The quality and chemical composition of eggs derived from Kampung Unggul Balitbangtan (KUB) crossed with Merawang and Murung Panggang local chickens

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Abstract. The efforts to support food security and increase the income of farmers, local chickens have a great potential to be developed into superior breeds, including superior egg production. This study aimed to evaluate the quality and chemical composition of eggs produced from Kampung Unggul Balitbangtan (KUB) Jatinom chickens crossed with Merawang Sembawa, Merawang Bangka and Murung Panggang chickens. The evaluation of the quality of chicken eggs included the exterior and interior quality, while the chemical composition of the eggs was evaluated by proximate analysis included moisture, ash, protein, fat and carbohydrate content. The research data were analysed by One Way ANOVA. The results showed that the eggs of the three types crossed of local chickens were generally oval in shape and intermediate in colour. Local chicken crossed type had a significant effect ($p<0.05$) on weight, albumen index, yolk index, yolk color, Haugh Unit (HU), albumen pH and yolk pH, but had no effect on egg specific gravity, egg index, shell thickness and shell weight. The crossed type of local chicken had a significant effect ($p<0.05$) on the moisture content of the yolk, but had no effect on the moisture, ash, protein and carbohydrate content of albumen as well as ash, protein, carbohydrate and fat content in egg yolk. In conclusion, the best quality of the exterior namely weight of the eggs, were the eggs from crossed of KUB with Merawang Bangka chicken. While, the best quality of interior namely albumen index, yolk index, yolk color and HU value, were the eggs from crossed of KUB with Murung Panggang chicken. In general, differences in the types of local chicken crossed did not affect the chemical composition of the eggs produced.

Keywords: Egg exterior quality, Egg interior quality, Chemical composition, Local chicken crossed

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1 Introduction

The efforts to increase the productivity of local chickens in Indonesia have not been maximized from various aspects. The development of local chickens also have problems, namely the traditional rearing system, low productivity, both egg and meat production, reproduction rate, and growth. However, local chickens in Indonesia have a good potential, namely high diversity of phenotypic and genotypic traits, good adaptation, resistance to heat stress, and resistance to disease [1].

Local chickens have a great potential to be developed into excellent breeds in an effort to promote food security and enhance farmers' welfare. In Indonesia, it is reported that there are 32 types of local chickens (ecotype) and each type has its own advantages [2]. The advantages of local chicken are that it has meat production with a distinctive taste and texture, and the properties of eggs that are specific and commonly used for mixing traditional herbal drinks. In addition, native chickens are resistant to several types of diseases [3]. The uniqueness of local chickens still needs to be explored further so as to benefit farmers, because so far there have not been many sustainable efforts to utilize local chickens as genetic resources in breeding programs to form chicken breeds for the livestock industry [4]. Merawang chickens from Bangka Belitung, Merawang Sembawa from Palembang and Murung Panggang from South Kalimantan as well as KUB Bogor and KUB Jatinom are some examples of dual-purpose local chickens, which so far have not been widely studied regarding the quality and functional properties of their eggs.

Eggs are widely used as an ingredient by the food industry in a variety of commercial products because of their unique taste, nutritional value, and physicochemical or functional properties such as water-holding capacity, oil binding, emulsification, foam formation, gelation and viscosity [5]. The complete balance and variety of nutrients along with their high digestibility and relatively cheap in price make eggs a leading subject [6]. Various factors that affect egg quality include poultry strain, age, feed, temperature and storage time [7]. Generally, these factors are classified into two influence, namely genetic and environmental factors. Therefore chickens with below-standard egg quality must be removed (culling), as well as chicken management can also help in improving egg quality [8]. External egg quality characteristics, including shell thickness, which is a measure of shell strength, are considered very important for breeders to reduce egg breakage. Regarding internal egg quality characteristics, egg white (albumen) thickness is an important measure to assess egg freshness [9].

This study aimed to evaluate the quality and chemical composition of eggs produced from three types of crossed of local chickens, namely KUB x Merawang Bangka, KUB x Merawang Sembawa and KUB x Murung Panggang. The results of the research on the quality and chemical composition of eggs produced from the three types of local chicken crosses are expected to be used later as a consideration in the selection of superior local chicken breeds and also as information for the food industry to choose quality local chicken eggs with chemical compositions in accordance with desired product criteria.

