

Relationship models between egg weight and internal quality of Alabio duck eggs (*Anas platyrhynchos Borneo*)

Model hubungan antara berat telur dengan kualitas internal telur itik Alabio (*Anas platyrhynchos Borneo*)

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ABSTRACT

This research aimed to determine the relationship models and phenotypic correlation between the egg weight of Alabio duck (*Anas Platyrhynchos Borneo*) and the Haugh unit (HU), albumen weight, yolk weight, albumen index, and yolk index. Five hundred eggs weighing 65.7 ± 4.62 g were collected from a flock of 32-week-old commercial laying hens as objects for this experiment. The observed variables were egg weight, albumen weight, yolk weight, albumen index, and yolk index. The data was analyzed using simple linear regression and Pearson's correlation coefficient (r). A significant correlation ($P < 0.05$) was found between egg weight and HU, albumen weight, yolk weight, and yolk index., with an r of -0.11, 0.83, 0.70, and 0.19, respectively. However, there was no significant correlation between egg weight and albumen index ($P > 0.05$). These results indicated that egg weight could be used as a variable to appropriately predict albumen weight and yolk weight with the equations $y = -0.11 + 0.56x$ and $y = -2.10 + 0.37x$ for albumen and yolk weight, respectively. However, egg weight as a single variable could not accurately predict the HU and yolk index of the Alabio duck egg.

ABSTRAK

Penelitian ini bertujuan untuk mengetahui model hubungan dan korelasi fenotipik antara berat telur itik Alabio dengan kualitas internal telur yang meliputi nilai Haugh Unit (HU), berat putih telur, berat kuning telur, indeks putih telur (IPT) dan indeks kuning telur (IKT). Sebanyak 500 butir telur dengan berat rata-rata ($\pm SD$) $65,7 \pm 4,62$ gram yang berasal dari induk itik Alabio berumur 32 minggu digunakan sebagai materi penelitian. Peubah yang diukur adalah berat telur, Haugh Unit, berat putih telur, berat kuning telur, indeks putih telur dan indeks kuning telur. Data dianalisis menggunakan model regresi linier sederhana dan korelasi Pearson (r). Terdapat korelasi yang nyata ($P < 0,05$) antara berat telur dengan HU, berat putih telur, berat kuning telur, dan indeks kuning telur, dengan r berturut turut sebesar -0,11, 0,83, 0,70, dan 0,19. Tidak terdapat korelasi antara berat telur dengan indeks putih telur ($P > 0,05$). Hasil penelitian menunjukkan bahwa berat telur dapat digunakan sebagai variabel untuk memprediksi berat putih telur dan berat kuning telur dengan menggunakan model regresi linear sederhana dengan persamaan $y = -0.11 + 0.56x$ untuk putih telur and $y = -2.10 + 0.37x$ untuk kuning telur. Berat telur sebagai variabel tunggal tidak dapat digunakan untuk memprediksi HU dan IKT itik Alabio secara akurat.

Kata kunci:

Berat telur

Kualitas telur

Itik Alabio

Regresi linear

Korelasi



INTRODUCTION

Alabio duck (*Anas platyrhynchos Borneo*) is a typical duck of South Kalimantan, better known as a laying duck. Consumers, mainly the local community, prefer its eggs to purebred chicken eggs (Sulaiman et al., 2018). This trend was caused by consumer behavior that was increasingly selective in choosing products based on quality (Aulia et al., 2016). The egg quality was generally divided into external and internal quality. External qualities include eggshell color, cleanliness, shape, index, weight, and thickness, while internal qualities include yolk index, yolk color, albumen index, haugh unit (HU) (Stadelman et al., 1995), albumen weight, albumen length, and yolk length (Nasr et al., 2016).

Egg quality was determined by consumer acceptance of several egg criteria, including cleanliness, freshness, egg weight, surface area, shell strength, haugh unit, albumen index, yolk index, and egg chemical composition (Narushin, 1997 in Duman et al. 2016). Consumers have their criteria for choosing eggs according to their needs. Consumers of consumed eggs paid more attention to egg weight, shell quality, egg uniformity, and yolk color, while consumers of hatched eggs paid more attention to the ideal weight of the egg, shell quality, and the fertile egg's age. Traditional consumers were concerned about price, egg freshness, egg size, shell color, and yolk color. Egg consumers for cake production also have their own criteria (Yuwanta, 2010).

