

Effect of Feeding Quails with Mixture Feeds Composed of Crab Waste Meal, Leubim Fish Waste Meal, and Broken Rice Grains as Partly Substitution of Commercial Diet on Egg Quality

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Abstract. In rearing quails, many attempts have been done to reduce feed cost among other things by replacing partly commercial diet with numerous alternative feed sources such as crab waste meal (CWM), *leubim* fish (*Canthidermis maculata*) waste meal (LFWM), and broken rice grains (BRG). The purpose of this study was to determine the effect of using a mixture feeds composed of CWM + LFWM + BRG as a substitute for commercial laying chicken diets on the quality of quail eggs. This research was conducted at the Field Laboratory of Animal Husbandry and the Laboratory of Poultry Production Science, Syiah Kuala University. This study used 80 female quails (*Coturnix-coturnix japonica*) females aged 4 weeks. The treatment was feeding quails with the commercial diet of laying hen (324-1M) of which 0, 10, 20, and 30% of the diets was substituted by the mixture feeds composed of CWM + LFWM + BRG. The study was performed into block randomized design (BRD) consisting of 4 treatments and 4 replicate blocks. The blocks were established based on the different initial body weights of 4-week ages of female quails. Each treatment was an experimental unit consisting of 5 female quails each. The measured parameters were Yolk Index (YI), yolk color, Albumen Index (AI), eggshell thickness, and egg weight. The results of the study indicated that using up to 30% mixture feeds composed of 7,5% CWM + 9,1% LFWM + 13,4% BRG as a substitute for commercial laying chicken diets most significantly increased yolk index and yolk color of quail eggs. However, the albumen index, eggshell thickness, and egg weight were not significantly affected.

Keywords: crab, *leubim* (*Canthidermis maculata*), broken rice, egg quality, quails

Abstrak. Dalam pemeliharaan puyuh petelur, berbagai upaya telah dilakukan untuk menurunkan biaya pakan, antara lain, penggunaan bahan-bahan pakan alternatif seperti limbah cangkang kepiting, limbah ikan *leubim*, (*Canthidermis maculata*), dan menir. Tujuan penelitian ini adalah untuk mengetahui pengaruh penggunaan bahan pakan campuran yang tersusun dari tepung limbah kepiting (TLK), tepung limbah ikan *leubim* (TLIL), dan menir sebagai substitusi sebagian ransum komersil terhadap kualitas telur puyuh. Penelitian ini dilakukan di Laboratorium Lapangan Peternakan (LLP) dan Laboratorium Ilmu dan Teknologi Produksi Ternak Unggas, Universitas Syiah Kuala. Penelitian ini menggunakan 80 ekor puyuh (*Coturnix-coturnix japonica*) betina dara umur 4 minggu. Rancangan penelitian yang digunakan adalah Rancangan Acak Kelompok (RAK) terdiri dari 4 perlakuan dan 4 kelompok yang merupakan ulangan. Setiap kelompok merupakan unit percobaan yang masing-masing terdiri dari 5 ekor puyuh betina dara. Pengelompokan didasarkan pada berat badan puyuh dara umur 4 minggu. Parameter yang diukur adalah Indkes Kuning Telur (IKT), warna kuning telur, Indeks Putih Telur (IPT), ketebalan kerabang, dan berat telur. Ransum perlakuan adalah ransum komersil ayam petelur yang disubstitusi dengan bahan pakan campuran (TLK + TLIL + menir) sebanyak 0, 10, 20, dan 30%. Hasil penelitian memperlihatkan penggunaan 30% bahan pakan campuran yang tersusun dari 7,5% TLK + 9,1% TLIL + 13,4% menir sebagai substisusi ransum komersil sangat nyata meningkatkan *yolk index* dan warna kuning telur puyuh, sedangkan *albumen index*, ketebalan kerabang dan berat telur tidak berpengaruh nyata.

Kata kunci: kepiting, *leubim*, menir, kualitas telur, puyuh

Introduction

Eggs are the mostly consumed poultry products. Egg contains plenty protein and the taste is so delicious. Chicken eggs are greatly demanded food, but other poultry eggs like quail eggs are also frequently required and

served by the restaurants. The quality of eggs, such as its performance may affect people choice and its storability. Hence, quail egg producers need to not only increase egg production, but the quality of eggs should be paid attention as well.

