number on the eggshell of the unincubated Peking duck eggs (*Anas platyrhynchos* f. *dom.*) were investigated. The findings were compared with both those of reported in literature concerning the eggs of domestic duck and other forms of domestic duck and mallard, and with values estimated from equations given for the precocial bird species. Thus, the compatibility of the physiological properties of eggs of Peking duck with the model described for precocial species was studied, and also we investigated whether or not there are differences between wild and domesticated forms for egg characteristics.

2. Material and Method

Fresh laid eggs that were obtained from the “Peking Duck Breeding Station” of Dicle-University were used as study material. The eggs received from

nesting-box and in variable numbers were brought to the laboratory, cleaned, selected and marked.

2.1. Measurement of egg dimension, mass, composition and volume

The length and breadth of the eggs were measured with a calliper to the nearest 0.05 mm. An electronic balance accurate to 1 mg was used for the determination of mass. For determination of the egg composition, eggs were boiled about 15 min in water until their content became solid. After thawing, eggs were separated into eggshell, albumin and yolk components, which were then separately weighed. Albumin and yolk were separately wrapped in aluminium folio and placed into desiccators and then dried to constant mass at +55°C. After the drying process, component parts were reweighed, and their dry mass was measured. The volumes were determined by immersion method.

2.2. Pore counts

The pore density (pore number/cm²) in the shell was determined by using the method of Booth (1989) (Booth 1989): Inside surfaces of shell fragments were stained with Evans Blue stain dissolved in 70 %alcohol. The staining solution was taken into pores by capillary action so that each pore could appear as a blue dot on outside surface. The number of pores per 25 mm² was counted for five different areas of each fragment with the aid of a dissecting microscope. For calculation of the mean pore density for the entire egg, the mean value for the equatorial region was multiplied twice, added to the values from both ends, and divided into four. This was done because pores were not evenly distributed over the shell, and the equatorial region was taken to represent approximately twice as large a portion of the shell as either of the end pieces. The total number of pores per egg was obtained by multiplying the mean pore count by the total area of the egg estimated from the equation of surface area according to Hoyt *et al.* (1979) (Hoyt et al. 1979).

2.3. Shell thickness

Measurements of shell thickness was performed on shell fragments of approximately 3 cm² surface area taken from blunt pole, equator and sharp pole of unincubated eggs. Fragments were boiled in sodium hydroxide solution (2.5 %g/lit) for about 5 min to remove the shell membranes and most of cuticle, then rinsed in distilled water and air-dried. The thickness of the shell fragments were determined by using a micrometer calibrated to nearest 0.01 mm. An average shell thickness was calculated for each egg according to the method sequenced for the calculation of a mean pore number for single eggs (Hoyt et al. 1979).

3. Results and Discussion

All values obtained from this study and predicted from equations in the literature, in comparison to values that of other domestic forms and also of mallard, are summarized in Table 1.

Egg mass of birds ranges from about 0.28 g (hummingbirds Trochilidae) to 1600 g (ostriches Struthionidae) (Nys et al. 2004; Rahn and Paganelli 1988a). Elongation (the proportion of length to breadth) in bird eggs ranges from 1.67 (long eggs, example: flamingos Phoenicopteridae) to 1.17 (spherical eggs, example: bee-eaters Meropidae). The mean in 169 species of Anseriformes, was determined as about 1.42 (Carey et al. 1980). The measured value of egg mass and elongation of Peking duck were approximately similar to the predicted value for precocial species, but egg mass had different values from the other domestic duck forms and wild mallard (Table 1). The reason of this differentiation may be genetically or environmental conditions. Because, the egg size in birds is determined genetically with an efficiency factor to 70%, while the effects of environmental conditions, such as feeding resources, altitude and ambient temperature at last 3-4 days before egg-laying, are relatively restrained (Föger and Pegoraro 1996).

