Replacing some corn bran with wheat bran as an additional source of protein for the productivity of Isa Brown laying hens

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Abstract
Two hundred 28-week-old hens with an average body weight of 1570 g were used for 8 weeks (n=200, 28 weeks old), randomly distributed in 20 pens of ten hens each. All pens were housed in a covered, well-ventilated building, and each pen contained a feeder and a drinking trough. Hens in the control group received a commercial diet based on yellow corn (P0). Hens in the other groups received a diet based on yellow corn substituted with pollard at 5% (P1), 10% (P2), and 15% (P3). The feed used was commercial feed from Charoen Pokphand Indonesia Limited, antibiotic-free, with an isoenergy composition of 2900 kcal/kg and an isoprotein composition of 18%. The feed was provided in crumble form and was provided as abundantly as possible. Water was available ad libitum, and feed was distributed twice daily. The results showed that the diet substituted with pollard had no significant effect ($P>0.05$) on egg weight. However, substitution of yellow corn with pollard in the diet had a significant effect ($P<0.05$) on hen-day-production, egg yolk color and Haugh unit. Conversely, it reduced blood serum cholesterol content ($P<0.05$). It was concluded that the inclusion of polard in a yellow corn-based diet for laying hens was effective in reducing cholesterol content, increasing egg production and improving the yolk color of Isa Brown laying hens.

Keywords: Yellow corn, Pollard, Egg production, Cholesterol, Hens.

Introduction

Commercial poultry farming has grown rapidly in Indonesia over the past ten years. This growth is driven by high demand for eggs and poultry meat, which has resulted in investment in poultry farming projects. During the same period, there has been rapid growth in population and living standards, leading to high demand for poultry products. However, the rapidly increasing demand for poultry products has not significantly boosted local poultry production as expected due to high imports of feed ingredients, particularly yellow corn [1]. There is high demand for eggs in developing countries. Feed for laying hens is expensive, making it difficult for farmers to afford commercial feed. Therefore, it is important to explore the quality of new potential feed ingredients for egg production.

The high cost of conventional raw materials caused by the boom in biofuel production and the global economic crisis has impacted animal production, particularly the poultry industry, where feed represents between 60 and 70% of total production costs. Corn is the main source of ethanol in some countries, and although corn prices have stabilized with increased production of this cereal, prices remain very high and unprofitable for the poultry industry {2}. Therefore, developing countries must seek alternative feeds for poultry while maintaining product quality.

Corn is a commodity with considerable potential for development as an alternative staple food for food diversification, due to its high production rate and its nutritional content, particularly protein and carbohydrates, which are comparable to rice. The energy source used for these alternative feeds comes from agro-industrial waste such as wheat bran. In addition, the processing process is relatively easy and people are accustomed to consuming corn [3].

Wheat bran (*Triticum sativum*) can be an economical and nutritious alternative for animal feed in many tropical countries [4]. This feed is a by-product of dry wheat milling and consists of the hard outer layer of the grain. Wheat bran has adequate protein content for poultry and a high crude fiber content of 106–136.3 g/kg [5], but its metabolizable energy content is lower than many other ingredients such as corn, sorghum, and barley.

Pollard is a residue from wheat milling where the percentage of this raw material from the total weight of wheat is 13-17% [6]. Sztupecki et al.[7] reported that pollard contains approximately 12-14% protein, 1-2% fat, 10-14% fiber, and approximately 60-65% starch. It is also rich in B vitamins (thiamine and niacin) and minerals (Fe and Zn). Pollard also contains 2180-5220 mg of phytic acid [6]. In addition, [8] found that dietary supplementation with wheat bran arabinoxylooligosaccharides has prebiotic and competitive exclusion effects by increasing intestinal colonization by *Lactobacillu*s and *Bifidobacterium* and the production of short-chain fatty acids. Arabinoxylan is indigestible by the digestive enzymes of laying hens and is expected to suppress cholesterol synthesis in the liver. Reducing blood cholesterol levels is crucial, as it accumulates in the yolk, given the growing awareness of the health risks associated with high cholesterol consumption [9]. Arabinoxylan is a complex polysaccharide fiber found in the cell walls of cereal grains such as wheat. This compound functions as a prebiotic, supporting the growth of beneficial bacteria in the gut and may help improve digestive health [10]. Consumption of wheat bran will lead to a decrease in total serum cholesterol [11]. The use of 15% pollard significantly increased feed consumption. However, it significantly decreased feed efficiency, hen-day production, and eggshell thickness compared to the control. The results of this study concluded that the use of 15% pollard in the ration significantly reduced egg production [12].

