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Utilization of Indigofera Leaf Flour (*Indigofera zollingeriana* Miq) as Feed to Increase the Production and Internal Quality of KUB Chicken Eggs

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ABSTRACT

One of the variants of native chicken that is quite potential to be developed in Indonesia is the KUB chicken. The quality and production of free-range chicken eggs can be increased by providing the quality feed. One alternative source of quality feed is the use of *Indigofera zollingeriana* leaves. This study aims to determine the increase in egg production and internal quality by adding *Indigofera zollingeriana* Leaf Flour (ILF) in KUB chicken rations. This study used a completely randomized design (CRD) consisting of 5 treatments, namely R0 (control), R1 (7.5% ILF), R2 (15.0% ILF), R3 (22.25% ILF), and R4 (30.0% ILF) and 6 replicates. Observation parameters include Feed Conversion Ratio (FCR), egg production, egg weight, Hen Day Production (HDP), and internal egg quality. The results showed that adding ILF significantly increased production, internal egg quality, and ration conversion but had no significant effect on ration consumption. The highest increase in egg production was obtained by treatment with 15% and 22.5% ILF, with HDP 53.87%. The increase in egg weight quality, egg yolk index, white egg index, and egg yolk color were highest in the treatment with 30% ILF compared to the control. Giving ILF 22.5% gave the lowest FCR value compared to other treatments. It was concluded that providing ILF in the ration significantly increased egg production and internal quality in KUB chickens.

Keywords: KUB chicken; Indigofera zollingeriana; egg production and internal quality.

INTRODUCTION

The potential development of KUB chicken holds a strategic role, especially as the source of animal protein, to fulfil people's nutritional needs. Together with people's preferences for KUB chicken meat and egg, the business prospect of this chicken is quite promising in Indonesia (Sayuti, 2002). At the national level, KUB chicken egg contributes only 196,138 tons (9.95%) to the total production, far lower when compared to duck egg (14.72%) and layer chicken egg (72.47%). The KUB chicken's low contribution appears to be accounted for by various factors, including nurturing genetic patterns, and lack of disease control and feeding factors.

KUB chicken is one of the KUB chicken variants resulting from improvement breed of native chicken. Compared to regular KUB chicken, KUB chicken weighs between 1200-1600 grams and exhibits higher egg production (45-50%). Its production peak reaches 84% at the age of 31 weeks. The egg's first weight ranges between 35-36 grams and increases to 45 grams at the end of the second production month. Furthermore, KUB chicken also exhibited higher productivity (160-180 eggs/year) with earlier first egg large (20-22 weeks). Its feed ranges between 80-85 gram and exhibit 10% hatching behaviour (Sartika et al., 2015; Hidayat et al., 2011).

The success of KUB chicken farming highly depends on several factors, including breeder, feeds, nurturing pattern, and animal health. The feed should be seen as one of the top priorities, as it represents the highest costs (60-80%) and contributes directly to animal productivity. In this regard, farmers dependence on commercial feeds puts them disadvantaged due to higher costs and poor egg quality. Therefore, it is necessary to improve the feed quality using locally available materials, such as *Indigofera zollingeriana* Miq. This *I. zollingeriana* is among the legumes serving as a potential source of feeds for ruminants and poultries. According to Yumiarty (2006) and Edwards et al. (2012), Indigofera sp. is an excellent forage feed as it contains 27.9% raw protein, 15.25% crude fibres, 77% digestibility, 0.22% calcium, and 0.18% phosphor. In the same vein, Tambunan et al. (2015) also state that this plant serves as the protein source with dry matter content up to 89.47%, 3788 kcal/g of energy, 15.3% of crude fibre, and 22.30-31.10% of crude protein, and low tannin, which is safe for animal forage feed.

