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Feed Composition and Nutrition Affecting Duck Egg Quality in Central Java Intensive Farming, Indonesia

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Abstract. *Various feeds are widely used to increase egg productivity in the Central Java duck-intensive farming system. However, the proper composition and nutrition in the feed are still debatable. This study aims to analyze the applied feed composition and nutritional content related to duck egg quality from intensive Central Java farms. This research is an observational, exploratory survey involving duck farms in five egg duck production centers, including Semarang, Temanggung, Magelang, Pati, and Salatiga regions. The feeds and 10 duck egg samples were collected from each farm to identify the raw nutritional content and quality. The result showed that the duck feed composition differs depending on the abundance of local resources and farmers' knowledge. Duck farms in coastal areas mainly use fishery products, including small rough fish and dried shrimp waste, while farmers in highland areas prefer to use commercial feed. Farmers in all regions often supplement their diets with additional feed, such as water spinach, rice bran, snails, wrinkles, and weeds, for varying durations from every day to once a week. Meanwhile, the best feed nutrition was identified from Temanggung, which uses concentrate feed as the main diet, which is composed of sweet corn, soy, and bran. The feed has a balance of raw protein around 24.19 ± 4.11% and 2500 to 2700 kcal calories. The egg productivity in the Temanggung farms also produces high egg production with larger sizes compared to duck farms from other regions. Furthermore, corn and soybeans in duck feed may increase antioxidant activity in yolk significantly, better than shrimp waste.*

Keywords*: antioxidant, duck, egg, nutrition, poultry, yolk*

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INTRODUCTION

Duck farming in Indonesia has experienced significant development over the last decade. Statistic Indonesia (Statistic Indonesia [SI], 2019) shows that the duck population in Indonesia reached more than 60 million heads in 2018 and continues to increase. Central Java Province is the third-largest producer of ducks nationally, with production reaching more than 7 million heads. The farming model in Central Java adopts intensive systems to produce eggs as the primary commodity rather than meat. In Central Java, several duck-egg producers are located in different regions and locations.

The geographical location of the farm may contribute to the farmer's preference for the farming system application, and also affect genetic distribution and diversity of local duck species, such as Tegal and Magelang ducks, mainly bred in Central Java (Susanti et al., 2022). According to Ismoyowati and Purwantini (2013), local ducks have superior genetic quality in producing high-quality eggs. Based on previous research, there are genetic variations related to the quality and quantity identified from a duck farm in Central Java, including in the coastline areas, including Semarang City, Pati and Tegal, as well as highland areas, including Magelang and Salatiga (Susanti et al., 2019; Susanti & Yuniastuti, 2020).

Feed composition, environmental conditions, and the farming system model influence duck egg productivity. In their study, Ahmad et al. (2021) explained that feed is among the most important factors influencing duck egg production in livestock business commodities. In addition, the feed compositions and nutritional qualities are likely different in each farm depending on the origin area, procurement cost, and raw materials availability. High-protein feed from less desirable fisheries products is very common in coastal areas, while in agricultural production centers, high-carbohydrate feed such as bran, rice grains, and leftover rice is more common. Furthermore, according to Ismoyowati and Purwantini (2013) that high protein feeding increases egg weight significantly.

Feed composition significantly affects egg quality, while the egg condition affects consumer product preferences. For example, egg yolks with bright orange color are preferred over pale-yellow yolks because of the assumption that the orange color represents high vitamin A content. Therefore, this study analyzes fodder's composition and nutritional content based on farmers' habits and their correlation to duck egg quality. This is an effort to optimize high-quality duck egg production using effective and economical feed.

MATERIALS AND METHODS

This study was an observational survey conducted on five intensive duck farms in the northern and middle region in the Central Java. Research locus was selected purposively following criteria: 1) five highest duck egg-producing regions/cities in Central Java during 2018-2020, and 2) representing different geographical conditions, there are coastal, lowland, and highland. Then, the farms in each city were selected using a purposive sampling method with criteria, including 1) producing eggs using intensive farming systems, 2) breeding the Kalung duck variant (the origin comes from Magelang Region, Central Java), 3) aged between one to three-year-old and actively producing eggs, and 4) having more than 200 heads duck (average minimum number of brood ducks raised on a large scale of intensive farming). Based on these criteria, five intensive duck farms were obtained as described in Table 1.