The main problem of rearing quails is the high diet cost that takes almost 80% of the total cost. The commercial diets are still expensive, and some feed ingredients formulated into the diets are imported and making competition for human food. Many attempts have been done to reduce feed cost that includes replacing commercial diet partially with numerous alternative feed sources, like broken rice. This feedstuff contains high ME (384 kcal) but low Ca (10 – 80 mg), P (0.17 – 0.35 g), and protein 7.3% (Chaudhari et al., 2018).

The results of previous studies indicated that incorporating broken rice into the diet reduced diet price. Conversely, the quality of products tended to decline. Zulfan et al. (2016) reported that combining broken rice with coconut meal reduced the color appearances of broiler carcasses. It was suggested due to the decreased *carotene* and Ca within the diets containing both feed ingredients. For this reason, the inclusion of other alternative for yellow pigment and Ca sources, for instance, crab shells, was taken into consideration to support the adequate amounts of pigments and Ca.

Crab (*Scylla sp*) is decapod crustaceans habitually living in ocean or fresh water and occasionally walks ashore. The crabs are very preferable to human. However, only crab meat is edible, while crab shell is discarded as a waste. Every year, as many as 1000 tons of crab shell waste is disposed (Trisnawati et al., 2013). In several areas such as Aceh, the crab wastes are so abundant resulted from the culinary of Mie Aceh. The wastes are not merely the shells but also the abdomen-attached meat.

The waste may be an enormous potency explored as an alternative quail feedstuff. Crab shell contained 19.78% Carbon (C), 24.53% Oxide (O), 4.81% MgO, 3.98% P, and 71.42% CaO (Haryati et al. 2019) and rich *astaxanthin* sources as the composition of ample *carotenoid* in crustacean, such as lobsters, crabs, and shrimps. Permana et al. (2014) reported that

administering 10% of crab shells as the substitution of commercial diet significantly increased the weight of duck eggshell and whole egg. So far, lack of information was found on the effect of using crab shell on the quality of quail eggs.

The limiting factors to incorporate crab shells into the diet were the low protein and energy content. The use of crab waste should be combined with other feed ingredients, such as *leubim* fish waste meal (LFWM) and broken rice grains (BRG) for protein and energy sources, respectively. The purpose of this study was to examine the effect of mixing some feed ingredients composed of crab waste meal (CWM) + *leubim* fish waste meal (LFWM) + broken rice grains (BRG) on the quality of quail eggs.

Materials and Methods

Place and Time

The research was conducted at the Field Laboratory of Animal Husbandry, Animal Husbandry Department, Syiah University, Banda Aceh. The study ran for 10 weeks encompassing 2-week adaption period and 8-week experimental feeding.

Animals and Cages

The study used 80 female quails (*Coturnix-coturnix japonica*) 4 weeks of age. The quails were allocated into 16 cages with 0.75 x 0.35 x 0.30 m/cage. Each cage was completed by a cup feeder and gallon drinker.

Experimental Diets

The study used laying-hen commercial diet with the code of 324-1M produced by PT Charoen Pokphand, Medan. The diet has been being formulated to laying hen, but since balance diets is rarely found in Aceh, the farmers fed the quails with laying hen diets, inflating the production cost. The 324-1 M was partly replaced with feed ingredients composted of different levels of the mixing of

Table 1. Compositions and nutrient contents of the treatment diets

Composition	Treatment diet			
	D _A	D _B	D _C	D _D
Feed ingredients:			--- (%) ---	
Commercial laying hen (324-1M) ¹	100	90.00	80.00	70.00
The mixture feeds				
Crab waste meal (CWM) ²	0.00	2.50	5.00	7.50
<i>Leubim</i> fish waste meal (LFWM) ²	0.00	5.60	7.40	9.10
Broken rice grains (BRG) ³	0.00	1.90	7.60	13.40
Total mixture feeds	0.00	10.00	20.00	30.00
Total	100	100	100	100
Calculated nutrient content:				
Crude protein (%)	18.00–19.00	20.00	20.02	20.01
Crude fiber (% max.)	7.00	7.00	6.70	6.39
Crude fat (% min.)	7.00	6.51	6.13	5.76
Ca (% min.)	3.25	3.94	4.24	4.53
P (% min.)	0.60	1.15	1.49	1.81

¹ Nutrient content based on market label: protein 18–19%, crude fiber max. 7%, crude fat max. 7%, Ca min. 3.25%, and P min. 0.6%

² The contents of crude protein (CP), crude fiber, and crude fat based on Examined Laboratory of Biotechnology, LIPI, Ca and P based on Laboratory of Feed Certification and Quality Analyzing, Bekasi

³ Nutrient contents based on Hartadi et al. (2005)

crab waste meal (CWM) + *leubim* fish waste meal (LFWM) + broken rice grains (BRG) bringing to 20% of protein content in the present diets excluding control.