2 Materials and methods

Eggs were taken from three types crossbread of native chickens KUB Jatinom x Merawang Bangka, KUB Jatinom x Merawang Sembawa and KUB Jatinom x Murung Panggang (ranged from 26-30 weeks old), which were reared in Semanu Gunungkidul, Yogyakarta using commercial feed.

2.1 2.1. Exterior and interior quality evaluation

Evaluation of egg quality including exterior (egg weight, eggshell thickness, density and egg index) and interior (albumen weight, yolk weight, albumen index, yolk index, HU, pH of albumen and yolk, and yolk color) quality. Egg weight was measured by analytical weight, and thickness of eggshell was measured using micrometer, the length and breadth of albumen were measured by caliper, the height of albumen and yolk were measured by tripod micrometer. The density or specific gravity of egg is a function of egg weight and volume [10]. Egg index (shape index) were calculated by using (breadth/length) of egg. Yolk index = (yolk height/yolk diameter), and albumen index = albumen height/(long diameter of albumen + short diameter of albumen/2). Shell thickness = (pointed end + equator + blunt end)/3 [11], and Haugh Unit was calculated by the method of [12] as follows:

$$\text{Haugh unit (HU)} = 100 \log (H + 7.57 - 1.7\, W^{0.37}) \quad (1)$$

where H = albumen height and W = weight of egg. Yolk color was determined using the yolk color fan with a scale range of colour from 1-15 based on color density [13].

2.2 Chemical composition analysis

Chemical analysis of albumen and yolk including moisture content, fat, protein and ash were carried out by AOAC [14].

3 Results and discussion

3.1 Exterior quality

Egg shape. Based on Table 1, KUB chicken crossed with Merawang Sembawa, Merawang Bangka and Murung Panggang are overall good because the oval is the ideal egg shape. The best egg shape is oval, because oval-shaped eggs have high hatchability, which ranges from 70 to 75%, while eggs that are too round or too long have hatchability ranging from 30 to 35% [15].

Factors that affect egg shape include age of chickens, strain, and feed. Old-aged chickens produce eggs with unstable shapes due to decreased ability to absorb nutrients so that the shape of the eggs varies [16]. According to [17] the eggs produced by chickens have various distinctive shapes because egg shape is an inherited trait.

Shell color. The color of egg shells produced by local chickens crossed in this study ranged from white to dark brown. According to [18], that local chicken eggs basically have a brownish white or white shell color. Therefore, the color of the egg shells of local chickens crossed KUB with Merawang Sembawa. Merawang Bangka and Murung Panggang chickens is in accordance with [18].

Factors that affect shell color include the type of poultry, color pigments in the uterus, feed and environment, age or phase. Color pigments in the uterus consist of melanin,carotenoids, porphyrins, oocyanins, and oophorphirins. Differences in shell color were influenced by the type of pigment, pigment concentration, and shell structure. Eggs with dark brown shells have stronger and thicker shells than eggs with intermediate shell colors. So that eggs with dark brown shell color tend to experience lower quality degradation than those with intermediate color [19].

Table 1. Exterior quality of egg produced by local chicken crossed

Quality	Chicken crossed		
	KUB x Merawang Sembawa	KUB x Merawang Bangka	KUB x Murung Panggang
Egg shape (%)			
Oval	80	100	80
Conical	-	-	-
Biconical	-	-	-
Elliptical	10	-	10
Spherical	10	-	10
Shell colour			
White	70	20	30
Intermediet	30	80	50
Dark brown	-	-	20
Very dark brown	-	-	-
Tinted	-	-	-
Weight (g)	43.70^{a}±6.92	48.30^{a}±3.07	41.20^{b}±4.04
Density (g/ml)^{ns}	1.08±0.10	1.06±0.46	1.05±0.70
Egg index (%)^{ns}	78.89±3.82	78.64±1.80	78.23±2.39

$^{a.b}$ Different letters within the same row indicate significantly different ($p<0.05$)

^{ns} not significant

Egg specific gravity. The results of the present study on the specific gravity of local chicken eggs from KUB crosses with Merawang Sembawa, Merawang Bangka and Murung Panggang chickens (Table 1) were still in the normal range according to [20], that the specific gravity of eggs ranged from 1.09 to 1.15.