The eggshell mass in birds generally constitutes 6%-12% of total egg mass, and is about 8% in Anseriformes (Rahn and Paganelli 1988a). Both eggshell mass and eggshell proportion in egg content of Peking duck in our study were higher than the predicted value for precocial species and the other domestic duck forms and mallard (Table 1). The egg density of content is calculated by dividing egg mass to egg volume. The egg density is given as 1.031 g/mL for all birds in general and 1.034 g/ml for *Anas platyrhynchos*. The egg density of *Anas platyrhynchos* has also been estimated as 1.078 g/mL and measured as 1.087 g/mL (Rahn and Paganelli 1989b). In our study, the density of peking duck eggs is lesser than the estimated value from equation, but it is more than the other domestic duck forms and mallard (Table 1).

Water proportion of egg is 67% to 75% for precocials, depending on water content of yolk (about 50%), which is relatively lesser than that of other tissues (Carey et al. 1980; Sotherland and Rahn 1987; Föger and Pegoraro 1996). Furthermore, Ricklefs (1977) pointed out that lipid content of yolk increases, depending on precociality (Ricklefs 1977). Water proportion of Peking duck eggs (71%) is similar to that of other domestic duck forms and mallard (Table 1).

Table 1. Some characteristics of the eggs of Peking duck (*Anas platyrhynchos* f. *dom.*) determined in the study and predicted from literature equations, in comparison to the other forms of domestic duck and wild mallard.

Symbols used in equations: A: Area (cm²), B: Breadth (mm), D: Density of content (g/mL), El: Elongation (L:B), E: Energy content (kJ), FLC: Fraction of lipid content (% in egg content), FYC: Fraction of yolk content (% in egg content), I: Incubation period (days), L: Length (mm), L_s: Thickness of eggshell (mm), M: Egg mass (g), M_c: Mass of egg content (g), M_s: Eggshell mass (g), N: total Pore number, V: Volume (mL), Y: Yolk mass (g).

Parameter	Peking duck				Domestic duck / Mallard	
	Measured value *	Estimated value	Equation	*R	Measured value	*R
Egg mass (g)	69.51 ± 9.96 (162)	67.90	$M = 54.19 \cdot (L \cdot B^2)$	11	82.3	5
					58.2	12
					80.0	3
					47.8	13
Length (mm)	62.74 ± 3.75 (162)	62.44	$L = 14.7 \cdot M^{0.341}$	14	-	-
Breadth (mm)	44.69 ± 2.15 (162)	45.23	$B = 11.3 \cdot M^{0.327}$	14	-	-
Elongation (L:B)	1.40 ± 0.06 (162)	1.38	$El = 1.30 \cdot M^{0.014}$	14	-	-
Eggshell thickness (mm)	0.509 (60)	0,35	$L_s = 0.0546 \cdot M^{0.441}$	15	0.28	5
					0.31	12
Eggshell mass (g)	7.97 ± 0.93 (20)	5.88	$M_s = 0.0524 \cdot M^{1.113}$	15	-	-
Eggshell proportion in egg content (%)	10.28 ± 0.77 (20)	-	-	-	8.9	12
Volume (mL)	70.19 ± 6.82 (20)	89.85	$V = 0.1 \cdot (L_s \cdot A) + (M - M_s / D)$	13	51.4	5
		65.64	$V = 0.001 \cdot \pi / 6 \cdot L \cdot B^2$	16		
Surface area (cm ²)	-	80.14	$A = 4.835 \cdot M^{0.662}$	17	-	-

Density (g/mL)	0.990 (20)	0.756	$V = 0,1 \cdot (L_s \cdot A) + (M - M_s / D)$	11 18	1.087	13
Total pore number	9625 (60)	8827 7865 8738	$N = 1041 \cdot M^{0,504}$ $N = 3520 \cdot M / I$ $N = 304 \cdot M^{0,767}$	5 19 20	9000	5
Pore diameter (μm^2)	-	-	-	-	350	5
Content mass (g)	69.54 ± 6.39 (20)	-	-	-	72.3 47.8 53.0 47.5	4 21 12 22
Water proportion in egg content (%)	70.90 ± 0.75 (20)	-	-	-	64.5 71.8 72.4 71.0	4 21 12 22
Lipid proportion in egg content (%)	-	-	-	-	11.2 11.7 13.2	4 21 12
Albumin mass (g)	41.51 ± 4.52 (20)	-	-	-	-	-
Albumin proportion in egg mass (%)	53.51 ± 2.10 (20)	-	-	-	51.3	12
Water proportion in albumin content (%)	86.34 ± 0.98 (20)	-	-	-	85.0 90.0	4 12
Albumin density (g/mL)	-	-	-	-	1.031	12