The experimental diets were as following:

D_A = 100% commercial diet (control)

D_B = 90% commercial diet + 2,5% CWM + 5,6% LFWM + 1,9% BRG

D_C = 80% commercial diet + 5% CWM + 7,4% LFWM + 7,6% BRG

D_D = 70% commercial diet + 7,5% CWM + 9,1% LFWM + 13,4% BRG

Compositions and nutrient contents of the experimental diets were given in Table 1.

Experimental design

The research was established into a randomized block design (RBD) with 4 treatments and 4 blocks. Since the experimental diets were commenced fed on the quails on the first day of the fifth week, to diminish unintended effects, different body weights were blocked into 4 groups. The BW of 80 birds were recorded and ranked from the highest to the lowest then blocked every 20 highest BW groups, hence 4 blocks. The 4 highest BW groups from the same blocks were randomly selected one-by-one to allocate the

treatments of D_A, D_B, D_C, and D_D, then repeated in a different order to the next 4 highest BW groups. Block 1 was completely randomized when each treatment was occupied by 5 birds. The same procedures applied to Block 2, 3, and 4.

Each block was denoted as a replicate which was an experimental unit with 5 birds each. The model for this randomized block design according to Ott (1991) was $Y_{ij} = \mu + \alpha_i + \beta_j + \epsilon_{ij}$ where Y_{ij} = the j^{th} sample measurement selected from population i , μ = an overall mean, α_i = an effect due to population i , β_j = an effect due to BW block j , and a random error associated with the response on diet i , BW block j .

Preparing CWM and LFWM

The crab waste meal was processed by the following procedures: (1) by-products of crabs consisted of shells, residual crab abdomens attaching meat, residual noodles, and other materials were gathered from the restaurant of Mie Razali, Peunayong, Banda Aceh, (2) the leftovers and undesirable matters were excluded resulting simply crab wastes, (3) the waste then washed using clean water, and (4) cooked until boiling for 30 minutes, (5) the cooked waste was poured into the basket

passing out the water, then (6) dried, and finally (7) pulverized into crab waste meal (CWM). The *leubim* fish waste meal was processed by following procedures: (1) by-products of cutting *leubim* fish consisted of head, gills, viscera, bone, skin, and scales were collected from TPI Lampulo, Kabupaten Aceh Besar, (2) the waste washed, and (3) the next step run similar with making CWM.

Dry matter, crude fiber, crude protein, and crude fat of both CWM and LFWM were analyzed in Examinated Laboratory of Biotechnology, LIPI, while Ca, P, and gross energy (GE) were analyzed in the Laboratory of Feed Certification and Quality Analyzing, Bekasi. The methods of analysis were typical for each variable, namely destruction auto analysis for crude protein, auto fat extraction for crude fat, auto auto fiber analysis system for crude fiber, MP21-BPMSP bomb calorimeter for GE, AOAC 2012 Method 968.08, for Ca and AOAC 2012 Method 965.17, for P. The nutrients contents of both CWM and LFWM are presented in Table 2.

Experimental Procedures

Cage and diet preparatory. Cages and with equipment in the Field Laboratory of Animal Husbandry, Animal Husbandry Department, Syiah Kuala University were rinsed using detergent agents and disinfected using rodalon. The cages were rested for a week, then blocked into 16 units of 0.75 x 0.35 x 0.30 m/unit for experimental unit. Each unit was provided with

a feeder and drinker, as well as randomly coded. A total of 80 young female quails were selected from 100 birds with the criteria of health, good conditions, and proper sizes. Selected birds were distributed into 4 blocks of BW with 20 birds each. Then, birds from each block were randomly assigned one by one into every treatment. Diet preparation was initially commenced by formulating the experimental diets. Feed ingredients were prepared by making CWM and LFWM, while BR was bought from Poultry Shop. Mixing feeds were done based on the formulation of experimental diets.