Egg specific gravity is the quotient of egg weight and egg volume, therefore factors that affect egg specific gravity include egg weight and volume. Egg weight is influenced by shell thickness and genetics, feed also affects egg shell thickness. According to [21], when the thickness of the shell increases, the specific gravity also increases. In addition, the egg-specific gravity indirectly formed the shape of an egg as well as the resistance and structure of the shell.

Egg index. There were not significantly differences in the egg index produced by three type of local chicken crossed (Table 1), with in the average of 78%. Stated by [18], that the index of a good egg ranged from 70 to 79%. Egg index 75% has a hatchability of 70 to 75%. Therefore, the local chicken egg index of KUB crosses with Merawang Sembawa, Merawang Bangka and Murung Panggang chickens is in the normal range.

Factors that affect the egg index include genetics, feed, and egg age. The egg index is influenced by genetics, brood age, production period,sex maturity age, reproductive tract and feed quality. Chickens in the reject period tend to have various egg indices and egg sizes due to their decreased ability to absorb nutrients [16].

3.2 Interior quality

Table 2. Interior quality of egg produced by local chicken crossed

Quality	Chicken crossed		
	KUB x Merawang Sembawa	KUB x Merawang Bangka	KUB x Murung Panggang
Albumen index	$0.06^{a}\pm0.02$	$0.06^{a}\pm0.02$	$0.09^{b}\pm0.02$
Yolk index	$0.38^{a}\pm0.06$	$0.40^{ab}\pm0.02$	$0.43^{b}\pm0.03$
Yolk colour	$7.00^{a}\pm0.00$	$7.50^{ab}\pm0.53$	$7.70^{b}\pm0.82$
Haugh Unit	$68.68^{a}\pm10.56$	$73.13^{a}\pm12.15$	$83.65^{b}\pm7.23$
Shell thickness (mm)^{ns}	0.33±0.04	0.30±0.03	0.33±0.03
Shell weight (g)^{ns}	4.65±0.71	4.26±0.38	4.13±0.56
Albumen pH	$9.21^{a}\pm0.21$	$9.01^{ab}\pm0.15$	$8.85^{b}\pm0.44$
Yolk pH	$6.32^{a}\pm0.14$	$6.19^{ab}\pm0.11$	$6.22^{b}\pm0.08$

$^{a.b}$: Different letters within the same row indicate significantly different ($p<0.05$)

^{ns}: not significant

Albumen index. The albumen index of egg produced by chicken crosses KUB x Murung Panggang was higher ($p<0.05$) than chicken crosses KUB x Merawang Sembawa/Merawang Bangka. Fresh eggs had an albumen index ranging from 0.05 to 0.17 [22]. According to [23], the quality standard of albumen index is divided into quality I ranging from 0.134 to 0.175, quality II ranging from 0.092 to 0.133 and quality III ranging from 0.050 to 0.091. The present study showed that the albumen index of local chicken eggs from KUB crosses with Merawang Sembawa, Merawang Bangka and Murung Panggang was included in quality III.

Thick albumen that turns into a liquid will cause the diameter of the albumen to become wider. Stated by [24], the decrease in the albumen index occurred due to the loss of CO2 and then the breakdown of carbonic acid into CO2, and then the mucin fiber lost its structure which formed a thick texture so that the albumen turned watery.

Yolk index. The yolk index of egg produced by chicken crosses KUB x Murung Panggang was higher ($p<0.05$) than chicken crosses KUB x Merawang Sembawa. According to [23], fresh eggs have a yolk index ranging from 0.33 to 0.52. While, the yolk index is divided into quality I ranging from 0.45 to 0.52, quality II ranging from 0.39 to 0.45 and quality III ranging from 0.33 to 0.39 [23]. The present study showed that the chicken egg yolk index was classified as quality III (KUB x Merawang Sembawa crosses), while the chicken egg yolk index of KUB x Merawang Bangka/ Murung panggang crossed included quality II.

