e-ISSN 2579-9479
p-ISSN 2828-4348
Accredited by a Directorate General of Higher Education, Research and Technology No. 79/E/KPT/2023

Jurnal Ilmu Peternakan Terapan
October 2024, 8 (1): 22-30
DOI: https://doi.org/10.25047/jipt.v8i1.5327
Available online at https://publikasi.polije.ac.id/index.php/jipt

Model of the relationship between egg weight and the external quality of Pengging duck (*Anas plathyrynchos*)

Model hubungan antara berat telur dan kualitas eksternal telur itik Pengging (Anas plathyrynchos)

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ARTICLE INFO

Received:
16 August 2024
Accepted:
25 October 2024
Published:
28 October 2024

Keywords:
Egg weight
External quality of egg
Pengging Duck
Quantitative observational
Relationship model

ABSTRACT

This research was designed to analyze the relationship between egg weight and the external quality of Pengging duck eggs. The method used in the research was quantitative observational. Samples of Pengging Duck eggs were taken from the Banyubiru Satker Center, Semarang Regency, totaling 250 eggs. The variables measured include egg weight, egg length and egg width, egg length and width circumference, egg volume, egg specific gravity, egg index and egg circumference index. The analysis used was regression analysis with egg weight as the dependent variable (Y) and external egg quality (egg length, etc.) as the independent variable (X). Relationship models obtained for egg length-egg weight (Y=13.872x-11.994), egg width-egg weight (Y=21.392x-31.395), egg circumference index-egg weight (Y=1.9624x+33.523), width circumference-egg weight (Y=3.8527x+8.4576), egg specific gravity-egg weight (Y=-8.931x+76.308), egg index-egg weight (Y=-8.166x+72.718), egg circumference index-egg weight (Y=-7.339x+72.69). It could be concluded that the length, width, length perimeter, width perimeter, and specific gravity of the eggs were found to be highly related to egg weight of Pengging Duck.

Kata kunci:
Berat telur
Kualitas eksternal telur
Itik Pengging
Observatif kuantatif
Model hubungan

ABSTRAK

Penelitian ini disusun untuk menganalisis hubungan antar berat dan kualitas eksternal telur itik Pengging. Metode yang digunakan dalam penelitian adalah observatif kuantatif. Analisis yang digunakan adalah analisis regresi. Sampel telur Itik Pengging di ambil dari Balai Satker Banyubiru, Kabupaten Semarang sebanyak 250 butir telur. Variabel yang diukur meliputi bobot telur, panjang dan lebar telur, keliling panjang dan kelliling lebar telur, volume telur, berat jenis telur, indeks dan keliling indeks telur. Persamaan regresi yang diperoleh panjang telur-bobot telur (Y=13,872x-11,994), lebar telur-bobot telur (Y=21,392x-31,395), keliling panjang telur-bobot telur (Y=1,9624x + 33,523), keliling lebar telur-bobot telur (Y=3,8527x+8,4576), volume telur-bobot telur (Y=0,3782x+44,07), penjang telur-indeks telur (Y=- 0,107x+1,413), berat kerabang-bobot telur (Y=1,645x+51,352), lebar telur-indeks telur (Y=0,1214x+0,2572). Dapat disimpulkan bahwa berat telur Itik Pengging mempunyai hubungan yang sangat nyata dengan panjang telur, lebar telur, panjang lingkar, lebar lingkar telur, dan berat jenis telur.

INTRODUCTION

Eggs are the most popular and highly nutritious food originating from various types of animals, especially poultry such as chickens, ducks, and other birds. One type of egg commonly consumed is the Pengging Duck egg. Pengging Duck eggs have the advantage of being larger and having higher nutritional content thanchicken eggs. The superiority of Pengging Duck eggs can be a determining factor for the community or consumers in choosing good-quality eggs. The external quality of eggs can influence consumer

perception and enhance egg hatching capability. This has led to the testing of egg quality, especially the external quality of Pengging Duck eggs, aimed at determining the level of egg quality before consumption and incubation. The external quality of Pengging Duck eggs is believed to have a relationship that indicates correlation among external variables such as egg weight influenced by egg length and width, length circumference and width circumference of the egg, egg volume, and egg shape.