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Table 1. Research site

Regions/Cities	Farm Location	Coordinates	Characteristics of Geography
Semarang City	Tambak Lorok, Tanjung Mas, North Semarang, Semarang	6°56'46.1"S 110°26'20.0"E	North Java Sea Coast (0 m.a.s.l) fishing settlement and directly adjacent to the sea.
Pati	Rejoagung RT 09 RW 01, Trangkil	6°39'29.7"S 111°05'21.4"E	North Java Sea Coast (0 m.a.s.l) 2 km from the beach, bordered by rice fields, and far from settlements
Temanggung	Gilingsari Village, Temanggung	7°19'04.8"S 110°09'01.9"E	Highland (986 m.a.s.l) located in a rice field area, the availability of running water is abundant
Magelang	Jl. Kalipeh, Ketonggo, Plosogede, Ngluwar	7°38'02.7"S 110°16'26.0"E	Lowland (12 m.a.s.l) located in a rice field area, the availability of running water is abundant
Salatiga City	Jl. Melati, Gemenggeng Hamlet, Ngrapah, Banyubiru.	7°17'30.7"S 110°23'45.8"E	Highland (585 m.a.s.l) located in a rice field area, far from settlements

Note: m.a.s.l: meter above sea level

Feed Quality Analysis

A total of 1 kg of feed sample was collected proportionally from the selected duck farm. The feed samples were then prepared and dried in an oven at 40-50 °C for three days. Dry feed samples were then re-weighed and analyzed for water, ash, crude protein, carbohydrate, and fat content.

Egg Quality Analysis

A total of 10 samples of new eggs were randomly taken from the nesting unit of each duck farm at the sampling site. The egg sample was then measured to describe the egg shape index, weight, volume, shell weight, and thickness to determine the morphological quality of the eggs. The analysis continued by measuring eggs' content qualities, which included color, weight, volume, and antioxidant activity of yolks, as well as the weight and volume of albumen.

The Quality of Duck Eggshells from Different Locations on Farms

The egg shape index was determined by measuring the length and width of the egg using a manual caliper with an accuracy of 0.1 mm. Egg shape index (SI) was calculated according to Reddy et al. method:

$$SI = \frac{\text{wide}}{\text{length}} \times 100\% \quad [1]$$

The eggs were cracked to measure the eggshell thickness using a digital caliper with an accuracy of 0.01 mm. Then the yolk and albumen were separated to measure the weight and volume using a digital scale with an accuracy of 0.001 g.

Yolk Color Determination and Antioxidant Activity

The yolk color analysis was carried out four times, using a digital calorimeter application (iOS version) placed in a mini studio measuring 20x35x40 cm with a continuously controlled lighting of 50 Lm. The measurement of yolk color serves as an indicator to confirm the potential carotenoid content, assess the freshness, and evaluate the visual appeal of the egg (Bertoncelj et al.,

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2019). Furthermore, the instrument was calibrated according to the CIELAB color space system at color point, L*=97.79; a*=-0.11; b*=2.29 (Moroney et al., 2012). The color points score L* represent brightness, while values a* and b* represent hue (a*=red-green and b*=yellow-blue spectrum).

The antioxidant activity of yolks was carried out using the method of 2,2-Diphenyl-1-picrylhydrazyl (DPPH) assay following (Gasic et al., 2014) method. As many as 0.01 mL of the yolk was dissolved in 10 mL of methanol until homogeneously, then inserted into testing cuvette and added 1 mL of 0.2 mM DPPH solution. The standard solution was prepared by mixing 1 mL of DPPH solution with 1 mL of methanol, and the blank solution was 2 mL of methanol. All test materials were then incubated in a lightless room at room temperature for 30 min. Antioxidant activity (AA) was read using a spectrophotometer at a wavelength absorption (λ) of 517 nm and calculated using Formula 1:

$$AA = \frac{A_{517\ control} - A_{517\ sample}}{A_{517\ control}} \times 100\% \quad [2]$$

Farmer's Fed Formulation and Cultivation Pattern

Data of farmers' feeding habits, farming system, and maintenance were collected using in-depth interview to complete the information on duck feed composition. The data was then tabulated and reduced as additional information to explain the quantitative data that had been obtained.

