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Substitution of commercial cation with cation containing bean sprout waste on production and physical quality of egg

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Abstract. This research was aimed to evaluate substitution of commercial rations with rations contains bean sprout waste on production and physical omega 3 egg quality. Bean sprouts are a waste of green beans the remainder of beans sprout production consisting of green bean skin and shredded bean sprout. The use of bean sprout in layer diet is very limited because the bean sprouts are low palatability and high crude fiber. This experiment used eighty female birds strain of Lohman Brown were in a Completely Randomized Design allocated to five dietary treatments in four replicates. The treatment diets were R0: 100 % commercial feed, R1: 75 commercial feed + 25 % experiment feed, R2 : 50 % commercial feed + 50 % experiment feed, R3: 25 % commercial feed + 75 % experiment feed, R4: 100 % Experiment feed, respectively variable observed were egg production, feed consumption, feed conversion, Hen Day, IOFC, layer mortality, egg weight, egg mass, weight percentage of albumen, yolk, and shell, shell thickness, yolk color, egg, albumen and yolk index, and Haugh unit. The results showed there is no effect on all cumulative production (except on hen day and ration conversion) and physical quality of omega-3 eggs (except eggshell thickness). The highest IOFC value and the highest egg production were obtained at 50% substitution of commercial rations and 50% of research rations containing 2.5% of bean sprouts waste.

1. Introduction

The development of poultry farms in Indonesia is currently increasing, one of which is laying chicken farms because egg production from year to year is increasing. Egg production by province from 2009-2017 increased, which amounted to around 90,951,931 tons in 2009 and increased to 152,713,487 tons in 2017 [1]. Egg production of commercial hybrid laying hens in hot and humid area can reach 180-200 egg/year whereas in temperate area commercial can reach 250-300 egg/year [2]. The composition of eggs physically consists of 9.5% shells (eggshells or shells), 61.5% albumin, and 29% egg yolks [3]. Good quality eggs are eggs that have clean, smooth, slippery, non-cracked, and normal-shaped shell [4].



Ration is the main factor that influences the success of laying chicken farms in addition to seedlings and maintenance management. Feed must meet all the food needs of laying hens and do not contain chemicals that can endanger livestock to keep egg production stable and even increase and produce quality eggs. Commercial feed for laying hens on the market tends to have higher prices [5], so alternative feed is needed to reduce production costs and increase egg productivity and quality. One alternative feed to reduce the use of commercial feed is waste bean sprouts.

Bean sprouts waste is organic waste the residual production of bean sprouts consisting of green peanut shells and broken pieces of green bean sprout can be used animal feed [6]. Bean sprouts waste is easy to obtain, especially in the Bogor area, because the total production of bean sprouts in the Bogor area can reach 6.5 tons/day and the chance to produce sprouts waste is 1.5 tons/day. Bean sprouts waste also has good nutritional value, with active compounds, i.e. tocopherol, folic acid, vitamin c, flavonoids and phenols [7]. The use of bean sprouts waste for laying chicken feed has not been widely studied, so it is necessary to analyze the effect of its use on egg production and quality.

In addition to the addition of bean sprouts waste in the research ration, all rations were given an omega 3 supplement as a breakthrough product to produce value-added food products. Omega 3 supplementation (Patent no ID P 0023652) in commercial rations and research is intended to increase the value of functional food products in the form of omega 3 eggs. Omega 3 supplements are obtained from the mixing of lemuru fish oil processing waste with fermented tofu waste which functions as a filler. Omega 3 supplements are mixed with commercial rations and research with mixing methods.

Based on the description, substitution of commercial rations with rations containing bean sprouts waste are expected to maintain the production of omega-3 eggs and improve egg quality. This study aims to test the substitution of commercial rations with rations containing omega 3 bean sprouts waste to the production and physical quality of omega 3 eggs.

2. Materials and Methods

2.1 Birds and Cages

The birds used were 80 Lohman Brown laying eggs in the final phase of production with 98 weeks of age. The enclosure used is a battery cage made of wire with 20 cages. Each cage contains 4 chickens that are equipped with a place to eat and a drinking water container in the form of nipple. The cages are also equipped with lights and fans.

2.2 Ration

The ration used is commercial rations and research rations in the form of mash. The composition of commercial ration ingredients consists of corn, bran, corn gluten, Pollard, meat and bone flour, soybean oilcake, oil, calcium phosphate, calcium carbonate, sodium chloride, amino acids, vitamins, trace minerals, antioxidants, and omega 3 supplements. While the composition of research ration ingredients consists of corn, Pollard, soybean oilcake, coconut oilcake, bean sprouts (2.5%), DDGS, meat flour, CPO, CaCO_3 , DCP, L-Lysin, DL-Methionine, vitamins and minerals and omega 3 supplements. Nutrient content of commercial rations and research rations can be seen in Table 1.