Eggs are nearly perfect as a food ingredient, providing a complete range of nutrients and essential elements for the growth of living organisms. Duck eggs, as a source of animal protein, contain essential amino acids required by the body. Essential amino acids are crucial for fulfilling the structural and functional components of the body, serving as building blocks for cell membranes, replacing damaged tissues, serving as substrates for energy metabolism, forming enzymes or hormones, supporting growth, and contributing to the synthesis of other organic compounds in the body (Windoro, Kasiyati, Djaelani, & Sunarno, 2020). According to Suryana (2013) the ability of local ducks to produce eggs varies widely, and their genetic diversity is presumed to be significant. As per the Ministry of Agriculture's 2010 data, the population of Pengging ducks is recorded at 34,369. The advantages of Pengging ducks include higher egg production compared to other ducks, such as Magelang ducks and Tegal ducks (Suselowati, Kurnianto, & Kismiati, 2019). Pengging ducks are a superior layer duck breed capable of producing 110 to 130 eggs per year (Mulyono, Sumekar, & Sunarti, 2017). Egg quality is crucial for food safety, consumer preferences, and product value (Evanuarini, Thohari, & Safitri, 2021). External characteristics of duck eggs include egg weight, index, shell color, shell thickness, and eggshell weight.

Quality is a set of characteristics of a product that determines its goodness and can influence the level of consumer demand. According to Effendi, Nismawarnib, & Ahmad (2024) consumers' primary judgment of livestock products is generally based on the physical quality of the product. The determination of external egg quality can be done through measurements using tools. Different egg shapes can affect the number of eggs per kilogram and the selling price of eggs. Egg weight is a crucial factor in determining the success of hatching eggs because egg weight not only affects hatchability but also influences chick weight (Sutanto, Kurnia, & Aspriati, 2019). Egg quality, in general, refers to several standards that determine both internal and external quality. Yulianti, Hamiyanti, Prayogi, Andri, & Setiawan (2022) states that egg quality depends on the quality of the inner part (egg content) and the quality of the outer part (eggshell). Egg quality is divided into two parts: external egg quality and internal egg quality. External egg quality includes egg weight, shell weight, egg length, and egg width (Harmayanda, Rosyidi, & Sjofjan, 2016). External egg quality generally does not have a direct correlation with egg nutritional quality. The external quality of eggs can be a reference for the public in selecting quality duck eggs. The availability of eggs that are always present and have high nutritional value must be balanced with public knowledge about egg quality (Purwati, Djaelani, & Yuniwarti, 2015).

The research by Suselowati et al. (2019) states that there is a weak correlation between egg shape index and egg surface area. Dirgahayu, Septinova, & Khaira Nova (2016) states that generally, more rounded egg shapes tend to have a higher egg index. Based on this description, if the relationship between egg quality is known, it is possible to estimate the value of a quality parameter if the value of another parameter is known. Research on the relationship between the external quality of Pengging Duck eggs needs to be conducted with the aim of determining the external quality of Pengging Duck eggs and understanding the relationship between egg weight and the external quality of Pengging Duck eggs.

MATERIALS AND METHOD

Equipments and Materials

The tools used in this study include a caliper, digital scale, 1000 ml graduated cylinder, flat glass, petri dish, oven, tissue, string, and writing instruments. A total of 250 Pengging duck eggs were used in this study, sourced from freshly hatched ducks aged 1-2 days. These 13-month-old ducks had an average body weight of 1.5 kg and were obtained from the Banyubiru Satker Office located at Jl. Kunir, Mendut, Ngrapah, Banyubiru Sub-district, Semarang Regency, Central Java.

Feeding for the Pengging ducks was given twice a day, in the morning and afternoon. The type of feed used was a concentrate feed with the brand IP-3Super.

Methods

This research employs a quantitative observational method, where in data collection was conducted through observation accompanied by recording of the target objects. Subsequently, information was gathered using measuring instruments to examine variables, with numerical and statistical characteristics. The parameters observed in this study included egg weight, egg length, egg width, egg length circumference, egg width circumference, specific gravity, egg circumference index, and egg index.