Indeed, egg yolk coloration is desirable and actually needed because it is a consumer preference, and consumers perceive dark yellow yolks as indicating that laying hens are free-range and in better condition [13]. Therefore, this trial also incorporates studies comparing yellow corn-based diets substituted with pollard, as well as the effects of supplementing yellow corn-based diets for laying hens with pollard, whose endosperm cell walls are predominantly composed of arabinoxylan.

Material and Methods

Experimental Design and Feeding Trial

Two hundred 28-week-old hens with an average body weight of 1570 g were used for 8 weeks (n=200, 28 weeks old), randomly distributed in 200 pens of ten hens each. All birds were housed in individual cages (35 cm long, 40 cm high, and front side width 20 cm) tiered and made of aluminum wire. All pens were housed in a covered, well-ventilated building, and each pen contained a feeder and a drinking trough. Hens in the control group received a commercial diet based on yellow corn (P0). Hens in the other groups received a diet based on yellow corn substituted with pollard at 5% (P1), 10% (P2), and 15% (P3). The feed used was commercial feed Merk Piala (PL241) from Charoen Pokphand Indonesia Limited, Indonesia, antibiotic-free, with an isoenergy composition of 2900 kcal/kg and an isoprotein composition of 18%. The feed was provided in crumble form and was provided as abundantly as possible. Water was available ad libitum, and feed was distributed twice daily.

Egg quality

Egg production and feed intake (FI) in each cage were tabulated daily. Production performance (FI, egg numbers, and egg weight) was monitored weekly. Measurement of egg quality using an egg multitester machine (model EMT-7300, Japan) which includes (albumen, yolk, shell, yolk color, haugh unit, and egg shape) and the shell thickness was measured using a vernier caliper (mm). Cholesterol in egg yolk was analyzed according to

the Lieberman-Burchard method [14]. The concentration of cholesterol in the yolk, expressed in mg/100 g yolk. Blood lipid profiles were analyzed using the methods described by [15].

Statistical analysis

One-way ANOVA was conducted to see whether there was a significant difference ($P<0.05$) between all treatment means, and if there was, Duncan's Multiple Range Test (DMRT) was used to precisely identify treatment pairs that had a significant difference at the significance level of $P<0.05$ [16].

Results

Table 1 presents the results of the effect of substituting yellow corn with pollard in the diet on egg production and egg quality. Replacing yellow corn with pollard in the diet did not significantly ($P>0.05$) affect feed consumption, average egg weight, feed conversion ratio (fc/total egg weight; g/g), egg white percentage, egg yolk percentage, and egg specific gravity. However, partially replacing yellow corn with pollard in the diet significantly affected hen-day production, egg yolk color, and Haugh Units ($P<0.05$).

Table 1. The effect of substitution of yellow corn with pollard in the diet on egg production and egg quality of hens.

Variable	Level of substitution of yellow corn with pollard in the diet (%)				SE
	0	5	10	15	
Feed consumption, g/hen/day	117.03	117.94	118.15	118.27	0.20
Hen-day-production, %	84.69^{a}	88.04^{b}	88.35^{b}	87.90^{b}	0.63
Average egg weight, g/hen	62.65	63.14	63.25	62.66	0.54
Feed conversion ratio (FC/total egg weight), g/g	1.88	1.86	1.87	1.88	0.35
Egg white percentage, %	59.12	59.05	58.98	59.15	0.61
Percentage of egg yolk, %	23.91	24.05	23.98	24.19	0.98
Egg yolk color (1-15)	9.05^{a}	9.75^{b}	9.88^{b}	9.03^{a}	0.05
Egg specific gravity	1.09	1.12	1.11	1.09	0.01
Haugh Unit (HU)	72.54^{a}	78.27^{b}	78.30^{b}	78.65^{b}	0.97

^{a,b} Means with different superscripts in the same row differ at probability P = 0.05

Partial replacement of yellow corn with pollard in the diet at levels of 5%; 10% and 15%, significantly ($P<0.05$) increased HDP, namely: 4.32%; 7.94% and 3.79% significantly ($P<0.05$) higher than the control. The yolk color of laying hens is primarily determined by the presence of carotenoids in their feed, pigments found in plants. Laying hens fed a diet rich in carotenoids, such as those found in corn, alfalfa, and other forages, will produce eggs with dark yellow or deep orange yolks. Diets high in wheat and white cornmeal produce pale yellow yolks. Partial replacement of yellow corn with pollard in the diet at levels of 5% and 10%, significantly ($P<0.05$) increased egg yolk color, namely: 7.73% and 9.17% significantly ($P<0.05$) higher than the control.