Egg weight was used in egg selection. Egg weight was related to internal egg quality (Sarica et al., 2012). An association for one of the external qualities was needed to estimate the egg's internal quality, so it was unnecessary to break the egg to know the quality inside. This experiment aimed to develop models to predict internal egg quality using egg weight as a single predictor. The egg quality includes HU, albumen weight, yolk weight, albumen index, and yolk index.

MATERIALS AND METHODS

The research was conducted at the Animal Nutrition Laboratory, Department of Animal Science, Faculty of Agriculture, Lambung Mangkurat University, Banjarbaru.

Research Materials

The material used in this study was 500

eggs of 100 Alabio ducks aged eight months, with an average egg production per day was 60% in an intensive maintenance system.

The tools used included an analytical balance of the O'Haus brand with an accuracy of 0.001 g to weigh egg, shell, and yolk weights. A New England-brand calliper with 0.01 mm accuracy that used to measure albumen (length, width, and height) and yolk (diameter and height). Glass as a flat surface was used to place the cracked eggs. A spoon was used to help separate the yolk from the albumen. A Petri dish was used to put the egg yolk to facilitate the weighing process of the egg yolk.

Research Methods

The study was conducted using the quantitative observation method. The independent variable was egg weight, while the dependent variables were Haugh Unit (HU), white and yolk weight, albumen index (AI), and yolk index (YI).

Observed Parameters

Parameters observed included egg weight, HU, albumen weight, yolk weight, albumen index, and yolk index. Egg weight was obtained by weighing using an O'Haus brand analytical balance with an accuracy of 0.001 g.

Haugh Unit (HU) was obtained by logarithmically calculating the height of thick albumen, which was transformed into a correction value with egg weight (Tugiyanti and Iriyanti, 2012). The height of the albumen was measured using a caliper at the edge of the yolk and albumen. The HU value was calculated using the formula from Haugh's Formula (Eisen et al., 1962) as follows:

$$HU = 100 \log (h+7.57 - 1.7*W*0.37)$$

Description:

HU : *Haugh Unit*

h : Height of condensed albumen (mm)

W : Egg weight (g)

The yolk weight (YW) was obtained by weighing the egg yolk, which broke the egg and separated the yolk from the albumen using a spoon (Alkan et al., 2013). Then, the yolk was placed into a Petri dish to facilitate weighing.

The albumen weight (AW) was obtained by subtracting the egg weight from the yolk and shell weights (Alkan et al., 2013). Egg shells were

weighed after drying to obtain the shell weight.

Albumen Index (AI) was the ratio between the height of albumen thickness and the average of albumen length, and width (Swacita and Cipta, 2011). Height, length and width of albumen thickness were measured using a calliper. The albumen index was calculated using the formula based on the National Standardization Agency (2008) as follows:

$$AI = \frac{\text{the height of albumen thickness (cm)}}{\frac{1}{2}(\text{albumen length} + \text{albumen width}) \text{ (cm)}}$$

Yolk index (YI) was the ratio between yolk height and diameter (Swacita and Cipta, 2011). Yolk height and diameter were measured using a calliper. The egg yolk index was calculated using the formula based on the National Standardization Agency (2008) as follows:

$$YI = \frac{\text{yolk height (cm)}}{\text{yolk diameter (cm)}}$$

Data Analysis

Degree of equivalence between egg weight and internal quality of Alabio duck eggs

The relationship between egg weight as the independent variable (x) and internal quality, such as HU, white and yolk weight, albumen index (AI), and yolk index (YI) as the dependent variable (y), was analysed using the Pearson's correlation formulation (Siregar, 2015).

$$r = \frac{\sum_{i=1}^n (x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_{i=1}^n (x_i - \bar{x})^2 (y_i - \bar{y})^2}}$$

Description:

r: correlation coefficient

n: number of data

x: independent variable (egg weight)

y: dependent variable (internal egg quality)