2.3 Ration Making

The research ration used contains sprouts waste taken from Bogor market which was then dried and milled. The making of study feed was prepared based on nutrient requirements recommended by Lesson and Summers for laying hens aged more than 72 weeks (End Period) [8]. Feed formulation is carried out by trial and error while still considering the balance of protein and energy content in the ration.

2.4 Omega-3 supplementation in ration

Omega-3 supplements are made through the process of emulsifying and dispersing from the lemuru fish boiling waste material (which is known to contain lots of Omega-3, 6 and 9, and has good quality compared to the Omega-3 sources of plants) with tofu pulp (as filler), in order to obtain an omega-3 supplement formula which is then mixed in commercial and research feed as much as 5%.

Table 1. Nutrient content of commercial and research rations (%)

Nutrient	Commercial rations ^a	Research rations ^b
Dry matter (%)	88	89.44
Crude protein (%)	18	21.61
Crude fat (%)	7	4.87
Crude fiber (%)	6	3.8
Ash (%)	13.5	16.68
Nitrogen Free Extract (%)	55.5	53.04
Calcium (%)	3.4-3.6	-
Phosphor (%)	0.6-0.9	-
Metabolizable energy ¹ (kcal kg)	3443.94	3198.32

^aThis value was obtained from the ration product label used

^bThis value was obtained from proximate analysis in Center for Research on Biological Resources & Biotechnology Laboratory, Bogor Agricultural University

2.5 Rearing

Chicken rear was done for 7 weeks. The chickens were divided into 5 treatments with 4 replications, each of which was cage filled with 4 chickens. The placement of chickens in a cage is done randomly. Feeding is carried out 2 times a day, namely morning and evening. Drinking water is given ad libitum.

2.6 Productivity Measurement

The number of eggs produced is recorded every morning and evening. Weighing is carried out every morning and evening and weighing the remaining food is done every morning. Calculation of food consumed is done once a week. Productivity measured include: feed consumption and conversion, egg weight, hen day production, egg mass.

2.7 Physical Quality Test of Eggs

Testing the physical quality of eggs is done 6 times in the 2nd, 3rd, 4th, 5th, 6th and 7th weeks of maintenance. The eggs tested are all eggs produced during the test day. The physical quality of the eggs measured were weight, length, and width of the egg; weight, length, height, and yolk score; weight, length, and height of albumen; thickness and weight of eggshell. Albumen and yolk indexes were calculated by dividing height with a diameter of albumen and yolks multiplied by 100%. The egg index is calculated by dividing the width by the egg length times 100%.

2.8 Statistic analysis

This study used a Completely Randomized Design (CRD) with 5 treatments of ration substitution and 4 replications. Treatment includes:

R0 = Commercial Feed 100%

R1 = Commercial Feed 75% + Experimental Feed 25%

R2 = Commercial Feed 50% + Experimental Feed 50%

R3 = Commercial Feed 25% + Experimental Feed 75%

R4 = Experimental Feed 100%

The data obtained were analyzed statistically using the SPSS Application with variance analysis (ANOVA), and if the results of the analysis showed different effects, then further testing would be carried out using the Duncan test. Data analysis was carried out based on the equations of Steel and Torrie [9] with the following mathematical formula.

$$Y_{ij} = \mu + \sigma_i + \varepsilon_{ij}$$

Note:

Y = The value of the observations in the ith treatment and jth replication

μ = General average value

σ_i = Effect of the ith treatment

ε_{ij} = The ith treatment error dan jth replication

3. Results and Discussion

3.1 Productivity

The results of the analysis of variance (can be seen in Table 2) show that the substitution of the research ration had no effect on all parameters of productivity, except for the production of hen day eggs ($P < 0.01$) and ration conversion ($P < 0.05$).