Observation

Egg weight

Egg weight could be measured using a digital scale (Sulistyawan, Ismoyowati, & Prasetyo, 2022). The egg weight was be determined by turning on the digital scale first, then pressing the tare button to zero out the display. The egg was placed on the digital scale, and the measurement result was be observed on the scale's display and recorded.

Egg length

The measurement of egg length was conducted using a vernier caliper (Depison, Prawira, Gushariyanto, & Erina, 2021). In the first step, the vernier caliper was prepared, and then a prepared egg was taken. The egg was placed horizontally between the jaws of the caliper until the jaws touched the pointed and blunt ends, ensuring stability. Subsequently, the measurement result was be observed on the scale of the vernier caliper and recorded.

Egg width

The measurement of egg width was be carried out using a vernier caliper (Depison et al., 2021) by placing the egg in an upright position between the jaws until it touched two different points on the widest side. The measurement result for egg width was then read from the vernier caliper scale and recorded.

Egg specific gravity

The specific gravity of an egg could be measured by weighing an empty container, such as a bowl or glass (Karabulut, 2021)the relationships between the weight, volume and specific gravity of eggs are revealed by calculating egg's volume and specific gravity depending on the weight of the egg, breadth and length, which are only three variables, with mathematical equations. Eggs to three goose genotypes, Grey China, Linda and Native geese from Aksaray region taken from six breeders were used. Eggs (n=481. The container, after being weighed, was filled with enough water. Subsequently, the egg was carefully placed into the container already filled with water, ensuring the egg was completely submerged. Calculate the difference in weight between the container filled with water and the egg and the weight of the empty container. The specific gravity of the egg could be calculated using the formula:

$$\text{Egg specific gravity} = \frac{\text{egg weight (g)}}{\text{volume}(\text{g/ml}^3)}$$

Egg length circumference

The measurement of the length circumference of an egg could be conducted using a measuring tape (Ukwu, Ezihe, Asaa, & Anyogo, 2017). The egg was placed horizontally on a flat surface, and then the measuring tape was positioned at one end of the egg. Subsequently, the measuring tape was wrapped around, following the contour of the egg closely without applying excessive pressure. The measurement result of the length circumference of the egg could be read on the measuring tape where it met the starting end.

Egg width circumference

The measurement of the width circumference of an egg could be carried out using a measuring tape (Ukwu et al., 2017). The egg was placed upright on a flat surface so that the widest point was in a horizontal position. The measuring tape was then wrapped around the egg, following the contour at its widest point closely. The measurement result of the width circumference of the egg could be read on the measuring tape where it met the starting end.

Egg circumference index

The measurement of the egg circumference index could be determined by knowing both the width and length circumference of the egg (Ukwu et al., 2017). The egg circumference index was

calculated using the formula:

$$\text{Egg circumference index} = \frac{\text{width circumference}}{\text{length circumference}} \times 100\%$$

Egg index

The measurement of the egg index could be conducted by knowing both the width and length of the egg (Ukwu et al., 2017). Once both are known, the egg index was be calculated using the formula:

$$\text{Egg Index} = \frac{\text{Egg Width (mm)}}{\text{Egg Length (mm)}} \times 100\%$$

Data Analysis

The data obtained from the variables were analyzed using linear regression analysis to find out the relationship between variables (Maulud & Abdulazeez, 2020). The results of the linear regression analysis included correlation coefficients, determination coefficients, and the regression equation derived from the coefficient table.

RESULTS AND DISCUSSION

The results of average parameter data and the regression analysis on the relationship between the external quality of Pengging ducks and egg weight are presented in Table 1 and Table 2.