Relationship model between egg weight and internal quality of alabio duck eggs

The data presented were HU, albumen weight, yolk weight, AI, and YI as dependent variables positioned on the Y-axis, while egg weight as the independent variable was placed on the X-axis. When the relationship pattern showed a linear trend, the following model was used to develop a relationship model between the independent and dependent variables. The simple linear regression model (Harlan, 2018) was as follows:

$$y_i = \beta_0 + \beta_1 x_i ; i = 1,2,\dots,500$$

Description:

y: dependent variable (internal egg quality)

x: independent variable (egg weight)

β0: constant/intercept

β1: regression coefficient

The contribution of Alabio duck egg weight diversity as an independent variable (x) to the internal quality of eggs as the dependent variable (y) was calculated using the coefficient of determination (r²) (Sugiyono, 2014).

RESULTS AND DISCUSSION

The measurement results of the research eggs resulted in egg quality data as listed in Table 1. Based on USDA standards (Jones, 2012), eggs used as research material are included in AA quality because the HU value is more than 72. The average albumen index (AI) was 0.11, with a CV of 23.05%. According to SNI standards (National Standardization Agency, 2008), the average value is included in AI quality II. The average yolk index (YI) was 0.34 with a CV of 10.85% and was included in YI quality III (National Standardization Agency, 2008). Egg quality is influenced by many factors, including internal factors (genetics, health, age, and production phase) and external factors such

Table 1. Summary statistics of the egg quality

	Egg weight (g)	Haugh unit (HU)	Albumen weight (g)	Yolk Weight (g)	Albumen index	Yolk index
n*	500	500	500	500	500	500
Minimum	52.48	55.95	27.57	14.13	0.05	0.23
Maximum	81.87	98.18	46.96	29.22	0.20	0.45
Average	65.68	87.29	36.32	22.22	0.11	0.34
SD	4.62	9.83	3.09	2.44	0.03	0.04
CV	7.03	11.26	8.50	10.98	23.05	10.85

*=number of eggs; SD= Standard deviation; CV=Coefficient of variation

Table 2. Models of the relationships between egg weight and egg quality

	Regression equation model	RMSE	r	r ²
HU	$y = 103 - 0.24x$	9.78	-0.11	0.01*
AW	$y = 0.11 + 0.56x$	1.75	0.83	0.69**
YW	$y = - 2.10 + 0.37x$	1.74	0.70	0.49**
AI	$y = 12.81 - 0.03x$	2.53	-0.05	0.00ns
YI	$y = 24.07 + 0.16x$	3.66	0.19	0.04**

x= independent variable; y= dependent variable; HU= Haugh Unit; AW= Albumen Weight; YW= Yolk Weight; AI= Albumen index; YI= Yolk Index; RMSE= Root Mean Square Error; r= Correlation coefficient; r² = Coefficient of determination; *= significant (P < 0.05); **= highly significant (P < 0.01); ns = not significant (P > 0.05).

as nutrition, housing, and microclimate (Ledvinka et al., 2012).

The degree of closeness and the relationship model between egg weight and egg quality can be seen in Table 2. There was a positive linear relationship between egg weight and albumen weight, yolk weight, and YI, where the contribution of egg weight to each variable was 69%, 49%, and 4%, respectively. A negative linear relationship was found between egg weight and HU, where the contribution of egg weight to HU was 1%.

There was no significant relationship between egg weight and AI. The highest degree of association was between egg weight and albumen weight (r=0.83), while the lowest was between egg weight and AI (r=-0.05).

Relationship between Egg Weight and Haugh Unit (HU)

The relationship between egg weight and Haugh Unit (HU) is presented in Figure 1. HU is one of the criteria for determining inner egg quality by measuring egg weight and albumen height (Purdiyanto, 2018). The correlation value between Alabio duck egg weight and HU was -0.11. The negative correlation value indicates an inversely proportional relationship, meaning the HU value will decrease when egg weight increases. However, the level of relationships is deficient (Siregar, 2015).

The egg weight and HU regression equation was $y = 103 - 0.24x$, with a negative r. The regression slope shows that every one-gram increase in egg weight will decrease HU by 0.24, while the r² (0.01) indicates that there is an effect of egg weight on HU by 1%, and the rest is due to other variables. The low r² demonstrates that the simple linear regression model using egg weight as a single variable cannot accurately predict the HU of Alabio duck eggs.