Factors that affect the yolk index include feed and egg size. Stated by [24], that the yolk index will decrease due to the entry of water in egg white into the yolk as a result of the difference in osmotic pressure between the egg white and the yolk, so that the yolk will become watery. The level of the yolk index was influenced by the content of the feed given. Protein in the feed affects the thickness of the egg white which is the yolk wrapper. Amino acid (methionine) is a nutrient needed in the formation of the structure of albumen and ovomucin network, the more and stronger the ovomucin mesh, the thicker the albumen so that the albumen viscosity is also higher [25].

Yolk color. The yolk color of egg produced by KUB x Murung Panggang chicken crossed was better ($p<0.05$) than KUB x Merawang Sembawa crossed. The good yolk color is with a score of 10 on the Roche scale [26]. In addition, the commercial eggs with a yolk color score of 7-8 on the Roche scale were classified as a good quality [24]. The present study indicated that egg yolk color score produced by three types of chicken crosses had a good quality.

Factors that affect the color of the yolk include feed and the ability of chickens to consume feed and absorb nutrients in the feed. Egg yolk contains dyes which are generally included in the carotenoid group, namely xanthophyll, lutein, and zeaxanthin and a small amount of carotene and cryptoxanthin [26].

Haugh Unit value. The Haugh Unit value of egg produced by KUB x Murung Panggang crossed was higher ($p<0.05$) than KUB x Merawang Sembawa/Merawang Bangka (Table 2). The Haugh Unit value of egg divides into several qualities. AA quality chicken eggs have a Haugh Unit value of 72 to 100, A quality chicken eggs have a Haugh Unit value of 60 to 71, B quality chicken eggs have a Haugh Unit value of 30 to 59, and C quality chicken eggs have a Haugh Unit value below 29 [27]. Therefore, it can be seen that the Haugh Unit value of egg in the present study had a good standard and was in the AA category for egg produced by crossed KUB x Merawang Bangka / Murung Panggang chicken, while egg produced by KUB x Merawang Sembawa was in category A.

The Haugh Unit value was influenced by egg weight and albumen height. The ambient temperature affects the Haugh Unit value because it affects the rate of CO2 loss which causes the albumen height to decrease, so that the more CO2 is lost, the lower the Haugh Unit value [28]. According to [29], the Haugh Unit value was influenced by the high and low in egg weight and albumen thickness. The lower the egg weight causes the albumen thickness and the Haugh Unit value to also decrease.

Shell thickness. There was no differences in the shell thickness of egg produced by three types of chicken crossed (Table 2), and the shell thickness was in the normal range. The thickness of local chicken shells ranged from 0.32 to 0.35 [30].

Factors that affect the thickness of the shell include genetics, feed and age of chickens. There are various factors that affect shell thickness, namely age, genetic factors, health, environment, and feed. Thin shells have more and larger pores, so that the decline in egg quality due to evaporation occurs faster than eggs with thick shells [30].

Shell weight. The shell weight of egg produced by three types of chicken crosses was not significantly different, and in the normal range (4.13-4.65 g) (Table 2). The shell weight was in accordance with [31], that the average of shell weight of local chickens was 5.24±0.98 g.

Factors that affect the weight of the shell include the thickness of the shell and genetics. The weight of the shell is closely related to the thickness of the shell. Eggs that have thick shells have smaller pores and fewer so that the weight of the shell tends to be higher. Storage for 21 days resulted in low H2O evaporation so that the pores of the eggshell did not widen so it did not cause a decrease in eggshell weight [32].

Albumen pH. Based on Table 2, the albumen pH produced by KUB x Murung Panggang chicken crossed was lower ($p<0.05$) than KUB x Merawang Sembawa chicken crosses. However, the range of albumen pH produced by three type chicken crosses was higher than the range of fresh albumen pH. According to [33], the pH of fresh egg albumen ranges from 7.6 to 7.9 and will continue to increase during storage until it becomes more alkaline.