Data Analysis

The data, including physical quality of eggs, albumen, yolk, and feed raw nutrition, were analyzed for normality using Shapiro-Wilk's test, followed by Levine's homogeneity test. Normally distributed data was continued with one-way ANOVA with a confidence level of 95%, while data that was not normally distributed were analyzed using Kruskal-Wallis's test. Further tests were carried out using the least significant difference (LSD) test for parametric analysis and Mann-Whitney for non-parametric tests. All statistical analyses were performed using the SPSS rev-21.0 application with a confidence level of 95%, and a significance level of p = 0.050.

RESULTS AND DISCUSSION

The quality of duck eggs is closely related to the feed composition and can be characterized by shell morphology, albumen, and yolk composition. The feed composition from five duck farms in Central Java has different characteristics depending on the abundance of economic raw materials in each sampling locus (Table 2). The farmers explain that cheaper feed materials better support their livestock business continuity than high-quality feed. Furthermore, a similarity in feeding patterns was found in all regions. Farmers in coastal areas such as Semarang City and Pati Region use trash fish and shrimp heads as additional feed to increase egg productivity. Trash fish are then mashed both in dry and wet conditions and mixed in duck feed as the primary source of protein. Local raw feed materials are the primary consideration for additional feed because they are more economical, efficient, and effective in increasing the growth rate of ducks.

In highland areas, the main source of protein is obtained from the concentrate feed without trash fish or other fish-processing products. In addition, the feed is also mixed with bran as the main source of carbohydrates or calorie source. Furthermore, dried leftover rice is popular among farmers in Central Jawa, used to accelerate fattening in ducks. In addition, the farmers give additional feed twice per week as a supplement to increase fiber or protein intake. The most commonly

used additional feeds in Magelang and Salatiga (lowland areas) are chopped water spinach and wrinkles or conchs. On the contrary, the farmers in Temanggung (highland area) use no additional feed and rely on concentrates feed as the main diet.

To increase egg productivity, farmers use feed concentrates for the main production period (layer) for egg production and fattening because they are easy to obtain and apply. However, different concentrate feed brands were found on all farms, except in Semarang, where no concentrate feed was used. Furthermore, the farmers in Pati region tend to increase duck's body proportions, while farmers in Temanggung, Magelang, and Salatiga choose different concentrate feed that ensures high egg productivity. In this research, there were four concentrate feeds (labeled A-D) that the farmers widely useare. Based on the analysis, all of the concentrates have different ingredients and nutrition depending on the livestock performance targets (Table 3).

Table 2. The composition of duck feed is based on the habits of breeders in each of the research loci.

Parameters	Feed Composition				
	Semarang	**Pati**	**Temanggung**	**Magelang**	**Salatiga**
Raw materials	Grated coconut pulp, aking rice, trash fish and shrimp heads. No centrats Feed mixtures are given on all conditions and time.	Morning feed: aking rice, bran and concentrate B Afternoon feed: Aking rice Bran, Ground agile fish	Concentrate A	Bran, Concentrate B Aking rice	Bran, Concentrates C and D
Sources of drinking water	Artesian	Regional drinking establishments	Spring water	Well Water	Well water
Time range feeding	Morning: 07:00 am Afternoon: 04:00-04:30 pm	Morning: 7:30 am Afternoon: 04:00-05:00 pm	Morning: 06:00 am Afternoon: 03:00 pm	Morning: 07:00-07:30 am Afternoon: 04:00-04:30 pm	Morning: 06:00 am Afternoon: 04:00 pm
Additional feed	Water spinach (once a week)	Water spinach (daytime)	Winkle or *Littorina sp.* (once a month)	Water spinach and grass	-
Feeding and supplementation habits	There is no clear measure for mixing the composition of the feed. Feeding with a complete composition in the morning while the addition of shrimp heads and wet trash fish in the evening	Additional feed is given only for daylight hours. Farmers do not give vaccines, vitamins, or herbs. In addition, the feeding of chopped fish every afternoon.	Feeding concentrates as the main feed without mixing with other materials. Supplementation in the form of sugar water, multivitamins, and vaccines once a month.	Additional supplementation in the form of palm java sugar, molasses once every 3 days, and multivitamins to increase egg productivity once a month.	The main feed is rice milling residual bran with a mixture of two concentrates for fattening and laying. Multivitamin administration is given regularly for every day.

Note: m.a.s.l: The type of concentrate is based on the origin of the manufacturer.