Indigofera leaves also contain beta-carotene and xanthophyll as sources of yolk pigmentation (Akbarillah et al., 2010). In this regard, Palupi et al. (2014) report that replacing 45% of soybean meal protein with 15.6% indigofera sp to leaf shoot flour to the ration can improve the yolk's yellow color and result in AA-quality egg. A good quality egg has a normal shape, strong shell, and reddish yellow or orange yolk (Akbarillah et al., 2010). However, using 15% Indigofera-based-fermented feed does not significantly affect the production and mass of local broiler's egg (Daini et al., 2017). The present study aimed to see the effect of Indigofera zollingeriana leaf flour on KUB chicken's egg production and internal quality.

MATERIALS AND METHODS

Time and place

This research was carried out in a nursery (trial) at the Papua Institute for Agricultural Technology (BPTP Papua) and was carried out for approximately 2 (two) months, namely (November 2021 - January 2022)

Tools and materials

The tools used in this study include a feed mill, mixer, feed scale, egg scale, glass plate, ruler, vernier scale, chicken feeder, basin, bucket, egg rack, coloring pen, tissue, and yolk color fan. The study materials were thirty KUB chicken with 62 weeks of production age. The coop used in this study was 30 two-level battery chicken coops made from a wooden zoard, with a size of 40x60 for each unit. The raw feed materials included *I. zollingeriana* leaves, maize flour, rice bran, rice groats, factory feed (511 Charoen Pokphand), and $CaCO_3$ (calcium).

As the raw material, *I. zollingeriana* leaves were processed into flour. First, leaves were collected and mixed. To obtain 15-20 kg of flour, around 100kg of I. zollingeriana leaves are needed. The leaves were sun-dried for about three days. The dry leaves were processed into flour using a mixer or mill. The next step was to make the ration by mixing other materials (i.e., maize flour, rice bran, rice groats, 511 feed, and $CaCO_3$.

Research design

This study applied a wholly randomized design comprising five experimental rations with six repetitions. The standard ration formula (basic feed) consisted of 35% maize flour, 12% rice bran, 35% 511 Charoen Pokphand, 17.5% rice groats, and 0.5% $CaCO_3$. The experimental ration was made by adding Indigofera zollingerian leaf flour to the standard ration (Table 1), with determined nutritional composition (Table 2).

The research began by weighing the chickens before putting them randomly into a coop. The ration was given twice a day (07.30 - 09.30 morning and 15.30 -17.30 afternoon) under the KUB chicken's egg-laying period needs (i.e., 110-115g/unit) (Sartika et al., 2015). The water was given *ad libitum*. The observed variable included egg production, Hen Day production, weight, feed intake, ration conversion, and internal egg quality. The internal egg quality measurement includes albumen index and yolk indices. Yolk quality was determined visually by comparing the yolk color to Roche yolk color fan (a score of 1-15) (Kurtini et al., 2014).

Table 1. Standard ration formula and *I. zollingeriana* concentration for each treatment

Material	Treatment (%)				
	R0	R1	R2	R3	R4
Standard ration formula (basic feed))	100.0	92.5	85.0	77.25	70,0
Indigofera leaf flour (ILF)	0.0	7.5	15	22.5	30.0

Description: R0= Standard Ration (Control, without ILF), R1 = ILF 7.5%, R2= ILF 15 %, R3 = ILF 22.25%, R4= ILF 30%

Table 2. Standard ration composition.

Feed composition	Nutrient content			
	Crude Protein (%)	Crude fat (%)	Metabolic Energy (Kcal/kg)	Crude Fiber (%)
I. zollingeriana leaf flour*	25.66	3.78	2900	12.15
Rice bran*	11.20	13.51	2400	10.44
Maize*	8.50	2.32	3300	8.82
511 Charoen Pokphand	22.0	6.5	3075	5.0

Source: *) Pagala *et al*. (2018).