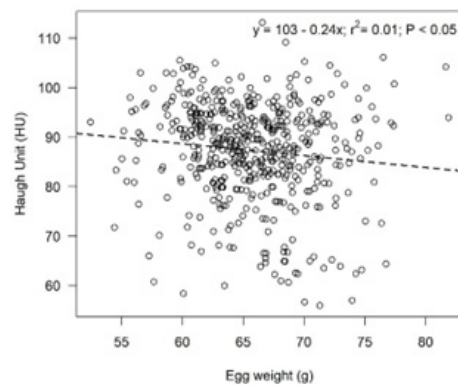


Figure 1. Association between egg weight and HU of Alabio ducks

Factors that can affect the HU value are albumen height and egg weight, albumen height is determined by albumen density, and albumen density itself is influenced by protein content in the diet (Stadelman et al., 1995). The higher the HU value, the higher the ovomucin, and the better the inner quality of the egg (Purdiyanto, 2018).

Relationship between Egg Weight and Albumen Weight

The relationship between egg weight and albumen weight is presented in Figure 2.

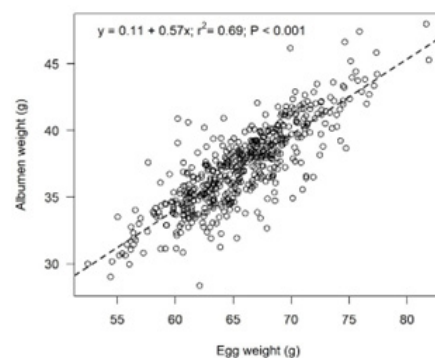


Figure 2. Association between egg weight and albumen weight of Alabio ducks

Egg weight was found to be correlated with albumen weight. In the study of partridge eggs, the correlation between egg weight and albumen weight was 0.76 (Alkan et al., 2015). In this study, the r value between egg weight and albumen weight of Alabio ducks was 0.83. The positive correlation value indicates a proportional relationship directly, which means that the more the egg weight increases, the more the albumen weight increases. The correlation between egg weight and albumen weight was higher than that found in egg yolk, as reported by Sreenivas et al. (2013), who examined White Leghorn chicken eggs. According to Siregar (2015), the level of relationship found is very high.

The regression equation between egg weight and albumen weight was $y = 0.11 + 0.56x$ ($P < 0.001$). The regression slope indicates a 0.56 gram increase in albumen weight for every one-gram increase in egg weight. The r^2 of 0.69 shows an effect of egg weight on albumen weight at 69%, and other variables influence the rest. Other variables that correlate with albumen weight besides egg weight include egg length, surface area, egg volume (Kgwatalala et al., 2016), yolk weight, shell weight, egg index, yolk height and width, and albumen height and width (Alkan et al., 2015).

Relationship between Egg Weight and Yolk Weight

The relationship between egg weight and yolk weight is presented in Figure 3.

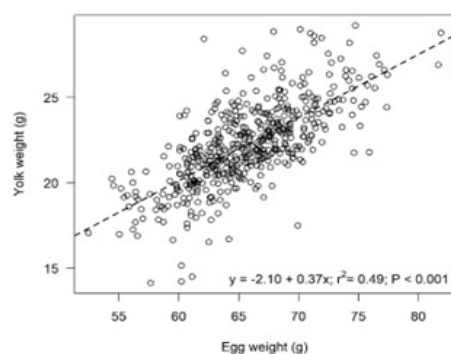


Figure 3. Association between egg weight and yolk weight

The correlation value between egg weight and yolk weight of Alabio ducks was 0.70. Similar results were reported by Kgwatalala et al. (2016) on Tsawana chicken eggs, but higher than those reported by Alkan et al. (2015) on partridge

eggs, which amounted to 0.455. A positive correlation value indicates a directly proportional relationship, meaning that yolk weight will also increase if egg weight increases. The level of this relationship is high (Siregar, 2015).