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Table 3. The compositionand nutritional protection of k oncentrat used by duck breeders in the research locus

Composition and nutrition content	Concentrate Feed			
	A	B	C	D
Performance Targets	egging	fattening	egging	egging
Composition				
Large yellow corn	v			
Soybean meal	v		v	v
Fish meal	v		v	
Meat flour	v		v	v
Wheat shards			v	
Leaf meal			v	
Soya bean meal (SBM)		v		
Distillers dried grains with solubles (DEGS)				v
Meat bone meal (MBM)		v		
Corn glutein meal (CGM	v	v		v
Rapeseed				v
Pollard	v			v
Grit (limestone, clamsshell, fine gravel, etc)	v			v
Dicalcium phosphate (DCP)	v			
Salt	v			
Crude palm oil (CPO)	v			v
Essential Minerals	v	v	v	v
Premix Vitamins, vitamins	v	v	v	v
Essential Amino Acids		v		
Antioxidant	v			
Prebiotics	v			
Macronutient Content per Kg of feed				
Water (%) max	13.00	11.00	12.00	10.00
Protein (%)	17.00-19.00	37.00	37.00-39.00	37.00-39.00
Fat (%) min	4.00	3.00-7.00	5.00	3.00
Fiber (%) max	6.00	5.00	6.00	6.00
Ash (%) max	14.00	38.00	35.20	33.00
Calcium (%) min	3.30-4.20	12.00-13.00	12.00	10.00
Phosphorus (%) min	0.60-0.90	0.80	1.40	1.00

Note: company informas and feed trademarks are kept secret for ethical reasons and avoid conflict of interest

Information on the content of macronutrients is the rough value indicated on the packaging of the products. Based on this information, the highest percentage of crude protein is obtained from concentrates C and D. High protein content in concentrate feed may play an important role in egg productivity. In addition, a high-protein diet also produces a leaner proportion of ducklings. Regarding concentrated feed as the main feed, farmers at all research sites except Magelang, use additional feed from kitchen waste or fishery production residues with coarse nutrient content as described in Table 4.

In this study, the farmers formulated feed samples collected from each farm and analyzed them proximately to determine the content of crude nutrients. The results of the proximate analysis show significant differences in some nutritional content, namely ash and fat (Table 5).

Table 4. The content of coarse nutrients of duck feed additives

Average Nutrition Content	Types of additional feed						
	Coconut pulp	Lefover rice	Trash fish	Shrimp head	Bran	Water spinach	winkle
Water (%)	14.53	12.85	7.33	8.33	9.41	68.34	2.23
Ash (%)	4.93	0.83	64.45	19.54	15.33	1.9	64.29
Protein (%)	4.81	13.83	24.03	39.39	4.27	0.4	22.12
Carbohydrates (%)	6.29	71.72	0.45	-	62.20	2.18	-
Fat (%)	26.57	0.07	0.17	2.08	0.76	0.87	0.22
Fiber (%)	42.42	0.49	2.38	20.88	7.23	25.63	10.26
Calcium (%)	-	-	-	2.23	0.08	-	-
Phosphorus (%)	-	-	-	1.4	0.28	-	-
ME (kcal)	-	3100.00	1122.00	2937.00	3157.00	1800.00	2700.00

Table 5. The results of proximate analysis of duck feed mixtures at various research sites

Raw Nutritional Content	Farms				
	Semarang	Pati	Temanggung	Magelang	Salatiga
Water (%)	17.60 ± 12.76	6.53 ± 0.60	7.10 ± 6.03	11.37 ± 1.07	6.88 ± 1.38
Ash (%)	21.59 ± 3.36 ac	27.15 ± 4.35 ab	20.69 ± 0.71 c	32.49 ± 1.13 b	27.11 ± 4.07 ab
Protein (%)	25.65 ± 4.08 a	15.32 ± 8.92 b	27.37 ± 5.82 a	18.83 ± 9.70 b	11.97 ± 9.33 c
Carbohydrates (%)	24.83 ± 6.60	24.58 ± 2.94	24.19 ± 4.11	22.62 ± 8.26	18.31 ± 4.59
Fat (%)	3.18 ± 0.16 a	3.57 ± 0.07 c	4.46 ± 0.12 b	4.60 ± 0.12 b	2.46 ± 0.22 d
Other compounds	7.15 ± 0,	22.85 ± 0,	16.19 ± 0,	10.08 ± 0,	33.27 ± 0,