Table 1. External quality average of Pengging Duck eggs

Parameters	Average
Egg weight (g)	66.1±4.452
Egg length (cm)	5.63±0.23
Egg width (cm)	4.56±0.157
Egg Length Circumference (cm)	16.65±0.703
Egg Width Circumference (cm)	14.95±0.694
Egg Specific Gravity	1.14±0.109
Egg Index	0.81±0.038
Egg Circumference Index	0.9±0.025

The Relation Between Egg Length and Egg Weight of Pengging Ducks

The analysis results indicate a highly significant relationship between egg length and egg weight. Egg length shows a highly significant correlation ($P<0.01$) with the egg weight of Pengging Ducks. The positive correlation value suggests that there is a direct relationship between egg length and egg weight, meaning that longer eggs tend to have a greater weight. This is likely because the length of the egg reflects the volume within the egg structure, and a larger volume typically results in higher weight. Egg length and width are variables used in calculating the egg index, determining the quality of the egg, especially its internal content. Therefore, the three factors are interrelated (Purdiyanto & Riyadi, 2018). Eggs have fixed components such as shells and membranes that protect their contents. A larger and elongated egg volume is caused by the growth of the shell and membrane, accompanied by an increase in egg weight (Marhayani, Henrik, Serli, & Muslimah, 2023). This statement is supported by Drabik et al. (2021), stating that egg length and shape reflect genetic influences. The regression equation between egg length and weight is $Y=13.872x–11.994$, with a determination coefficient (R^2) of 0.414, indicating that egg length influences egg weight by 41.4%, while the remainder is influenced by other variables. The correlation value (R) between egg length and weight is 0.644. The correlation between egg length and weight can be influenced by environmental factors such as feed quality. Harmayanda et al. (2016) state that the shape categories of eggs-elongated, oval, and round are influenced by feed quality, especially calcium, which plays a role in the shell's calcification and shapes the eggs. Egg weight includes nutrient components that make up the egg, such as the shell and egg membrane, namely the yolk and egg white that fill the inside of the egg. The formation of these three components is influenced by the nutrient content in the feed, especially protein, energy, calcium, and phosphorus, affecting the egg weight (Windoro et al., 2020).

Nurjannah, Yanto, & Patang (2017) stated that 10% of the total weight of an egg comprises the eggshell. The eggshell is the part related to the egg's weight. The calcium content in the diet, when higher, results in a larger eggshell weight (Permana, Lamid, & Mulyati, 2014). Besides feed consumption, other factors such as genetics have a more significant influence on determining egg shape. According to Shaker, Ameen, Torres, & Chassab (2020) factors affecting egg width include the breed or lineage of the livestock, the

Table 2. The relationship between egg weight (Y) and external quality (X) of Pengging Duck eggs

External Quality Parameters (X)	Egg Weight (Y)			
	Regression Equation	(R^2)	(R)	Sig.
Egg Length	Y=13.872x – 11.994	0.414	0.644	0.000**
Egg Width	Y=21.392x – 31.395	0.461	0.679	0.000**
Egg Length Circumference	Y=1.962x + 33.523	0.166	0.408	0.000**
Egg Width Circumference	Y=3.852x + 8.457	0.304	0.551	0.000**
Egg Specific Gravity	Y=-8.931x + 76.308	0.038	0.197	0.001**
Egg Index	Y=-8.166x + 72.718	0.003	0.059	0.344^{ns}
Egg Circumference Index	Y=-7.339x + 72.69	0.001	0.037	0.553^{ns}

Note: X=independent variable, Y=dependent variable, R^2=determination coefficient, R=correlation coefficient, Sig=significance, **highly significant (P<0.01), ns=not significant (P>0.05).

age of the parent, production period, body size, and egg quality.

This finding is predictable as mentioned above that longer eggs indicated more room of eggs' component inside the shell. However, for specific purpose usage of eggs, other parameters such egg width should be taken to account if the value of egg length does not good enough, then egg quality as whole does not good as well.