Rearing the quails. Birds were reared for cage adaption during the 4 – 5 weeks of age. All birds were fed on commercial diets. At 5 – 14 weeks of age, birds were fed on experimental diets based on each treatment. The diets and drinking water were supplied *ad libitum*. The feeds were added twice a day in the morning and afternoon. Drinking water was daily replaced with fresh water of which vita stress was supplemented during cage adaptation.

Data collections. In the beginning of the weeks of laying eggs (at 7 – 8 weeks of age), as many as five eggs were collected from each experimental unit and repeated with the same numbers at the end of the weeks (13 – 14 weeks of age), amounted 160 sampling eggs (40 eggs/treatment). All sampling eggs were brought and examined for fresh egg quality in the Laboratory of Poultry Science and Technology, Animal Husbandry Department, Syiah Kuala University.

Table 2. Nutrient contents of CWM and LFWM

Nutrients	CWM	LFWM
Dry matter ¹	92.37	92.52
Crude protein ¹	15.47	49.24
Crude fat ¹	1.10	1.61
Crude fibre ¹	0.90	11.33
Ash ¹	42.51	42.82
Gross Energy (GE) (kcal/kg) ²	1304.31	3208.41
Ca (%) ²	17.29	10.46
P (%) ²	1.03	6.21

¹ Analyzed in Examinated Laboratory of Biotechnology, LIPI

² Analyzed in Laboratory of Feed Certification and Quality Analyzing, Bekasi

Parameters

Parameters examined in this study were Yolk Index (YI), yolk color, Albumen Index (AI), eggshell thickness, and egg weight. The yolk index was calculated by dividing the yolk height by the yolk diameter. Yolk height was measured using a tripod caliper, and yolk diameter using a digital micrometer caliper. Yolk color was identified using a yolk color chart. Albumen Index (AI) was calculated by dividing the albumen height by the albumen diameter. Albumen height was measured using a tripod caliper, and albumen diameter using a digital micrometer caliper. The eggshell thickness was measured using an eggshell thickness gauge. Egg weight was obtained by weighting egg using an egg scale.

Data Analysis

The data were analyzed using *Analysis of Variance* (AOV). Analyzing was continued by Duncan's Multiple Range Test (DMRT) only for significant effects ($P < 0.05$ and or $P < 0.01$) were detected among the treatments (Ott, 1991).

Results and Discussion

Yolk Quality

The main parameters of yolk quality determined in the present study were yolk index (YI) and yolk color. The quality of egg yolk of quails fed experimental diets on eggs

collected at the beginning (7 – 8 weeks old) and end (13 – 14 weeks old) of the weeks of laying eggs were given in Table 3.

Yolk Index

Yolk index refers to yolk viscosity assisting to evaluate yolk quality. Results of AOV indicated that using CWM + LFWM + BR as substitution of commercial diets very significantly ($P < 0.01$) affected on yolk index at the end of the weeks (13 – 14 weeks old) of laying eggs. Eggs collected both from D_C and D_D had a notably significant higher yolk index than eggs from the control diet (D_A). The higher CWM + LFWM + BRG used the higher yolk index recorded.

The increasing of yolk index was caused by the most significantly decreases ($P < 0.01$) in diameter yolk in D_C and D_D compared to the control (D_A). Although no significant differences were statistically detected, eggs from D_B – D_D also had a higher yolk index than D_A . The yolk index is the ratio between yolk height and yolk diameter. Therefore, a higher yolk height, a smaller yolk diameter and a lower yolk index indicates a better-quality yolk.

Improving yolk quality was supposed to give positive effects of substitute mixture feeds especially originated from LFWM. It has been widely known that yolk formation was extremely affected by the quality of the diet.

Table 3. The average yolk quality of egg quails

Parameters	Experimental Diets				Average
	D_A	D_B	D_C	D_D	
Egg productions at 7 – 8 weeks of age					
Yolk height (mm)	11.36±0.52	11.27±0.25	11.39±0.41	11.53±0.34	11.39±0.36
Yolk diameter (mm)	21.28±2.09	22.42±1.59	21.86±2.41	20.78±1.26	21.58±1.81
Yolk index	0.539±0.070	0.505±0.041	0.525±0.047	0.556±0.025	0.531±0.047
Yolk color	6.55±0.30 ^{Aa}	6.75±0.34 ^{ABab}	7.30±0.35 ^{Bab}	7.40±0.54 ^{Bb}	7.00±0.51
Egg productions at 13 – 14 weeks of age					
Yolk height (mm)	10.95±0.49	11.23±0.25	11.57±0.09	11.52±0.50	11.32±0.42
Yolk diameter (mm)	23.62±0.22 ^{ab}	24.22±0.48 ^a	22.07±1.46 ^{bc}	21.10±0.54 ^c	22.75±1.47
Yolk index	0.463±0.022 ^a	0.464±0.005 ^a	0.526±0.036 ^b	0.546±0.022 ^b	0.500±0.004
Yolk color	7.85±0.53 ^{Aa}	8.40±0.59 ^{ABab}	9.40±0.28 ^{BCb}	8.90±0.35 ^{Cab}	8.64±0.72