Note: Different superscript letters on the same line indicate a noticeable difference ($p<0.05$). Feed feasibility criteria: moisture content ≤14%; crude protein ≥17%, crude fat ≥ 3%, ash ≤14%, and crude fiber ≤10% (Badan Standardisasi Nasional [BSN], 2017)

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Based on the feasibility criteria, almost all of the feed for laying egg ducks in each farm lacks nutrient content according to the BSN (2017) No: SNI 3910:2017 about standard feed for laying ducks. Most of the main compound is ash found in all feeds, especially in Magelang farming. Then, the highest formulated crude protein content is found in Temanggung and Semarang farming, which is higher than the BSN standardized feed (Table 5).

Previous studies have shown that sugar, as an energy source, and protein are the primary nutrients that must be considered when formulating a diet for poultry (Fouad et al., 2018) because it has the most significant impact on reproduction and productivity of egg-laying ducks. Energy requirements in egg-laying ducks range from 2500 to 2,700 kcal with a protein composition of more than 17% (Udayana et al., 2020). Furthermore, an increase in energy up to 3000 kcal contributes more to growth, although it negatively affects the quality of duck fat deposits (Xia et al., 2019a). Excess calories due to overfeeding during the laying egg period may weaken reproductive system such as oviduct and ovaries. High-calorie diet triggers fat deposition in the female reproductive organs of the duck, resulting in prolapse and oviductal inflammation that decreases egg productivity (Assersohn et al., 2021).

Cases of overfeeding in laying poultry result in obesity and the onset of erratic oviposition and defective egg syndrome (EODES), due to a hierarchy of multiple follicles and excessive follicles that interfere ovulation cycle (Eitan and Soller, 2009). Nonetheless, substantial compound changes in lipid metabolism are needed to form yolks, with an adequate composition and concentration (Assersohn et al., 2021). In other words, lipogenesis in ducks is so responsive to hormonal and dietary changes that a high-lipid diet allows for lipotoxicity including ovarian abnormalities and follicular atresia (Yang et al., 2019). Increased tissue relaxants due to lipids are likely due to a high-calorie diet, including too frequent use of leftover rice and high-calory bran. This condition can be seen in Semarang, Pati, and Mangelang farms that produce fewer eggs than Temanggung. Therefore, feed management and nutrient fulfillment must be arranged based on the type, performance, and stage of the duck egg-laying cycle. In addition, during egg-laying phase, the duck needs adequate mineral intake for eggshells synthesis. The adequacy of minerals, especially calcium (Ca) and phosphate (P) in duck feed, has a significant role in shell structure synthesis that affects the strength and weight of the duck eggshell (Xia et al., 2019b; Wang et al., 2020).

Egg Quality

Egg morphology criteria, yolk coloration, and antioxidant activity of the yolk characterize egg quality. Meanwhile, egg productivity from each farm ranges from 58-80 eggs/100 ducks/day. The highest egg productivity is obtained from ducks raised in Temanggung, reaching 80 eggs/ 100 ducks/ day (Table 6). The morphological characteristics of eggs produced on various farms in Central Java have diverse oval shapes. The egg shape is related to hatchability, where the proportional oval shape has a higher chance of hatching than the round or long shape (Salamon, 2020; Lase et al., 2021). The shape is generally formed by albumen volume that is secreted from oviduct (Quan and Benjakul, 2019), isthmus size and muscular wall activity of it (Mahmoud et al., 2018), pelvis anatomy, and other organs that passed by the egg (Shatkovska et al., 2018). Furthermore, nutritional feeding increases egg production and egg-nutrition contents.

The main composition of Ca minerals in eggshell comprises calcium carbonate 96%, and almost 60-70% of the total shell weight are Ca and P minerals in hydroxyapatite form (Agbeboh et al., 2020). Several studies have also explained that Ca, P, and vitamin D deficiencies in diet decreases gene expression related to Ca transport and eggshell biomineralization (Xia et al., 2019; Wang et al., 2022; Zhang et al., 2022).