The Relationship Between Egg Width and Egg Weight of Pengging Ducks

The analysis results between egg width and egg weight of Pengging Ducks yield a regression equation with the formula Y=21.392x – 31.395, with a p-value of 0.000, indicating a significant influence between egg width and egg weight. The determination coefficient (R^2) value of 0.461 indicates an influence of 46.1% between egg width and egg weight. This influence is likely due to the egg width, which reflects the horizontal shape of the egg and is also related to the surface area of the shell and the volume inside the egg. Stoddard et al. (2017) stated that shelf membrane affecting the egg shape. The relationship between egg width and egg weight is similar to the relationship between egg length and egg weight because all three factors are interconnected. Egg width typically reflects eggs with a heavier weight. This is related to the geometric and structural characteristics of the egg. Darmawati, Rukmiasih, & Afnan (2016) stated that eggs with a rounder appearance will have a higher weight in relation to egg width. The width of the egg produced is influenced by inheritance factors such as livestock breed, lineage, environmental factors, and management (Indrawati, Saili, Rahadi, & Nafiu, 2015).

The size of egg length and width influences egg weight, similar to the relationship between egg length and egg weight. This aligns with the findings of Sutanto et al. (2019) stating that egg weight shows a highly significant and positive correlation with egg length and width. A significant and positive correlation indicates that a wider egg has a positive effect on egg weight. Harmayanda et al. (2016) reported that wider eggs with a round shape have a balanced content in the egg. The components of the egg, apart from the shell, namely the yolk and egg white, can form depending on the balance of energy and protein. Penkov & Grigorova (2020) stated that amount of energy and protein that converted to be eggs are relatively high. Additionally, the birds' reproductive tract is also a factor in egg formation. Ducks with mature reproductive organs have larger and wider main organs, such as the isthmus or the site of egg formation, to produce eggs of good quality (Daud, Yaman, & Zulfan, 2020).

The Relation Between Egg Length Circumference and Egg Weight of Pengging Ducks

The regression analysis results between the length circumference and egg weight of Pengging Ducks yield the equation Y=1.9624x + 33.523, with a P-value of 0.000 or P<0.01, indicating a highly significant influence between the length circumference and egg weight. The coefficient of determination (R^2) value of 0.166 indicates an influence of the length circumference variable on egg weight by 16.6%, while the remaining is influenced by other variables. The relationship between the length circumference of the egg

and the weight of Pengging duck eggs occurs due to the relationship between the length of the egg and the weight of the egg. This is presumed because the definition of the length circumference is a part of the egg's length itself. The length circumference of the egg is the length of the outer edge that surrounds the long side of the egg measured from the pointed end to the blunt end of the egg (Siswantoro, 2018). The relationship between the length circumference of the egg and the weight of the Pengging duck egg is that the length circumference reflects the shape of the egg, whether it is elongated, oval, or round, which affects its weight. An increased length circumference reflects larger dimensions on the outer horizontal line of the egg, indicating a larger volume inside the egg or an increase in its weight components, such as the shell, egg white, and yolk. The formation of the yolk, egg white, and eggshell is influenced by the nutrient content in the feed, which affects the egg weight (Marcelina, Djaelani, Sunarno, & Kasiyati, 2020). The eggshell contains about 95% calcium in the form of calcium carbonate and the rest is composed of magnesium, potassium, phosphorus, sodium, zinc, iron, manganese, and copper (Tugiyanti & Iriyanti, 2012).

The Relation Between Width Circumference and Egg Weight of Pengging Ducks

The regression analysis results between the width circumference and egg weight of Pengging Ducks yield the equation Y=3.8527x + 8.4576, with a P-value of 0.000 or P<0.01. This means there is a highly significant influence between the width circumference of the egg and egg weight. The correlation between the width circumference of the egg and the weight of Pengging duck eggs is presumed to occur because of the correlation between the width of the egg and the egg weight. This assumption is supported by the statement that the width circumference is obtained by finding the longest distance between two pixels on the edge of the egg object perpendicular to the width of the egg (Siswantoro, 2018). The width circumference of the egg can increase as the width of the egg increases.

The relationship between the width circumference of the egg and the weight of Pengging duck eggs is that a high width circumference reflects an egg with a round shape, resulting in a larger volume and higher weight (Darmawati et al., 2016). The relationship between the width circumference of the egg and the weight of the egg is similar to the relationship between the length circumference and the egg weight, where both relationships reflect the shape of the egg and affect its weight. The width circumference of the egg depicts how round the egg shape is with a balance in the content. Montgomerie, Hemmings, Thompson, & Birkhead (2021) state that the oval or round shape of the egg is influenced by the walls of the egg duct during formation. The formation of the yolk, egg white, and eggshell components depends on the feed meeting the livestock's needs in egg formation (Kasiyati, Sumiati, Ekastuti, & Manalu, 2016).