Table 2b. Nutritional composition of treatment rations

Description	Treatment				
	R0	R1	R2	R3	R4
Crude protein (%)	13.4	14.3	15.2	16.2	17.2
Crude fiber (%)	6.1	6.6	7.0	7.5	7.9
Crude fat (%)	5.0	4.9	4.8	4.7	4.6
Metabolic energy (Kcal/kg)	3,038.1	3,027.7	3,017.4	3,007.0	2,996.7
Calcium (Ca)	0.8	0.8	0.7	0.7	0.6
Phosphorus (P)	0.5	0.5	0.5	0.4	0.4

Data Analysis

The data were analyzed using Analysis of Variance and followed by Duncan Multiple Range Test once the significant difference was noticed (Steel and Torrie, 1995).

RESULT AND DISCUSSION

Egg Production

The results showed that the addition of ILF showed a significant difference in egg production, HDP and egg weight (Table 3). Adding ILF 15.0 - 22.25% resulted in higher egg production compared to the control ration (i.e., up to 21.67%). This is because adding ILF will increase the protein content in the ration. According to Leeson and Caston (1996), egg production is strongly influenced by the protein content in the ration during the egg-laying period because the eggs produced are largely determined by the intake of protein that enters during the process of egg formation (Leeson and Caston, 1996). Regarding HDP, a higher increase was also found in the addition of ILF 15.0 and 22.22% (up to 21.76%), compared to the control ration. While the highest increase in egg weight was found in the addition of 30.0% ILF (increased to 11.97%).

The difference in egg production seems to be accounted for by the increase in nutritional content (i.e., protein) due to more ILF concentration addition. According to Lilburn and Myers (1990), the increase in egg production occurs along with the increase in protein content in the ration given before and after the egg-laying period. Similarly, Leeson and Caston (1996) state that egg production may significantly be affected by the protein content of the ration given during the egg production period.

Table 3. Average egg production, hen day production, and egg weight

Parameter	Treatment				
	R0	R1	R2	R3	R4
Egg production (egg/hen/week)	2.63[a]	2.80[ab]	3.20[c]	3.20[c]	2.98[bc]
Hen day production (%)	43.75[a]	46.73[ab]	53.27[c]	53.27[c]	49.70[bc]
Weight (g/egg)	41.78[a]	42.39[a]	45.11[bc]	44.00[ab]	46.78[c]

Description: different letters within a row are significantly different (p<5%). R0= Standard ration formula (Control), R1 = ILF 7.5%, R2= ILF 15 %, R3 = ILF 22.25%, R4= ILF 30%.

Increased egg production is determined by the breed factors and nutrition sufficiency, especially protein, obtained from the ration (Palupi et al., 2015). The egg production and quality can be optimized when the ration meets the animal's nutritional needs according to age and management procedure (Tumion et al., 2017). Factors affecting egg production include chicken originality, age, puberty age, chicken weight, moulting, environmental factors (e.g., temperature and lighting), feed, and feeding limit (Yuwanta, 2008). Chicken egg production appears to decline until the reject period, with an average production of 55% when the chicken was 82 weeks of age.

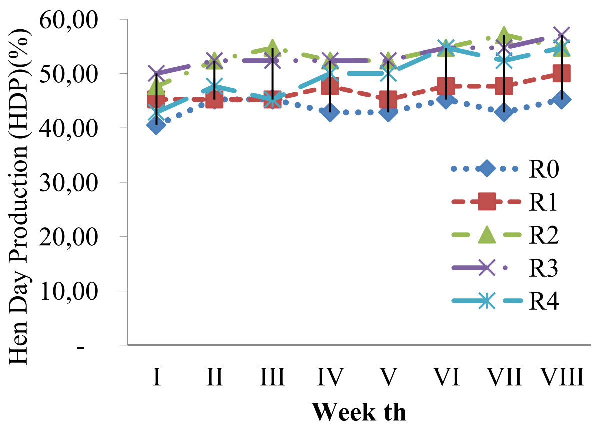

Figure 1. Hen day production of each treatment.