The Haugh unit (HU) is a measure of albumen quality based on albumen height and egg weight. The HU is a unit that correlates egg white height with egg weight. Replacing yellow corn with pollard in the diet at levels of 5%, 10%, and 15% significantly ($P<0.05$) increased the HU value to 7.90%, 7.94%, and 8.42%, respectively, significantly ($P<0.05$) higher than the control. More details are presented in Table 1.

Table 2 shows the effect of replacing yellow corn with pollard in the diet on the blood lipid profile of laying hens. Replacing yellow corn with pollard in the diet did not significantly affect (P>0.05) the concentrations of triglycerides, high-density lipoprotein (HDL), and low-density lipoprotein (LDL) in the blood serum of laying hens. However, replacing yellow corn with pollard at levels of 5%, 10%, and 15% significantly (P<0.05) reduced serum cholesterol levels by 9.27%, 11.22%, and 7.54%, respectively, compared to the control diet (diet without yellow corn replacement). More details are presented in Figure 1.

Table 2. Effect of substitution of yellow corn with pollard in the diet on blood lipid profiles of hens.

Variable	Level of substitution of yellow corn with pollard in the diet (%)				SE
	0	5	10	15	
Total cholesterol (mg/dl)	160.25[a]	145.39[b]	142.27[b]	148.15[b]	2.904
Triglycerides (mg/dl)	167.91	161.14	162.85	164.36	3.298
HDL (mg/dl)	89.47	92.48	90.39	94.73	2.095
LDL (mg/dl)	56.19	52.71	49.26	50.37	2.176

[a,b] Means with different superscripts in the same row differ at probability P = 0.05

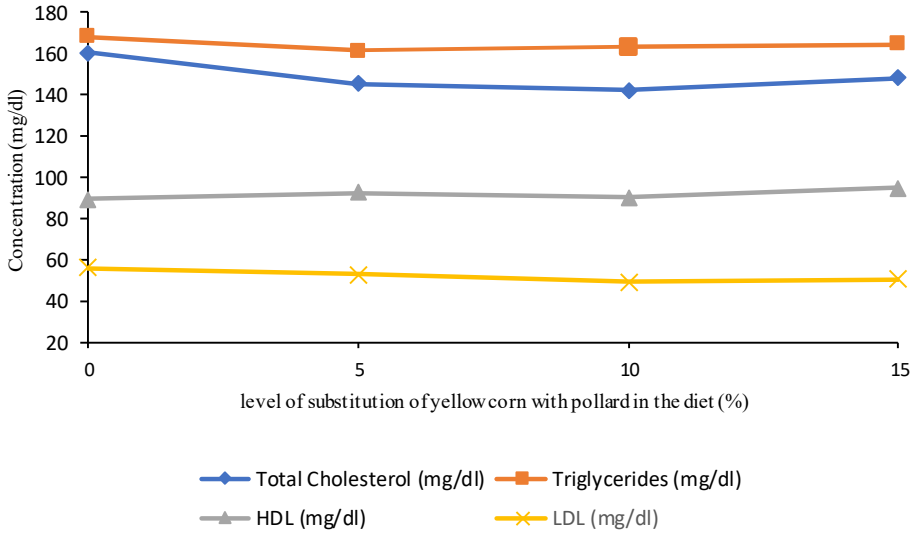

Figure 1: Effect of substitution of yellow corn with pollard in the diet on blood lipid profiles of hens.

Discussion

Overall, the results of this study indicate that replacing yellow corn with pollard in the diet can improve egg production and egg quality in hens. Feed consumption was not significantly affected by the replacement of yellow corn with pollard in the diet. Chickens remained relatively stable in feed consumption, despite changes in nutrient composition. This indicates that wheat bran is still palatably acceptable to laying hens. According to [17], wheat bran has a higher crude fiber content compared to other ration ingredients such as corn, but still contains sufficient metabolizable energy to support laying hen production. The addition of

wheat bran in the range of 5–15% in the ration can increase feed efficiency without reducing consumption.