Protein content of albumin (mg/g)	-	-	-		85.8	12
Yolk mass (g)	26.39 ± 2.79 (20)	-	-		-	-
Yolk proportion in egg mass (%)	34.06 ± 2.04 (20)	-	-		41.3 40.0 34.5	4 21 12
Yolk proportion in egg content (%)	37.96 ± 2.19 (20)	26.19	$Y = 0.346 \cdot M_c^{1.02}$	23	-	-
Water proportion in yolk (%)	44.86 ± 0.92 (20)	-	-		47.4 46.2	4 12
Yolk density (g/mL)	-	-	-		1.023	12
Protein content in yolk (mg/g)	-	-	-		179	12
Lipid proportion in egg mass (%)	-	12.58	$FLC = -0.015 + 0.332 \cdot FYC$	23	-	-
Energy density of content (kJ/g)	-	-	-		9.86 8.29 8.40	4 21 12
Total energy content (kJ)	-	517.80	$E = 6.026 \cdot M^{1.05}$	3	427 611	22 3

- mean ± standard deviation (sample size), *R=references; 3. Vleck and Vleck 1987; 4. Ricklefs 1977; 5. Hoyt 1979; 11. Hoyt 1979; 12. Roca et al. 1984; 13. Prinzinger et al. 1995; 14. Rahn and Paganelli 1988b; 15. Rahn and Paganelli 1989a; 16. Weimer and Schmidt 1998; 17. Paganelli et al. 1974; 18. Rahn and Paganelli 1989b; 19. Rahn and Ar 1980; 20. Rahn and Paganelli 1990; 21. Carey et al. 1980; 22. Ar et al. 1987; 23. Sotherland and Rahn 1987)

It has been assumed that there are relations between egg composition (Bucher 1987), and yolk size (Ar et al. 1987) and mode of development, individually. Irrespective of developmental mode, energy density of dried mass of yolk in all bird eggs has been determined as about 33.4 kJ per g (Sotherland and Rahn 1987). Because precocial species have a greater yolk size than altricials, eggs of precocial species contain relatively more energy (Ar et al. 1987; Bucher 1987; Prinzinger et al. 1991). For precocial species, Sotherland and Rahn (1987) have reported that the energy density of fresh egg is about 9.5 kJ/g (Sotherland and Rahn 1987). Moreover, total energy density in precocial species is 8.0kJ/g on average. Total energy density of Peking duck was estimated as 8,4 kJ/g.

Yolk proportion in egg mass (%) was reported by Carey *et al.* as 40 %-65 %; by Sotherland and Rahn (1987) as 35% for precocial species (Sotherland and Rahn 1987).

The egg content analysis (Tab. 1) showed that the Yolk proportion in egg mass (%) was lightly lesser than the other domestic duck forms and mallard. Yolk proportion in egg content (%) was lesser than the estimated value from equation (table 1).

The average pore density for an Anatidae egg has been reported as 9475 pores/cm², and the average eggshell thickness as 0.450 mm (Hoyt et al. 1979). The average pore density of Peking duck egg was higher than both Anatidae and other domestic duck forms and mallard and estimated value from equation (Table 1). Such porosity change is suggestive of induced conductivity of eggshell, implying improved hatching success (Chakravarty and Lahiri 1986). The average eggshell thickness of Peking duck eggs was higher than both estimated value from equation and the other domestic duck forms and mallard (Table 1). Such structural changes of thickened shells were associated with a significant increase (induction) in the level of calcium both of the plasma and of shell gland of the ducks (Chakravarty and Lahiri 1986).

In conclusion, we observed that, while some of our values obtained for parameters of the Peking duck eggs were similar to both the values of Domestic duck / Mallard and the predicted values from equations for precocial species, the other values were differed (Table 1). The reason of these differentiations may be genetically or environmental conditions.

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