Table 2. Productivity performance of research chickens for 4 weeks of maintenance ^a

Variables	Treatments				
	R0	R1	R2	R3	R4
Rations intake (g head ⁻¹ day ⁻¹)	84.16±6.97	89.89±8.35	90.13±8.00	87.15±6.90	79.71±8.13
Weight of eggs (g egg ⁻¹)	69.49±3.12	68.01±3.10	68.28±1.61	67.76±1.54	67.17±3.01
Hen day production (%)	46.80±10.35	39.73±10.68	55.65±15.73	51.79±13.12	43.06±12.74
Egg mass (g)	21829± 111.31	18226±118.55	25591±174.31	23541±139.35	15626 ±99.99
Rations conversions	2.56±0.83	3.40±1.07	2.49±0.62	2.70±0.81	2.70±1.23
IOFC (Rp)	434 062,50	286 481,10	549 381,10	493 766,64	234 492,56

^a Notes are referenced using alpha superscripts. capital letters show very significantly different ($P < 0.01$) and small letters show significantly different ($P < 0.05$)

R0: 100% commercial rations; R1: 75% commercial rations + 25% research rations; R2: 50% commercial rations + 50% research rations; R3: 25% commercial rations + 75% research rations; R4: 100% research rations

Hen-day egg production in R2 treatment (50% commercial ration and 50% research ration (containing 2.5% bean sprouts waste)) had the highest egg production rate (60.27%) compared to R1 (75% commercial ration, 25% research ration) and R4 (100% research ration). The ration conversion value in the group of chickens fed 100% (R4) real research ration ($P < 0.05$) had the highest conversion value compared to the other groups (R4 vs. R0, R1, R2, R3).

The consumption of research rations ranged from 84.40-92.87 g head⁻¹ day⁻¹ indicating that consumption did not meet needs optimally. The feed requirements of laying hens in the final phase of production are 110 g head⁻¹ day⁻¹ [8]. This can be caused by the content of crude fiber of bean sprouts waste contained in a high research ration, although the crude fiber content in the research ration is still within limits tolerable by chickens. The crude fiber content in commercial ration was 6% and in the research ration 3.8%.

The size/weight of eggs produced from this study is classified as large size (weight more than 60 g egg⁻¹) in accordance with the provisions of SNI (2008). Large egg weights can be produced because of the protein contained in high rations. Protein content in the commercial ration was 18%, and the research ration was 21.61%. Protein can increase egg weight because when there is no ovulation of egg yolk, protein accumulation will occur, so protein availability increases to form one egg the next day [10].

The hen-day egg production was very significantly ($P < 0.01$) highest in R2 treatment (50% commercial ration and 50% research ration (containing 2.5% bean sprouts)). This can be due to the right mix/substitution of rations to increase the production of hen-day. In line with high egg production because feed consumption is also high in R2 treatment, although not different from the consumption of feed in other treatments.

Bean sprouts contain vitamin E which can increase egg productivity. Vitamin E is able to break various chains of free radical reactions by removing hydrogen from free radicals from polyunsaturated fatty acids that have undergone peroxidation [11]. This is what improves the quality of egg productivity.

Egg mass is obtained from the sum / total weight of eggs produced in one week. The treatment does not affect egg mass. This can be due to the right combination of feed and high hen day production. Egg mass increases when production increases [12].

The results of the analysis of variance showed that the treatment significantly affected the value of feed conversion ($P < 0.05$). The ration is more efficient with a lower conversion value, shown in all four treatments (R0, R1, R2, and R3). Most inefficient in the treatment of 100% research ration (R4) with a conversion value of 5.98. This is because the treatment with 100% using the research ration of chickens undergoes a change in feed phase which can cause livestock to stress and ultimately decrease egg production. Feed conversion calculations are intended to determine the ability of chickens to convert the food consumed into eggs and see the chicken's response to the quality of feed given [13].

IOFC (Income over Feed Cost) is the result of income derived from the difference between revenue from the sale (in units) of omega-3 eggs and the cost of feed [14]. The addition of bean sprouts waste in the substitution of rations to produce omega-3 eggs as functional food has a positive effect on the IOFC value. IOFC values tend to increase as the research ration increases except for the R1 and R4 treatments because it produces low egg production, which causes the IOFC value to be low. The R2 treatment has the highest IOFC value of Rp 206,958.

3.2 Physical Quality of Omega-3 Eggs

The effect of giving substitution of commercial ration and ration containing 2.5% of bean sprouts waste gradually on the physical quality of omega-3 eggs is presented in Table 3.

The results of various analyzes of the physical quality of omega-3 eggs indicate that ration substitution does not affect on egg weight; weight and percentage of albumen, yolk, and eggshell; yolk color score; index of egg, white and yolk; Haugh units. Ration substitution of R4 (100% research ration) was significantly effected to decreasing eggshell thickness ($P < 0.05$).