This impacts the deposition of Ca in the eggshell due to low levels of Ca in plasma and shell gland cells. At least 2.90-3.25% Ca is needed in feed (Rohaeni et al., 2021) and 0.30-0.80% P for metabolic needs and maximizing egg production (Wang et al., 2020). It is supported by the findings in Temanggung farms that adequate provision of Ca, approximately 3-4% of total feed weight, produces high egg production in ducks compared to other farms. The lower egg production in other farms may also be correlated to Ca administration, which is too high reaching more than 10% of total weight feed. Therefore, further research is needed on this hypothesis.

Feed Supplementation and Albumen and Yolk Qualities

Farmers in all research areas supplement duck feed by adding water spinach or weeds and protein sources such as shrimp heads, trash fish, or winkles. Similar patterns of this supplementary feeding in all farms indicate the same understanding and information distribution between farmers. Giving additional feed is believed to improve the nutritional quality of the feed. The provision of trash fish and shrimp heads has been shown to increase protein levels relatively high, directly affecting eggs' quality. Meanwhile, water spinach, hyacinth, and shrimp heads as feed for duck increase of β-carotene content in the yolk. Even though the composition of carotenoids in shrimp heads is also high because their exoskeletons contain astaxanthin, zeaxanthin, lutein, and cryptoxanthin (Lopez-Cervantes and Sanchez-Machado, 2018; Hatta and Othman, 2020), which then accumulates and affects the color level of the yolk (Calislar, 2019).

Table 6. Antioxidant activity and quality of duck eggs in Semarang, Temanggung, Magelang, Pati, and Salatiga Areas

Variable	Duck Eggs				
	Semarang	Pati	Temanggung	Magelang	Salatiga
Egg Productivity	58-65 eggs/100 ducks/day	65 grains/100 ducks/day	75-85 eggs/100 ducks/day	65-70 eggs/100 ducks/day	70 grains/100 ducks/day
Antioxidant activity (%)	7.50 ± 1.96	9.16 ± 5.38	14.75 ± 3.60	9.43 ± 4.15	7.04 ± 3.22
The quality of the egg content:					
Egg Yolk Color					
L* (black-white level)	60.55 ± 2.39 a	57.50 ± 1.57 c	58.20 ± 9.50 a	52.95 ± 1.79 b	53.50 ± 2.18 b
a* (red-green color level)	11.75 ± 5.41 a	18.45 ± 4.72 d	6.95 ± 4.49 b	32.45 ± 4.07 c	27.30 ± 4.77 e
b* (blue-yellow color level)	65.65 ± 1.81 a	63.60 ± 0.99 c	63.30 ± 9.03 a	61.15 ± 1.04 b	61.05 ± 1.43 b
Egg white volume (mL)	27.80 ± 3.96 a	28.20 ± 3.70 a	34.75 ± 4.65 b	25.80 ± 1.48 a	29.20 ± 3.70 a
Yolk volume (mL)	25.50 ± 2.78 ac	23.50 ± 0.93 ab	27.13 ± 1.65 c	22.70 ± 1.89 b	22.90 ± 2.30 ab
Egg white weight (g)	28.58 ± 4.14 a	28.63 ± 3.46 a	35.38 ± 4.90 b	27.21 ± 1.24 a	28.89 ± 3.86 a
Egg yolk weight (g)	25.45 ± 2.88 ab	23.61 ± 1.13 a	27.38 ± 1.89 b	22.66 ± 2.12 a	23.12 ± 2.15 a
Characteristics of the shell and morphology of egg:					
Egg shape index (%)	78.73 ± 3.22 ac	79.37 ± 2.85 ac	75.93 ± 4.48 c	81.88 ± 2.41 b	81.74 ± 7.30 ab
Whole egg volume (mL)	65.00 ± 5.00 ac	64.00 ± 2.24 a	72.50 ± 6.45 c	58.00 ± 4.47 b	60.00 ± 3.53 ab
Whole egg weight (g)	69.80 ± 4.32 ad	67.60 ± 2.41 cd	77.50 ± 4.20 b	63.00 ± 3.46 ac	64.40 ± 2.19 c
Egg cage weight (g)	6.72 ± 1.24 a	6.75 ± 0.49 abc	7.31 ± 0.81 ac	7.07 ± 0.69 bc	6.56 ± 1.12 c
Thickness of the egg cage (mm)	0.38 ± 0.05	0.42 ± 0.03	0.43 ± 0.04	0.42 ± 0.05	0.39 ± 0.05