^{A-C} The numbers in the same rows with different *superscripts* indicated significant differences ($P < 0.05$)

^{a-c} The numbers in the same rows with different *superscripts* indicated highly significant differences ($P < 0.01$)

Dietary protein was moderately responsible to form yolk and affected yolk index representing egg interior. The inclusion of added fat and protein in the diet has been shown to increase the size of the developing yolk (Bell et al., 2002).

The LFWM used in the present study contained 49.24% CP. The protein within fish meal was constituted of essential amino acids (EAA) mainly lysine and methionine of which both exceedingly required by poultry. Ween et al. (2017) reported fish meal processed from fresh by-products of whitefish such as cod and saithe was a tremendous protein source with the presence of all nutritionally EAA and low content of free amino acids (0.7%) and biogenic amines (< 1000 mg/kg) that approve the high quality and freshness of the natural resource. Similarly, Souza et al. (2017) reported that fish waste meal originated from various kinds of fish including tilapia, tuna, salmon, and sardine had better proportion of glutamic acid, lysine, leucine, glycine, and aspartic acid. According to Cho and Kim (2011), fish meal and fish oils (FO) are major dietary sources of n-3 long-chain polyunsaturated fatty acids (PUFA), docosahexaenoic acid (22:6n-3), and eicosapentaenoic acid (20:5n-3).

The mixture feeds were also supported by the CWM with 15.47% CP. The meat attached in crab abdomens of CWM possibly to generate crab fatty acids dominated by unsaturated fatty acids, omega 3, DHA, and EPA (Maria et al., 2011). Meanwhile, the protein within crab shells was constituted of EAA such as methionine, arginine, and tryptophan. Bilgin et al. (2011) reported crab meat was a good source of protein and contained high Calcium, Sodium, and Potassium.

The effect of experimental diets on the yolk index did not emerge on eggs collected at the beginning of the weeks of laying eggs. Results of AOV indicated no significant differences ($P>0.05$) on average yolk diameters of eggs laid at 7–8 weeks of age resulting in an insignificant

yolk index as well. It meant feeding quails on the mixture feeds composed of CWM + LFWM + BRG to replace up to 30% of the commercial diet during a month had not able yet to affect yolk quality. The positive responses had occurred over two months of feeding experimental diets. In general, the yolk indexes of all eggs were similar between in the beginning or end of the weeks of laying eggs.

Results of AOV indicated no significant differences ($P>0.05$) on the yolk index of different initial body weights of birds. The eggs laid by quails with higher body weights (BW) had similar yolk index with the eggs laid by those with lower BW. It meant the yolk index did not associate with BW. The differences of BW blocks did not influence anything on yolk diameter and yolk height with the exception in earlier weeks of laying eggs in which the birds with the highest BW block had yolk height significantly lower perhaps caused by in optimal egg sizes yet.

Yolk Color

According to The American Egg Board, basically yolk color has no relationship to egg quality, flavor, nutritive value, cooking characteristics, or shell thickness. The macronutrient composition of darker-colored and lighter-colored eggs are identical. However, there may be some very minor differences in micronutrient concentrations like Vitamin A and lutein. Yolk color may quite concern with consumers' wishes.

The results of AOV indicated that using CWM + LFWM + BRG as substitution of commercial diets most significantly ($P<0.01$) affected yolk colors examined both at the beginning and end of the weeks of laying eggs. Yolk colors of eggs laid from the quails in $D_B - D_D$ were higher than those from control diets (D_A).