Table 3. Physical quality of Omega-3 eggs ^a

Variables	Treatments				
	R0	R1	R2	R3	R4
Weight of eggs (g)	70.45±4.61	67.15±5.27	69.64±3.69	67.97±3.69	68.47±4.21
Albumen					
- Weight (g)	45.59±4.21	44.01±4.34	45.46±3.68	44.25±3.51	44.55±4.18
- Percentage (%)	64.58±2.18	65.31±1.40	65.13±1.95	64.97±1.58	64.88±2.23
Yolk					
- Weight (g)	18.10±1.18	17.04±0.56	17.55±0.64	17.34±0.17	17.40±0.41
- Percentage (%)	25.81±2.32	25.57±1.24	25.34±1.65	25.62±1.37	25.58±1.88
Eggshell					
- Weight (g)	6.77±0.64	6.10±0.44	6.63±0.15	6.38±0.42	6.52±0.28
- Percentage (%)	9.61±0.41	9.12±0.35	9.53±0.36	9.42±0.48	9.54±0.40
Eggshell thickness (mm)	34.80±0.84 ^a	34.12±2.20 ^a	33.91±0.62 ^a	33.86±1.70 ^a	30.99±1.14 ^b
Yolk color	14.95±0.09	14.84±0.11	14.86±0.17	14.81±0.16	15.00±0.00
Egg index	0.72±0.02	0.72±0.02	0.73±0.01	0.73±0.01	0.72±0.03
Albumen index	0.10±0.01	0.10±0.02	0.09±0.01	0.10±0.01	0.10±0.01
Yolk index	0.37±0.00	0.38±0.02	0.37±0.00	0.38±0.02	0.36±0.02
Haugh Unit	84.30±5.05	84.12±5.39	81.78±4.70	86.24±4.58	87.69±2.33

^a Notes are referenced using alpha superscripts show significantly different ($P < 0.05$)

R0: 100% commercial rations; R1: 75% commercial rations + 25% research rations; R2: 50% commercial rations + 50% research rations; R3 : 25% commercial rations + 75% research rations; R4: 100% research rations

Albumen index is a comparison between albumen height and albumen diameter. The more protein content in the ration, it will produce thicker albumen. It means to be the higher index value of the albumen and then good to maintain during storage [4].

Yolk weight is affected by fat content because most fat deposits are in egg yolk [15]. The resulting yolk color score has the highest value in the yolk color fan scale on the substitution of commercial rations with 100% research ration (R4), which is equal to 15.00. This can be caused by the presence of 68 µg of carotenoid pigment in bean sprouts which is the main pigment to form yellow, orange, and red on yolks [7]. The yolk color score is affected by the nutrient content in the ration, such as beta-carotene and xanthophyll [16]. The yolk index is a comparison between height and diameter of yolk average. Factors that influence the yolk index include storage time, storage temperature, vitellin membrane quality, and feed nutrition.

The highest shell thickness ($P < 0.05$) was in the control treatment (R0 = commercial ration containing omega-3), while the R4 treatment produced the lowest shell thickness. This can be caused by the low calcium content found in the R4 ration compared to the commercial ration of 3.4-3.6%. Eggshells are mostly built on calcium carbonate (CaCO_3) so that calcium content in the ration needs to be considered to get the optimum thickness of the eggshell. Shell thickness should be noted because the thin eggshells have low ability to protect quality of inner egg [17].

The egg index is obtained from the ratio of the width and length of the egg which affects the shape of the egg. The index value of the egg will affect the appearance of the egg itself. The egg index is close to 1 if the egg is rounded, while it is close to 0 if the egg is elliptical. The egg shape is disproportionately affected by the content of Ca and P in the ration, if the content of the two nutrients is insufficient in the ration, it will also affect the shape of the egg and will greatly affect the egg index value [18].

Haugh Unit (HU) is the relationship between thick or high albumen/albumen with the overall weight of eggs, is the basis for measuring the egg quality index. The results showed that feed substitution did not affect HU values. A good HU value is affected by the freshness of the egg. The high value of HU in R4 treatment, which is equal to 87.69 can be due to the level of protein ration efficiency.

4. Conclusion

Substitution of commercial rations with rations containing 2.5% bean sprouts waste does not affect productivity (except hen-day egg production and ration conversion) and physical quality of omega-3 eggs (except eggshell thickness). The highest omega-3 egg production in R2 treatment, while the worst / highest conversion in R4. Eggshell thickness decreased with 100% substitution of commercial rations (R4). The highest IOFC value and the highest egg production were obtained at 50% substitution of commercial rations and 50% of research rations containing 2.5% of bean sprouts waste.

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