Research Article

Effects of the Substitution of Corn with Sorghum and the Addition of Indigofera Leaf Flour on the Performance of Laying Hens

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Abstract | Sorghum (*Sorghum bicolor* L. Moench) is an alternative feed ingredient that is often used to replace corn in poultry feed, especially in the tropics. This study aims to evaluate the substitution of corn with sorghum, with the addition of Indigofera leaf flour, on the performance of laying hens. A completely randomized study design was used in this research with four treatments: A. 26% commercial concentrate + 40% corn + 0% sorghum + 0% Indigofera; B. 23% commercial concentrate + 20% corn + 20% sorghum + 4% Indigofera; C. 22% commercial concentrate + 10% corn + 30% sorghum + 5% Indigofera; and D. 21% commercial concentrate + 0% corn + 40% sorghum + 6% Indigofera. Each treatment was repeated fivetimes. All the bird received Waretha probiotic in drinking water at a dose of 43x1012 CFU/mL. Feed consumption, egg mass, feed conversion, hen-day production, and egg weight were measured. The results showed that the substitution of corn with sorghum with the addition of Indigofera leaf flour did not produce significant differences (P>0.05) in feed consumption, egg period, feed conversion, hen-day production, and egg weight. In conclusion, the substitution of corn with 40% sorghum with the addition of 6% Indigofera leaf flour and the provision of Waretha probiotics in each treatment with doses as high as $43x10^{12}$ CFU/mL did not interfere with the performance of laying hens.

Keywords | Laying hens, Indigofera, Production performance, Waretha probiotic, Sorghum

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INTRODUCTION

Laying hen farms have been very dependent on imports of cereal feed ingredients as a source of protein and energy, including corn kernels. The structure of animal feed production costs is dominated by raw materials in the form of corn which comprises 51.4% of the costs. The problem of price and availability of corn as outlined above has encouraged much research on alternative feed ingredients for poultry feed. The efforts to replace corn with other grains have not been successful, so corn remains the main raw material for feed in the world (Kasryno et al., 2008). Among alternative ingredients are sorghum (*Sorghum bicolor* L. Moench), which presents adequate nutritional characteristics and is often used to replace corn, especially in semi-arid regions and the tropics where sorghum plants produce better nutritional production yields per area and sorghum prices are lower than that of corn (Legiro et al., 2009). Sorghum plants can produce seeds reaching 3-6 tons/ha (Supriyanto, 2015), while the national average corn production is still low at approximately 4.23 tons/ha (Swastika et al., 2011). In terms of nutritional composition, sorghum contains metabolic energy; however, the digestibility of sorghum is 5% lower than corn, but sorghum has a higher crude protein content (NRC, 1994). Another consideration of including sorghum in laying rations is the presence of tannins. Sorghum contains antinutrient compounds, such as tannins and phytic acid (Suarni and Singgih, 2002).

Tannins can form carbohydrates and complex proteins to reduce digestibility and ration palatability (Rostagno et al., 2005). However, the development of low tannin sorghum varieties has made it possible to increase the percentage of sorghum contained in non-Ruminant animal rations, including that ratio present in the feed of laying hens (Moreno et al., 2007). Sorghum plantshave the specialized ability to grow back after being cut or harvested called *ratoon.* Ratoon is the ability to grow back after pruning the rootstock in one crop. After harvest, new shoots will grow from the stem in the soil. However, sorghum also has a lower carotenoid pigment content *(xantofil* and *carotenoid),* which is responsible for yolk pigmentation. Until now, the low level of carotenoid pigments in sorghum was the main limiting factor in the ration of laying hens. Sorghum contained low the -carotene (Awika and Rooney, 2004). So that this must be compensated for with other carotene sources such as leaf tops of Indigofera.