Any improvements in yolk color were supposedly due to the escalating of absorption of yellow pigment supplied from CWM. Yolk color is subjected to any compounds of

xanthophyll and *beta-carotene* existing within the feeds (Stadellman and Cotteril, 1995). There are many *xanthophylls* and they represent a group known as *hydroxycarotenoids* (Bell et al., 2002). The composition of *carotenoid* sources within crab shells are *astaxanthin*, *astaxanthin monoester*, *astaxanthin dieter*, *β-carotene*, and *zeaxanthin* (Ross, 2001). These compounds are absorbed from the intestinal tract of the birds and deposited in the egg yolks (Bell et al., 2002).

The effect of experimental diets on yolk color had appeared since the earlier weeks of laying eggs. Results of AOV indicated eggs from $D_B - D_D$ exhibited very significantly ($P < 0.01$) higher yolk color than the control (D_A). Feeding the quails with experimental diets containing CWM + LFWM + BR for at least 4 weeks enhanced yolk color. These responses were more obviously seen after two months of birds consumed the experimental diets. Improved yolk color signaled the more absorption of yellow pigments within the diets especially originated from CWM.

At the beginning of the weeks of laying eggs, yolk color from D_A and D_B came out paler. However, over two months of laying eggs yolk color from all treatments met to deeper colors with the range of 7.85 – 9.40 or average 8.64. According to Stadellman and Cotteril (1995), yolk color is normally preferable by most consumers when in the range of 7 – 12. The average yolk index and yolk color of egg quails examined at 7 – 8 weeks and 13 – 14 weeks of age of all treatments were illustrated in Figure 1.

Results of AOV indicated no significant ($P > 0.05$) relationships between body weight and yolk color. Egg yolks from birds with higher BW displayed similar color to those with lower BW. It meant yolk color was not correlated to BW. Yolk color depends upon the composition

of the feeding mixture for laying hen (Dvořák et al., 2007). Ampode and Espina (2019) showed the yolk color of egg quails was significantly affected by the inclusion on different levels of fermented *Ipomoea aquatic* juice supplementation.

Albumen Quality

The main parameter of albumen quality was an albumen index. Albumen index refers to the albumen viscosity assisting to evaluate the albumen quality. Eggs with higher albumen index represented thicker albumen. Therefore, the higher the albumen indexes the better albumen quality. The average albumen quality of quail eggs was given in Table 4.

Results of AOV indicated using mixture feed composed of 7.5% CWM + 9.1% LFWM + 13.40% BRG up to 30% did not significantly ($P > 0.05$) affect on albumen index either examined at the beginning or end of the weeks of laying eggs. It was caused by no significant differences in albumen height and its diameter except for albumen height in D_A for which it seems to be higher in earlier weeks of laying eggs. Albumen index is influenced by the thick albumen height and its diameter. It meant using up to 30% CWM + LFWM + BRG as replacement of commercial diet did not affect anything on albumen quality. The albumen indexes of quails in the present study were in the range of 0.047 – 0.055 thought as good criteria. According to Buckle et al. (2013), the albumen indexes should be in the range of 0.09 – 0.12.

There were no significant differences in the albumen indexes among different BW. However, birds from the highest BW group (Block 1) had a tendency higher albumen index. Birds from this group formed somewhat heavier eggs with lower albumen diameter. Bigger birds undergo rapid reproduction organ development so that the albumen was more plentifully secreted. Agree to Laxmi et al. (2002), the albumen index correlated to the egg weight.

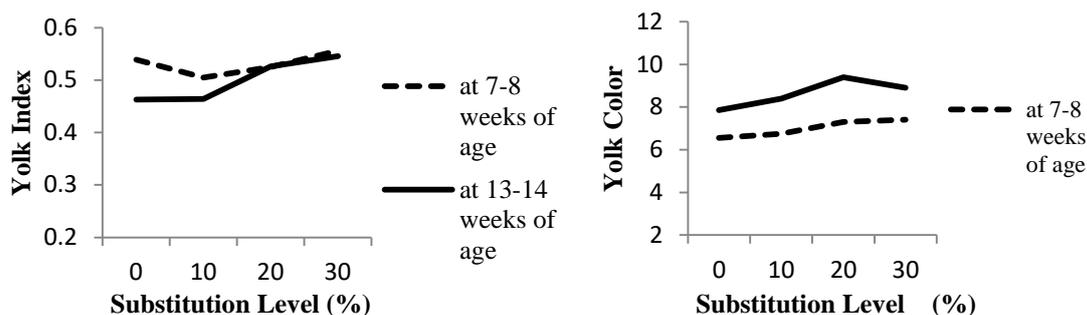


Figure 1. Average yolk index and yolk color of quail eggs of substitution levels of the diets