The Relation Between Egg Density and Egg Weight of Pengging Ducks

The regression analysis results between egg density and egg weight in Pengging Ducks yield the regression equation Y = -8.931x + 76.308, with a P-value of 0.000, indicating a significant influence between egg weight and egg density. The coefficient of determination (R^2) value of 0.038 and the correlation coefficient (R) value of 0.197 show that the correlation between egg density and egg weight is very low. The observed relationship between egg density and egg weight in Pengging ducks is presumed to be because of egg weight on its density, indicating a connection between the two.

This relationship is attributed to the fact that egg density is a result of the ratio of egg weight to egg volume (Sulaiman & Rahmatullah, 2011). The association between egg density and egg weight illustrates how dense or light an egg is in relation to its size. Sulaiman & Rahmatullah (2011) stated that as the egg weight increases, its specific gravity decreases. The lower specific gravity occurs because eggs with greater weight depict a larger volume ratio. Estimating egg density depends on both egg weight and volume. Conversely, if egg weight differs, the egg's specific gravity may also vary depending on the volume ratio of the duck. Egg density can also be influenced by shell weight (Sulaiman & Rahmatullah, 2011).

The Relation Between Egg Index and Egg Weight in Pengging Ducks

The regression analysis results between egg index and egg weight in Pengging Ducks yield the regression equation Y = -8.166x + 72.718,

with a P-value of 0.000, indicating no significant influence between egg index and egg weight. The coefficient of determination (R^2) value of 0.003 and the correlation coefficient (R) value of 0.059 indicate a very weak correlation between egg index and egg weight. The weak correlation in this study suggests that the relationship between the two does not have a direct impact. However, egg weight is related to the length and width of the egg, both of which are components of the egg index. Supported by Luthfiana, Santoso, & Rahayu (2020) who stated that genetically, egg weight will affect the increase in the length and width of the egg, determining the egg index value. Suselowati et al. (2019) added that the egg shape index and egg weight have an inverse relationship, meaning that the larger the egg index, the lower the egg weight.

As yolk, albumen, and egg' shell play an important role in egg weight. The result reported here should be taken to consideration while predicting egg weight by those parameters. As factors such as egg age, either in cold or warm storage temperature, study to find the difference on old or newly laid eggs is needed.

The Relation Between Egg Perimeter Index and Egg Weight in Pengging Ducks

The regression analysis results between the egg perimeter index and egg weight in Pengging Ducks yield the regression equation Y = -7.339x + 72.69, with a P-value of 0.000, indicating no significant influence between the egg perimeter index and egg weight. The coefficient of determination (R^2) value of 0.001 indicates that the egg perimeter index affects egg weight by 0.1%, while the rest is influenced by other variables. The correlation coefficient (R) value of 0.037 indicates a very low correlation between the egg perimeter index and egg weight. The low correlation between the egg perimeter index and egg weight is presumed to be because these two variables are not directly related. The egg perimeter index is derived from the variables of perimeter width and perimeter length, making them more related to the egg's shape. Supported by the statement of Darmawati et al. (2016) that the width perimeter of the egg reflects how round the egg's shape is, and the length perimeter of the egg reflects the length or oval shape of the egg. The length perimeter and width perimeter are more directly related to egg weight, where the values of both determine the egg's shape, while the egg perimeter index is a ratio comparison of the length perimeter and width perimeter described in percentage terms.

CONCLUSION

The parameters such length, width, length perimeter, width perimeter, and specific gravity of the eggs are found to be highly related to egg weight of Pengging. However, it is not significant with the egg index and egg perimeter index. Hence, in terms of considering usage of eggs based on their weight, it is advised to not to use value of egg index and egg perimeter index as they are not relating to the egg weight.

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