Indigofera (*Indigofera* sp.) is a type of legume plant that has been studied in the last 10 years. Indigofera that was cut at the age of 60 days with a cut height of 1.0 m can yield 31.2 tons/ha/year, which is the highest production value compared to yields provided by cutting older or younger plants (Tarigan et al., 2010). The nutritional composition of *Indigofera* sp. was 27.97% crude protein, 15.25% crude fiber, 0.22% calcium, and 0.18% phosphorus and samples contained 507.6 mg/kg of xantofil and carotenoids (Akbarillah et al., 2002). The leaves of legumes can be relied upon as a good carotenoid source in the ration of laying hens. Laying hens cannot synthesize pigments but have the ability to transport the pigment to the yolk of the rations consumed. The color or pigment found in egg yolk is strongly influenced by the type of pigment contained in the rations consumed (Winarno, 2002). Therefore, the carotenoid profile in the yolk reflects the carotenoid profile in the ration (Karadas et al., 2006).

Efforts to achieve ration efficiency require several ways so that the protein used can be digested optimally and gives an influence on productivity, one of which is by adding probiotics to drinking water. One of the probiotics that can be used is Waretha probiotics, Waretha Probiotics contain *Bacillus amyloliquefaciens*. *Bacillus amyloliquefaciens* have been used as probiotics for poultry (Zurmiati et al., 2017a; Zurmiati et al., 2017c; Tang et al., 2017). *B. amyloliquefaciens* produces enzymes: α-amylase, α-acetolactate, decarboxylase, β-glucanase, hemicellulase, maltogenic amylase, urease, protease, xylanase (Luizmera, 2005), phytase (Shim et al., 2012), lipase (Selvamohan et al., 2012) and mannanase (Zurmiati et al., 2017b). Probiotic can improve the efficiency of laying hens by the decrease of feed ratio (Kumari et al., 2010). In addition to being a probiotic, the *Bacillus amyloliquefaciens* contained in the Waretha probiotic has also been used as a fermentation inoculum. Fermentation of sago pith and rumen content mixture by *Bacillus amyloliquefaciens* is able to reduce crude fiber by 33% and increase crude protein by 42% (Wizna et al., 2008). Based on the information provided above, a study was conducted to measure the effect of substitution of corn with sorghum and the addition of Indigofera on the performance of laying hens.

MATERIALS AND METHODS

Bird, Feed and Laying Hens

As many as 200 birds of the ISA Brown strain were used. The birds were 30 weeks old with an average initial weight of 1625 ± 44.71 g. Each replicate consisted of 10 laying hens. The ration used in this study consisted of commercial rations, corn, sorghum, Indigofera leaf flour, palm oil, and premix. At the beginning of the study, each treatment was given Waretha probiotic (*Bacillus amyloliquefaciens*) at a dose of $43x10^{12}$ CFU/mL, and administration was done through drinking water. The nutrient (%) and metabolic energy (kcal/kg) contents of the laying hen feed are shown in Table 1.

Research Procedure

The preparation stages of the cage included the following steps: 1. preparing the feed and drinking containers; 2. cleaning the cages using water, a brush and soap; 3. whitewashing the walls, cages, and cage floors; 4. spraying the cages with disinfectant; 5. placing the chickens in their cages. Feeding trial phase: Feed and drinking water were given *ad libitum*. Routine maintenance was carried out for 4 weeks, and in the 4^{th} week, the eggs were collected. After that, the eggs were brought to the examination room for data collection.

Experimental Design

A completely randomized study design was used in this study with four treatments: A. 26% commercial concentrate + 40% corn + 0% sorghum + 0% Indigofera; B. 23% commercial concentrate + 20% corn + 20% sorghum + 4% Indigofera; C. 22% commercial concentrate + 10% corn + 30% sorghum + 5% Indigofera; and D. 21% commercial concentrate + 0% corn + 40% sorghum + 6% Indigofera. Each treatment was repeated five times.

Parameters Measured

Feed consumption g/bird/day, egg mass g/bird/day, feed conversion, hen-day production (%), and egg weight (g/egg) were measured.

Statistical Analysis

All data were analyzed by analysis of variance (ANOVA) using a general linear model procedure on SPSS software version 16.0. Duncan's multiple range test was used for determination of differences between treatment means (Steeland Torrie, 1980).