Excessively high crude fiber content in the diet can disrupt the efficiency of energy and protein utilization, causing chickens to physiologically limit consumption [18]. A similar finding was reported by [19] that non-starch polysaccharides contained in pollard in the digestive tract of poultry can affect intestinal histology and improve feed digestibility. Poultry digestive enzymes are unable to break down arabinoxylan-oligosaccharides, but xylanase enzymes can break down arabinoxylan-oligosaccharides in pollard [8]. Research by [20] reported that the use of 10-12% wheat bran in laying hen rations provides optimal consumption and production performance. Proper feeding will increase poultry productivity, particularly in accurately calculating protein levels [21]. Findings by [22] showed a beneficial effect of using 150 g/kg of wheat bran on the growth performance of laying pullets. However, adding up to 200 g/kg of wheat bran had no effect on organ weight and blood parameters.

The Feed Conversion Ratio (FCR) is the ratio between the amount of feed given to laying hens and the weight of eggs produced by those hens. FCR is a performance indicator for laying hens, as it is a crucial factor influencing the efficiency of egg production. The high crude fiber content in wheat bran can interfere with nutrient absorption if given in excessive amounts [23]. While high crude fiber content can be beneficial for chicken digestive health, excessive amounts can reduce feed conversion efficiency [24]. Therefore, it is important to consider the total nutritional balance in the ration when using wheat bran.

Hen egg yolk color improved with the replacement of yellow corn with pollard in the diet. This increase in yolk color was due to increased feed consumption, followed by increased nutrient consumption. Egg yolk color was not significantly affected by wheat bran. This is in line with the report by [3] that replacing 20% of corn in the ration with wheat bran can increase feed intake (feed consumed), but worsens feed efficiency. Sufficient dietary fiber can increase metabolism and absorption of calcium minerals, so that egg shell formation is optimal [25]. Partial substitution of corn with wheat bran, either with or without the addition of soybean oil, did not significantly impact egg quality, including the proportion and relative weight of yolk and albumen, as well as Haugh units as an indicator of albumen quality [26].

The main factor that determines the color of the egg yolk is the xanthophyll content in the feed ingredients, a pigment found in plants called xanthophylls [27]. The color of the egg yolk is produced by xanthophyll pigments obtained from the feed consumed, such as yellow corn which is a source of energy and a supplier of xanthophyll pigments. This statement is also supported by [9] who stated that the color of the egg yolk is influenced by substances contained in the feed, such as xanthophyll, beta carotene, chlorophyll, and cytosan.

There was an increase in the Haugh Unit of eggs due to the addition of wheat bran to the feed of laying hens, where wheat bran has a higher protein content compared to corn bran, so that the partial replacement of corn bran with pollard in the feed used in this study has a higher protein content compared to the control feed. According to [28], the higher the protein content of the feed given, the formation of albumen protein will increase, so that the eggs have a high HU. HU is a unit that provides a correlation between white height and egg weight. The higher the HU value, the better the quality of the egg. The average HU of eggs obtained in this study can be classified as AA quality. This statement is supported by the [29] which states that the HU value of eggs less than 31 is classified as C quality, the HU value of eggs between 31-60 is classified as B quality, the HU value of eggs between 61-72 is classified as A quality, and the HU value of eggs >72 can be classified as AA quality.). Partial substitution of yellow corn with pollard, with or without the addition of soybean oil, does not affect egg production and egg quality, but may reduce feed production [3].

Substituting yellow corn for pollard in the diet significantly reduced serum cholesterol levels, but had no effect on serum HDL and LDL triglycerides. The crude fiber in pollard can trap bile salts and excrete them in the feces. Bile salts function to digest fat, thus reducing fat absorption. According to [30], the inclusion of wheat bran in the diet can reduce abdominal fat and cholesterol levels in broilers. Although a numerical reduction in serum triglyceride levels was observed with increasing dietary wheat bran levels in the current experiment, this result was not statistically significant [22]. It was also reported that serum triacylglycerol, cholesterol, calcium, phosphorus, hematocrit, or hemoglobin concentrations did not differ significantly between treatments. These findings suggest a beneficial effect of 150 g/kg wheat bran on pullet growth performance during the developmental phase; however, feeding this cereal up to 200 g/kg had no effect on organ weights and blood parameters [22].

Conclusion

It was concluded that replacing 5-15% of yellow corn with pollard in the diet can increase egg production and egg quality, while also reducing serum cholesterol levels in hens. High egg production with low yolk cholesterol is highly desirable for consumers and laying hen breeders.

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