The increase in egg production with 15-22.5% ILF appears also to affect the HDP increase. The HDP increase is significantly affected by daily egg production. It was found that 15-22.5 % ILF addition resulted in the highest HDP (53.27%) (Figure 1.) A 15% ILF addition was found to reach the HDP peak at week VII, while the 22.5% ILF addition reached the HDP peak at week VIII. Regarding the HDP with 30% ILF addition, the egg production peak was noticed in weeks VI and VIII (i.e., 49.70%), higher than 7.5% ILF that reached production peak at week VIII (i.e., 46.73%) and the control ration that reached production peak at week II, III, VI, and VIII (i.e., 43.75%).

Among the factors affecting HDP is the feeding pattern that does not suit the standard needs, which leads to lower nutrition intake and eventually results in lower egg production (Hastuti et al., 2018). Meanwhile, other factors affecting egg production include chicken originality, age, puberty age, chicken weight, *moulting*, environmental factors (e.g., temperature and lighting), feed, and feeding limit (Yuwanta, 2008).

The study showed that the 30% ILF addition resulted in the highest egg weight (i.e., 46.78g/egg). This is higher than in Sartika et al.'s (2013) study, i.e., 36-45g/egg. However, the result is still lower than Muharlien (2010)'s study (i.e., 47.73 -50.59 g/egg). According to Latifah (2007), poultry egg size is heavily affected by the ration's protein and amino acid content. Amrullah (2003) states that metionin is the critical essential amino acid that significantly affects egg weight, considering that more than 50% of the dry egg weight comes from protein.

It is reported that changes in the protein level of a ration during the growth period significantly affect the egg weight, width, and volume Hidayat et al. (2011). In the same vein, Moreki and Gabanakgosi state that the egg weight is mainly affected by the protein content of the ration, genetic and environmental factor, and the chicken weight. Witantri et al. (2013) state that similar protein content of a ration in each treatment do not exhibit a significant difference in egg weight. Another study reports that adding moringa leaves to the ration can increase egg weight and production, thanks to its phytochemical substances such as folate, ascorbic acid, vit. A source, are pyridoxine, riboflavin, nicotinic acid, beta-carotene, calcium, iron, and α-tocopherol.

Egg internal quality

This study found that ILF addition results in a significant difference in internal egg qualities (i.e., yolk weight, albumen weight, yolk index, albumen index, haugh unit, and yolk color) among treatments (Table 4).

The results showed that adding ILF 22.5 - 30% would increase the protein content of the ration (Table 2b), thereby increasing the highest egg yolk weight, white egg index, yolk index and yolk color and significantly different from the control. The weight of the yolk in this study was higher than that of Surajat et al. (2018), who added 15% I. zollingeriana leaf meal to Arabic chicken rations (ie, 13.0 g/egg); Palupy et al. (2015), who added 5.2 -15.6% Indigofera sp. Leaf meal for laying hens (ie, 13.77 – 14.16 g/egg); and Angkow et al. (2017), who added skipjack tuna oil waste (ie, 14.48 – 14.76 g/egg).

Genetic factors and the feed can account for the difference in yolk weight. In this regard, Surajat et al. (2018) state that yolk weight is affected by the feed's essential fatty acid content, as the highest fat deposit is found in egg yolk. Agro et al. (2013) state that fat and protein contents are among the factors affecting yolk weight. A heavier egg indicates a correlation between egg weight and yolk weight (Radi, 1993).

Tugiyanti and Iriyanti (2012) state that yolk weight is affected by ovarian growth, chicken body weight, puberty age, feed quality and quantity, diseases, and feed consumption. The yolk formation process may result in different yolk weights, depending on genetic ability of each animal (Yuwanta, 2010).

As the yolk weight is affected by the egg weight, weightier egg may contain weightier yolk (Triyuanta, 1998). According to Anggorodi (1997), as cited in Purba et al. (2018), linoleic acid is among the factors affecting eggyolk size. According to Stadelman and Cotteril (1995), other factors affecting yolk weight include laying length and age. Agro et al. (2013) state that fatty acid content in yolk (i.e., linoleic, oleic, and stearic acids) may increase the yolk weight.