One indication of fresh eggs can be evaluated from the length and width of the thick albumen. Thick albumen that is getting longer and wider indicates that the egg is not fresh. Thick albumen is composed of long fibers called ovomucin. Factors that can affect egg albumen pH include a damaged buffer system and CO_2 evaporation. According [33] that albumen will be alkaline due to CO_2 lost through the pores of the eggshell so that the concentration of bicarbonate ions in albumen decreases and damages the buffer system, followed by damage to ovomucin fibers so that the albumen viscosity decreases and becomes watery.

Yolk pH. The yolk pH produced by KUB x Murung Panggang chicken crosses was lower ($p<0.05$) than KUB x Merawang Sembawa chicken crosses (Table 2). However, the range of yolk pH produced by three types of chicken crossed was higher than the range of fresh yolk pH. The good egg yolk pH is 6 [33]. Therefore, it is known that the average pH of local chicken egg yolks produced by three types of chicken crosses is in accordance with the good yolk pH range.

Factors that affect the pH of the yolk include a damaged buffer system, causing the albumen to become watery. According to [33] that an increase in egg pH causes egg protein content to be susceptible to proteolytic enzymes from eggs. The albumen that has become watery causes the transfer of H2O from the albumen to the yolk. This can

cause the weight of the yolk to increase and the vitelline membrane stretches so that there is mixing between albumen and yolk which can increase the pH of the yolk.

3.3 Chemical composition

The albumen moisture content of three types chicken crosses was not significantly different (Table 3), and in the range of 86.49-87.18%. These results are in accordance with the study by [34] which obtained the results of the albumen moisture content of chicken eggs, ranging of 87.83 to 88.73%.

Table 3. Chemical compostion of albumen produced by local chicken crossed

Chemical composition (%)	Chicken crossed		
	KUB x Merawang Sembawa	KUB x Merawang Bangka	KUB x Murung Panggang
Moisture^{ns}	86.49±0.55	86.86±0.48	87.18±0.61
Ash^{ns}	0.26±0.38	0.07±0.01	0.08±0.01
Protein^{ns}	10.96±0.74	10.19±0.53	11.33±0.85
Carbohydrate^{ns}	2.29±0.72	2.89±0.97	1.42±0.83

^{ns} : not significant

The albumen ash content of three types chicken crosses was not significantly different (Table 3), and in the range of 0.07-0.26%. These results were lower than the range of ash content according to [35], that albumen ash content ranges from 0.5 to 0.6%. Stated by [34] that the ash content is influenced by the metabolism and immune system found in chickens. Besides that it is also influenced by the rearing system and the environment.

The albumen ash content of three types chicken crosses was not significantly different (Table 3), and in the range of 10.19-11.33%. A previous study showed that Murung Panggang chicken eggs had highest albumen protein content with a percentage of 10.01% and the lowest was Merawang Sembawa chicken eggs with level of 8.53% [36]. The results of the present study was close to albumen protein levels according to [34], that albumen protein levels are 9.7 to 10.6%. The large differences in albumen protein in several types of chickens can occur due to genetics. Hens that have hereditary traits produce larger eggs, allowing for a higher protein content in their albumen. This is in accordance with the statement of [34] that genetic improvement leads to higher albumen weight without a reduction in yolk weight.

The albumen carbohydrate content of three types chicken crossed was not significantly different (Table 3), and in the range of 1.42-2.89%. According to [36], the average of carbohydrate content in the albumen of Merawang Sembawa, Merawang Bangka and Murung Panggang chicken eggs was in the range of 0.69 - 1.58%. The carbohydrate content in the present study was not too far from the albumen carbohydrate content range according to [34], which is in the range of 0.4 - 0.9%. According to [37] that albumen carbohydrate content was influenced by feed, ambient temperature, and age of chickens.