Table 4. The average albumen quality of egg quails

Parameters	Experimental Diets				Average
	D _A	D _B	D _C	D _D	
Egg productions at 7 – 8 weeks of age					
Albumen height (mm)	4.75 ^{Aa} ±0.07	4.14 ^{Cb} ±0.35	4.45 ^{Bab} ±0.30	4.27 ^{Bcb} ±0.34	4.40±0.35
Albumen diameter mm)	74.07±7.49	76.24±7.63	82.56±9.07	76.55±7.26	77.36±7.78
Albumen index	0.065±0.006	0.055±0.008	0.054±0.005	0.056±0.007	0.057±0.007
Egg productions at 13 – 14 weeks of age					
Albumen height (mm)	3.91±0.33	3.60±0.22	3.96±0.12	4.00±0.21	3.87±0.26
Albumen diameter (mm)	76.37±6.48	77.00±2.98	73.84±2.35	72.35±1.95	74.89±3.98
Albumen index	0.052±0.008	0.047±0.003	0.054±0.001	0.055±0.002	0.052±0.005

^{A-C} The numbers in the same rows with different *superscripts* indicated significant differences (P<0.05)

^{a-c} The numbers in the same rows with different *superscripts* indicated very significant differences (P<0.01)

Eggshell Quality

Results of AOV indicated using mixture feed composed of 7.5% CWM + 9.1% LFWM + 13.40% BRG up to 30% as substitution of commercial diets did not significantly (P>0.05) affect on eggshell thickness. However, at the beginning of the weeks of laying eggs, the eggshells of the birds fed the substitution diets containing CWM + LFWM + BR (D_B – D_D) were slightly thinner than those fed the control diet (D_A). Conversely, at the end of the weeks of laying eggs, birds from D_B – D_D tend to expose thicker eggshells than D_A. According to NRC (1994), calcium dietary was recommended within the range of 2.50 – 3.50%. The average eggshells of quails fed experimental diets were given in Table 5.

Statistically, no significant differences occurred on egg shell thickness. In contrast, visually and physically assessment the eggshells from the substitution diets containing CWM + LFWM + BRG quite thicker than those from the control diet. The egg membranes of these eggs were so solid and the egg did not easily crack as

touched down by the fingers. Calcium dietary is most responsible to form eggshells (Anggorodi, 1985). In the present study, Ca was specially furnished by CWM and LFMW since both contained high Ca (Table 2).

Egg Weight

Results of AOV indicated using mixture feeds composed of 7.5% CWM + 9.1% LFWM + 13.40% BRG up to 30% as substitution of commercial diets did not significantly (P>0.05) affect on egg weights of quails either examined in the beginning or end of the weeks of laying eggs. It meant the substitute diets were able to form eggs. The average egg weights of quail eggs were given in Table 6.

The eggs laid at the end of the weeks were heavier compared to those laid at the beginning of the weeks of laying eggs. As the birds get mature their reproduction organs more develop aiding to produce heavier eggs. Agree to Wahju (1997), in addition to the nutritional dietary, egg weights correlated to the age and maturity.

Table 5. The average eggshells of egg quails

Parameters	Experimental Diets				Average
	D _A	D _B	D _C	D _D	
Egg productions at 7 – 8 weeks of age					
Eggshell (g)	0.167±0.045	0.149±0.006	0.148±0.010	0.149±0.008	0.153±0.022
Egg productions at 13 – 14 weeks of age					
Eggshell (g)	0.176±0.004	0.182±0.002	0.181±0.002	0.182±0.007	0.180±0.005

Table 6. The average egg weights of egg quails

Parameters	Experimental Diets				Average
	D _A	D _B	D _C	D _D	
Egg productions at 7 – 8 weeks of age					
Egg weight (g)	10.66±0.25	11.22±0.65	11.18±0.81	10.96±0.80	11.00±0.64
Egg productions at 13 – 14 weeks of age					
Egg weight (g)	11.37±0.42	11.23±0.36	11.59±0.42	11.66±0.54	11.46±0.43

Conclusions

It was concluded that using mixture feeds composed of 7.5% crab waste meal + 9.1% *leubim* fish waste meal + 13.4% broken rice grains to substitute up to 30% commercial laying chicken diets has increased the yolk index and yolk color of quail eggs. However, it did not affect the albumen index and egg weight, but the eggshells tend to be thicker.

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