A 15% ILF addition to the ration contributed to albumen by 23.44 g/egg (51.95%), the highest among other treatments. However, the egg weight percentage in this study was lower than in Darmawan et al. (2016)'s study with 11% *Indigofera* sp. Addition to the ration, resulting in a 53.60% contribution to albumen. In other words, the protein quality of Indigofera sp. Good enough to support the formation of albumen.

Table 4. KUB chicken's average egg internal quality (treated with Indigofera leaf flour)

Parameter	Treatment				
	R0	R1	R2	R3	R4
Yolk weight (g/egg)	14.94^{a}	14.94^{a}	15.83^{ab}	15.89^{b}	17.33^{c}
Albumen weight (g/egg)	21.44^{a}	22.11^{ab}	23.44^{b}	22.17^{ab}	23.28^{b}
Yolk index	0.38^{a}	0.40^{ab}	0.43^{b}	0.43^{b}	0.44^{b}
Albumen index	0.07^{a}	0.08^{ab}	0.08^{ab}	0.09^{b}	0.08^{ab}
Yolk color	8.79^{a}	9.75^{b}	11.17^{c}	$12,88^{d}$	$13,17^{d}$

Description: different letters within a row are significantly different (p<5%). R0= Standard ration formula (Control), R1 = ILF 7.5%, R2= ILF 15 %, R3 = ILF 22.25%, R4= ILF 30%.

Figure 2. The yellow color for each treatment is R1 = control ration formula (basic feed), R2 = basic feed + 7.5% Indigofera leaf meal, R3 = basic feed + 15% indigofera leaf meal, R4 = basic feed + 30% leaf meal indigofera

According to Palupi et al. (2014), the protein quality of Indigofera sp leaf flour can be considered sufficient as its amino acid score is close to that of soybean meal.

This study showed that the 30% ILF addition to the ration results in a yolk index of 0.44, the highest among other treatments. The higher ILF concentration appears to result in a higher yolk index. The yolk index score in this study is similar to that in Rahmawati dan Irawan (2021), i.e., between 0,40 and 0,45 and Lesson and Summer (2005), i.e., between 0.33 and 0.50.

According to Argo et al. (2013), the yolk index is affected by the ration's protein, fat, and essential amino acid contents. The Yolk index represents the freshness quality, measured from the yolk height and diameter (Sudaryani, 2006). Wilson (1975), as cited in Christina *et al*. (2020), states that protein content of the ration affects the egg viscosity, representing its' internal quality and affecting the yolk index.

This study showed that the 22.5% ILF addition to the ration results in an albumen index of 0.09, the highest among other treatments. The albumen index obtained in this study is categorized in grade III quality, within the range of 0.050-0.091 (SNI, 2006). According to Winarno (2002), a fresh egg has an albumen index between 0.050 and 0.174. It is known that higher protein content of the ration may result in higher albumen index (Sudaryani, 2006). In this regard, Yuwanta (2010) states that ovomucin affects albumen, which heavily depends on protein consumption.

This study showed that the 30% ILF addition to the ration results in the yolk color score of 13.17, the highest among other treatments. The higher ILF concentration results in higher yolk color (Figure 7). Beta careotene and xantophyl content of ILF and maize can also account for this.

The yolk color obtained in the present study was higher compared to that in Mariana et al.'s (2017) study (i.e., 12.58 using 15% *I. zollingeriana* leaf flour to layer chicken's ration); Surajat *et al*. (2018)'s study (i.e., 7.38% using 20% *I. zollingeriana* leaf flour addition to 24-26 weeks old arabic chicken). The previous study conducted by Furqan (2012) reports that 22-28 weeks old arabic chickens exhibit a yolk color score of 6.00 - 10.00.