The yolk moisture content of crossed KUB x Merawang Sembawa chicken was higher ($p<0.05$) than yolk moisture of KUB x Merawang Bangka/Murung Panggang (Table 3). A previous study by [36], showed the similar content in the yolk moisture of three types of local chicken (Merawang Sembawa, Merawang Bangka and Murung Panggang) which in the range of 47.04 - 47.34%. According to [35], egg yolk moisture content is around of 48.7%. Storage will cause the moisture content in the egg albumen to penetrate into the yolk, therefore eggs that have been stored for a long time will have a watery yolk. The decrease in moisture content was caused by moisture evaporation and moisture diffusion from albumen to yolk [33]. The moisture content in eggs is also influenced by the rate of evaporation, temperature and humidity levels in the storage room. The high moisture content in the yolk may be related to the low HU value, because KUB x Merawang Sembawa chicken crossed showed the lowest HU value compared to other chickens crosses.

Table 4. Chemical compostion of egg yolk produced by local chicken crossed

Chemical composition (%)	Chicken crossed		
	KUB x Merawang Sembawa	KUB x Merawang Bangka	KUB x Murung Panggang
Moisture	50.25a±1.34	47.73b±0.40	47.64b±0.79
Ash^{ns}	0.29±0.04	0.28±0.03	0.26±0.02
Protein^{ns}	16.48±1.36	16.48±0.81	17.14±0.97
Carbohydrate^{ns}	7.21±1.78	9.53±2.25	8.61±1.82
Fat^{ns}	25.77±1.48	25.98±1.62	26.36±1.52

$^{a.b}$: Different letters within the same row indicate significantly different ($p<0.05$)

^{ns} : not significant

There was no significantly differences in yolk ash content resulted from three types chicken crossed (Table 3). The results of the present study different from a previous study by [36] that Merawang-Sembawa and Merawang-Bangka chicken eggs had a higher yolk ash content compared to the yolk ash content of Murung Panggang chicken eggs, which in around of 4.57-5.56%. In other previous study showed that ash content in the yolk is an average of 1.1% [35]. Chickens with different types will produce different percentages of egg components. Larger eggs will have a higher ash content. In addition, the type of chicken will also affect the ability to metabolize food substances. This is in accordance with [34], that different types of chicken and strains will produce significantly different levels of yolk ash. Ash content is influenced by the metabolism and immune system found in chickens, but it is also influenced by the rearing system and the environment.

Based on Table 3, there was no significantly differences in yolk protein content resulted from three types chicken crossed, which an average of 16.48-17.14%. The result different from a previous study by [36], that local chicken eggs namely Murung Panggang had highest protein content with a percentage of 19.05% and the lowest was Merawang-Bangka chicken eggs with a percentage of 12.72%. Stated by [35] that egg yolk protein content ranged from 15.7 to 16.6%. Therefore, these present study indicate that the yolk protein content resulted from three types chicken crossed was lower than

uncrossed local chicken, but it was similar to the study by [35]. This can occur due to genetic differences between crossed and uncrossed local chicken, which will have an effect on the yolk protein produced. According to [38] that genetics and the condition of the hen affect the quality of the eggs produced.

The carbohydrate content in egg yolk produced by three types of local chicken crossed showed no significant difference (Table 3). The results different from a previous study by [36], that the highest yolk carbohydrate content was on Merawang-Bangka chicken eggs with a percentage of 8.29% and the lowest was Murung Panggang chicken eggs with a percentage of 2.03%. However, the carbohydrate content in the present study was higher than the carbohydrate in egg yolk according to [35], which in a range of 0.2-1.0%. Factors that can affect the proportion and chemical composition of eggs are genetics, age of chickens, feed, temperature, and maintenance methods [39]. In addition, variation in the composition of avian eggs occurs among species and within species [40].

There was no significant difference in the fat content of egg yolks produced from three types of local chicken crossed, which in around of 25.77-26.36%. According to [41] that the yolk fat content ranged from 22.51% to 24.83%, close to the result in the present study.

4 Conclusions

Based on the exterior quality of the egg weight, the best eggs were derived from KUB Jatinom crossed with Merawang Bangka local chicken. However, based on the interior quality of the albumen index, yolk index, yolk color and HU value, the best eggs were derived from KUB Jatinom crossed with Murung Panggang local chicken. In general, the different types of local chicken crossed do not affect the chemical composition of the eggs produced.

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