The regression equation between egg weight and yolk weight was $y = -2.10 + 0.37x$ ($P < 0.001$). The regression slope indicates that an increase will follow every one-gram increase in egg weight in yolk weight of 0.37 g. The r^2 indicates an egg weight effect on yolk weight of 49%, and other variables influence the rest. Other variables correlating with yolk weight besides egg weight include egg length and width, egg volume, yolk width, shell thickness, yolk, and white ratio, in partridge eggs (Alkan et al., 2015). In Mutiara chicken eggs, yolk weight can be influenced by egg width, yolk diameter, egg volume, and yolk ratio (Alkan et al., 2013). Yolk formation affects the weight of the resulting egg; if the yolk is large, the resulting egg is also larger (Purwati et al., 2015).

Relationship between Egg Weight and Albumen Index (AI)

The correlation value between egg weight and albumen index of Alabio ducks was -0.05, but not significant ($P > 0.05$). Similar results were reported by Aryee et al. (2020) on quail eggs, which amounted to -0.03. Different results were reported by Sreenivas et al. (2013) on white leghorn chicken eggs. This may be due to differences in the types of poultry eggs used. The regression equation obtained was not significant ($P > 0.05$). These results indicate that egg weight cannot be used to estimate the AI of Alabio ducks. Other variables related to AI are the yolk index, HU (Alkan et al., 2013), egg weight, albumen weight, and albumen height and length (Alkan et al., 2015).

Factors that can affect AI are storage duration and storage temperature. The longer the egg is stored, AI will decrease. This condition is because the ability of ovomucin to bind water decreases so that water comes out of ovomucin, causing the albumen structure to be thinner. The higher the storage temperature, the more CO_2 disappears, and the pH of the albumen increases, so the condition of the thick albumen decreases (Widyantara et al., 2017).

Relationship between Egg Weight and Yolk Index (YI)

The relationship between egg weight and yolk index is presented in Figure 4. The correlation value between egg weight and YI of Alabio ducks was 0.19. This result is higher than the White Leghorn chicken egg of 0.154 (Sreenivas et al., 2013), and the partridge egg of -0.38 (Alkan et al., 2015). The positive correlation value indicates a direct proportional relationship, meaning that the more the egg weight increases, the more the YI increases. According to Siregar (2015), the level of relationship between the two is very low.

The regression equation between egg weight and YI is $y = 0.24 + 0.002x$ ($P < 0.01$). The positive regression coefficient value indicates that every one-gram increase in egg weight will be followed by a rise in YI by 0.002. The r^2 shows that there is an effect of egg weight on YI by 4%, and other variables influence the rest. Other variables correlating with YI are egg index (Alkan et al., 2015), HU, yolk height, and weight (Alkan et al., 2013). The low r^2 indicates that a simple linear regression model using egg weight as a single variable cannot accurately predict the YI of Alabio ducks. Factors affecting YI are egg size, length, and storage temperature, vitelline membrane quality, and feed nutrition (Bakuama et al., 2019). The longer the egg is stored, the larger the yolk, but the IKT will decrease. This condition might happen because the osmotic pressure of the yolk is greater than the albumen, so the water from the albumen moves to the yolk, causing the yolk to enlarge until it finally breaks (Romanoff & Romanoff, 1963).

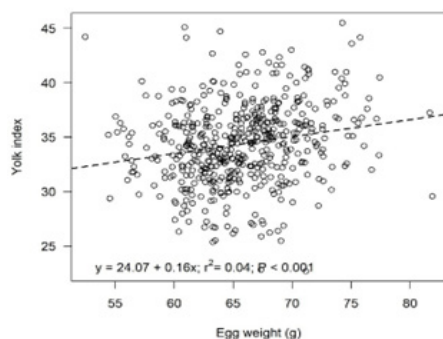


Figure 4. Association between egg weight and yolk index of Alabio ducks

CONCLUSIONS

There was a positive correlation between the egg weight of Alabio ducks and albumen weight, egg yolk weight, and YI, a negative correlation was found in HU, but no correlation was found in AI. Based on simple linear regression analysis, egg weight can only be used to predict the albumen and yolk weight of Alabio ducks. Although there was a significant relationship between egg weight and HU and YI, the low coefficient of determination indicates that egg weight as a single variable cannot be used to predict the HU and IKT of Alabio ducks accurately.

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