Note: Different superscript letters on the same line show noticeable differences (P<0.05). Egg shape index: sharp egg (SI< 72.00%), standard egg (SI= 72.00-76.00%), and round egg (SI > 76.00%)

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Interestingly, shrimp head additional feed in Semarang City farms makes the yolk color look orangy brighter, but uneven in all parts (Figure 1). Then, the highest red pigmentation (the largest a* value) is found in eggs produced from the farms in Magelang. Nonetheless, the darker orange color of the yolk is not correlated with antioxidant activity. This is shown in Table 6, where the duck eggs from Temanggung farms have higher antioxidant activity, even though the yolk color looks paler yellow (smaller a* value) than Magelang and Semarang. Antioxidant activity in duck yolks on farms in Semarang City has the second-lowest antioxidant activity after Salatiga farms.

Carotenoids are the primary source of retinol, which is important for embryo growth and development. A low carotenoid diet during the egg-laying phase leads to decreased egg production rates, a low chance of hatchability, and embryo disability. Adequate levels of carotenoids can optimize antibody production against parasites, increase egg production quality, and hatchability (Surai & Kochish, 2020). In addition, Gouda et al. (2022) explained that feed containing 2,500 IU of vitamin A as carotenoids source improves egg-laying duck performance. Furthermore, sweet corn and soybean meal are better carotenoid sources to meet the vitamin A requirement for egg performance and quality, which increases antioxidant content (Fouad et al., 2018). Similar findings were also obtained in this study, where the use of corn-soybean meal-based concentrates effectively increased duck egg production and yolk antioxidant content.

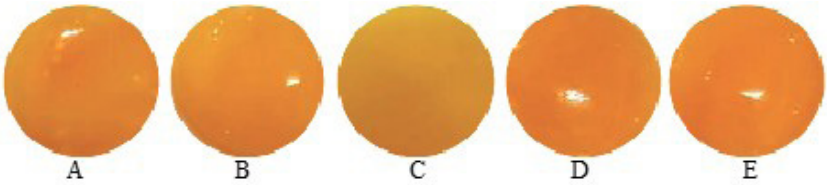

Figure 1. Yolk duck color of each farm location: A: Semarang City, B: Pati Regency, C: Temanggung Regency, D: Magelang Regency, and E: Salatiga City

The carotenoids and vitamin A content in concentrate feed correlate to yolk's antioxidant activity. Studies have proven that it is a mechanism for transferring carotenoids from feed into eggs (Calislar, 2019; Surai, 2020). The mechanism ensures the bioavailability of nutrients in the yolk to support embryo growth and development. However, the study of gene-related carotenoid transfer should be explored further. Furthermore, this study showed the absence of a relationship between yolk color and antioxidant content. The carotenoid content of the feed source is likely to affect the discoloration of the yolk significantly. The accumulation rate of carotenoids, especially the pigment astaxanthin from shrimp heads, which is relatively high, is found in duck eggs in Semarang City, but not on other farms. Meanwhile, in this study, the color characteristics of the yolk did not describe the antioxidant activity value. The brighter yolk color, such as the one produced in the Temanggung farm, has the highest antioxidant content.

CONCLUSION

The composition of the diet on duck feed largely depends on the abundance of local resources and farmers knowledge. Although the selected feed composition differs between farms, the eggs produced from the farms do not have noticeable morphological differences. They are of good quality for consumption, as the main ingredients in the feed, sweet corn and soybean meal, can increase the productivity of eggs in the Kalung variety of laying ducks. Providing complete feed based on cornmeal and soybeans and the correct dose of nutrients results in better quality eggs in terms of yolk antioxidant activity, egg volume, and egg weight, but they have a paler yolk color. The appearance of a more attractive yolk color is obtained from farms that use feed made from shrimp heads and skins.

JURNAL BIODJATI

http://journal.uinsgd.ac.id/index.php/biodjati

AUTHOR CONTRIBUTION

This article is presented as a collaborative work by the authors. Research concept and development: RS, MD; Funding and resources: RS; Administration: MD; Methodology development: MD. EY; Data collection and analysis: RS, EY, MD; Supervision: RS; Manuscript preparation: RS, MD, EY; Publication: RS. All authors read and approved the final version of the manuscript.

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CONFLICT OF INTEREST

There is no conflict of interest in this study.

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