Table 1: Composition, nutrient content and metabolic energy of the feed of laying hens feed

Feed materials (%)	Composition of the treatment material (%)			
	A	B	C	D
Commercial concentrate	26.00	23.00	22.00	21.00
Corn	40.00	20.00	10.00	0.00
Sorghum seeds	0.00	20.00	30.00	40.00
Indigofera leaf flour	0.00	4.00	5.00	6.00
Palm oil	0.00	1.00	1.00	2.00
Mineral B12	1.00	1.00	1.00	1.00
Bran	33.00	31.00	31.00	30.00
Total	100	100	100	100
Energy metabolism (kcal/kg)	2653.1	2692.6	2678.1	2659.3
Crude protein	17.65	16.952	17.104	17.146
Crude fat	3.7913	4.2718	4.4628	4.5909
Crude fiber	6.7315	6.888	6.5695	6.126
Calcium	3.2785	3.2405	3.2075	3.1735
Phosphorus	0.5825	0.594	0.614	0.632
Waretha probiotic	($43x10^{12}$ CFU/mL)	($43x10^{12}$ CFU/mL)	($43x10^{12}$ CFU/mL)	($43x10^{12}$ CFU/mL)

Table 2: Average feed consumption, egg mass, feed conversion, hen-day production and egg weight of laying hens treated with different experimental diets

Treatment	Feed consumption (g/birds/day)	Egg mass g/birds/day	Feed conversion	Hen-day production (%)	Egg weight (g/egg)
A	121.85	48.82	2.51	83.23	63.84
B	121.90	50.02	2.44	82.80	63.11
C	121.84	50.65	2.42	84.16	62.32
D	121.45	49.31	2.48	84.56	62.39
SE	0.22	1.87	0.14	1.33	0.0089

Data are presented as the mean of 5 biological replicates. Parameter values in the same column showed no significant differences (P>0.05).

RESULTS

Substitution of corn with sorghum and the addition of Indigofera leaf flour on the performance of laying hens. The effect of the substitution of corn with sorghum and the addition ofIndigofera on the feed consumption, egg mass, feed conversion, hen-day production, and egg weight of laying hens is shown in Table 2. At the end of the study, it was found that the use of 40% sorghum added with 6% Indigofera in the ration was able to replace corn by 100% and did not affect (P>0.05) the performance of laying hens.

DISCUSSION

The effect of the substitution of corn with sorghum and the addition of Indigofera on the feed consumption, egg mass, feed conversion, hen-day production, and egg weight of laying hens is shown in Table 2. At the end of the study, it was found that the use of 40% sorghum added with 6% Indigofera in the ration was able to replace corn by 100% and did not affect (P>0.05) the performance of laying hens.This is due to the availability of food substances from the rations consumed by the laying hens in each of the treatments. Nutritional composition analysis found that sorghum contains metabolic energy, and the digestibility of sorghum is 5% lower than that of corn, but sorghum has a higher crude protein content (NRC, 1994). In addition, Indigofera contains high levels of protein and the nutritional composition of *Indigofera* sp. is 27.97% crude protein, 15.25% crude fiber, 0.22% calcium, and 0.18% phosphorus; in addition, sorghum contains 507.6 mg/kg of xantofil and carotenoids (Akbarillah et al., 2002). The results of this study indicate that the substitution of corn with sorghum and Indigofera in addition to *Bacillus amyloliquefaciens* did not interfere with the feed consumption of laying chickens. This conclusion is supported by the fact that the nutrient content found in sorghum and Indigofera is able to match the contents of corn, and these nutrients function as an energy source. In addition, the addition of Waretha probiotics that are able to produce various types of enzymes aids in the digestion process in the digestive tract of laying hens so that feed is easier to digest. *Bacillus amyloliquefaciens* produces the enzymes α-amylase, α-acetolactate, decarboxylase, β-glucanase, hemicellulase, maltogenic amylase, urease, protease, xylanase (Luizmera, 2005), phytase (Shim et al., 2012), lipase (Selvamohan et al., 2012) and mannanase (Zurmiati et al., 2017b).