According to Akbarillah et al. (2010), the ration's beta carotene and xantophyl contents may significantly affect the yolk color score. Xantophyl is responsible for the the egg's viscosity (Winarno, 2002). Argo et al. (2013) state that egg yolk color is affected by substances contained in the ration, such as xantophyl, beta carotene, chlorophyll, and chitosan.

Yamamoto et al. (1997) state that feeds containing xantophyl give the yolk a reddish orange. Akbarillah et al. (2010) state that a good quality egg's yolk should have a reddish yellow or orange yolk.

Feed Intake and Conversion

The result showed that ILF addition did not significantly affect the feed intake, yet significantly affect the ration conversion (Table 5). A 7.5% -30% ILF addition to ration did not significantly affect the feed intake. This may occur since the ration was given in limited manner, eliminating chances for chickens to increase their intake. The food intake in this study is not significantly different from Ramadhan et al.'s (2018) study, i.e., 104-106g/hen/day. Lubis, (2018) State that a 1-15% addition of *I. zollingeriana* leaf flour does not significantly affect the laying hen's feed intake.

Table 5. Average feed intake and conversion of KUB chicken treated with Indigofera leaf flour (ILF)

Description	Treatment (g/hen/week)				
	R0	R1	R2	R3	R4
Ration consumption	798.15[a]	796.1[a]	798.73[a]	799.6[a]	799.17[a]
Feed conversion	6.40[a]	5.83[b]	4.94[c]	4.84[c]	5.03[c]

Description: different letters within a row are significantly different (p<5%). R0= Standard ration formula (basic feed), R1 = ILF 7.5%, R2= ILF 15 %, R3 = ILF 22.25%, R4= ILF 30%.

According to Tambunan et al. (2015), the factors affecting feed intake are body weight, temperature, feed palatability, feed energy, physical feed form, production phase, and animal age. In the same vein, Nuraini et al. (2012) Also state that palatability affects animal feed intake. According to Church (1979), feed palatability heavily depends on the ration's aroma, taste, and texture. In this regard, Kamal (1997) asserts that the animal feed intake may determine the animal's appearance, as feed energy contents is likely to affect the feed intake rate.

Feed conversion ratio (FCR) is one of the indicators to see the egg production efficiency. This study showed that the 22.5% ILF addition to the ration results in the most efficient FCR among other treatments. This probably occurs because the ration's nutrient balance matches the chickens' needs. According to Sagala (2009), the feed quality is significantly affected by its nutrient balance, as quality feed may lead to lower feed conversion value.

Meanwhile, the lower feed conversion value indicates that the chicken can process the feed to produce eggs more efficiently (Prawitya et al., 2015). Several factors affect the FCR value, including environmental conditions, feeding management, egg production, and the animal's daily feed intake (Risnajati, 2014). Lesson and Summers (2008) state that FCR value is affected by egg production, egg weight, feed nutrition content, and environmental temperature.

The FCR value of KUB chicken in this study is not significantly different from that of Hidayat et al. (2011),i.e., between 4,85 and 7,29. According to Sartika et al. (201The FCR value of the 4th generation of KUB-2 at the age of 20-24 weeks can be considered high (i.e., 9.0 to 9.4) because its new egg production reaches up to 10%. However, at 25-43 weeks when the egg production returns to normal level, the FCR value is 3.5, lower than that of KUB-1, i.e., 3.8. Wondmeneh et al. (2016) report that the FCR value of Horro chicken (improved breed), commercial ISA brown, Crossbred ISA x Horro, and Ethiopian native chicken during 6 months of egg production is 3.4; 2.4; 3.3, and 7.1, respectively.

CONCLUSION

Adding ILF to the ration significantly increases the production and internal quality of KUB chicken egg, particularly its production, hen day production, egg, albumen, and yolk weights, yolk colour, and feed conversion, yet not significantly affect the feed intake. It is recommended to add ILF to KUB laying hen's ration no more than 22.5%, as the 30% addition resulted in declined egg production.

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