The treatments had no significant effect (P>0.05) on egg mass. This is because there is no significant effect on hen-day production and egg weight. Egg mass is strongly influenced by hen-day production and egg weight. The egg mass value is determined by the percentage of egg production, hen-day production and the egg weight itself (Kartasudjana, 2006), The egg value depends on the percentage of hen-day production and egg weight. If the egg mass increases, the egg production increases, whereas if the egg mass decreases, the egg production also decreases (Amrullah, 2003).

The substitution of corn with sorghum by up to 40% and 6% Indigofera addition did not cause a decrease in the of the produced egg weight. The quality of nutrients, especially proteins from Indigofera and the energy content of sorghum can replace corn energy in the ration. The nutritional content of the ration, especially the energy sources and protein, can affect the feed conversion value (Lokapirnasari et al., 2011). Factors influencing feed conversion are livestock genetics, age, egg production, energy content in rations, body weight, nutrient content in the feed, air temperature, and ration palatability (Campbell et al., 2009). In general, feed conversion is the amount of feed given to produce a certain amount of product (Lokapirnasari et al., 2011).

The average of feed conversion of 34-week-old laying hens in this study ranged from 2.51 to 2.48. The results of this study are almost the same as those reported by Fenita et al. (2010) where the average feed conversion in the 32-44 weeks of laying hens ranged from 2.46 to 2.55.

The treatments had no significant effect (P>0.05) on hen-day productionof laying hens. This finding is due to the equal availability of nutrients in the rations of each treatment so that there was no significant effect on feed consumption, as feed consumption greatly influences hen-day production. The consumed energy and protein in rations is used for maintenance, growth, feather production, and egg production (Bell and Weaver, 2002). Energy and protein consumption that does not meet the standards is a factor that causes low hen-day production. The protein consumed in rations is broken down into amino acids, absorbed by the body and arranged into tissue proteins and eggs (Sultoni et al., 2006). The availability of protein rations is very influential on hen-day production because essential amino acid deficiencies can have an impact on the efficient use of protein for tissue formation and cause decreased egg production.

The average hen-day production of laying hens of the ISA Brown strain in this study ranged from 83.23 to 84.56%. The results of this study are similar to those reported by Setiawati et al. (2016), where the average hen-day production of laying hens of the ISA Brown strain ranged from 86.10 to 89.20%.

In Table 2, the egg weight of laying hens ranges from 63.84 to 62.39 g/egg. This is due to the level of feed consumption remaining constant across treatments. As a result, the nutrients received by chickens such as protein, crude fiber, fat, minerals, vitamins, and other nutrients were relatively the same, so the egg weights produced among the treatments were similar. Feed consumption is one of the most important factors affecting egg weight (Saputra et al., 2016). The most important dietary factor that is known to affect the size of eggs is adequate protein and amino acids in the ration. Proteins and amino acids (especially methionine) are food substances that have the greatest role in controlling egg size, in addition to genetic factors and poultry body size (Leeson and Summers, 2005). The average egg weights of the laying hens in treatment A, B, C, and D were 63.84, 63.11, 62.32, and 62.39 g/egg, respectively. The results of the study were higher than those reported by Pulupi et al. (2014), where the average weight eggs of laying hens ranged from 53.95 to 55.99 g/egg.

CONCLUSION

The substitution of corn with 40% sorghum, the addition of6% Indigofera leaf flour, and the provision of Waretha probiotics with treatments as high as 43×10^{12} CFU/mL did not interfere with the performance of laying hens.

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CONFLICT OF INTEREST

There is no conflict of interest.

AUTHORS CONTRIBUTION

Riesi Sriagtula carried out research and helped in making decisions. Ade Djulardi and Ahadiyah Yuniza provided input and criticism for article improvement, Wizna is the corresponding Author, and research organizer and Zurmiati helped with literature studies, data analysis, and helped with correction revisions of Advances in Animal and Veterinary Sciences.

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