

Utilization of *Indigofera zollingeriana* in layer feed on egg production and quality in Indonesia: A mini review

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ABSTRACT

Indigofera zollingeriana (IZ) is a nutrient-rich plant. It is rich in macronutrients, several minerals, and vitamins. This makes *indigofera* suitable for use as a feed ingredient or supplement for poultry. This review article aimed to collect and provide information on several research findings that use *indigofera* leaf meal as part of poultry feed. The methods used in this review article are literature review and descriptive method, which is a systematic and explicit method to identify, evaluate, and develop research results and ideas generated by researchers. The addition of *indigofera* leaf meal to poultry rations can affect egg production and egg quality. These include the number of eggs, egg weight, yolk weight, albumen weight, eggshell weight, and yolk score. The addition of *indigofera* leaf meal by 2% to 10% in feed can increase feed consumption and egg weight in layer. Several research cases reported that all *indigofera* leaf flour administration had a good effect and could maximize the benefits of *indigofera* leaves as feed, supplements and additives to increase poultry egg production and fertility.

Introduction

The keys to successful poultry farming are breed, feed, and management. These conditions remain problematic for open-housed poultry. Climate change due to global warming presents a challenge to poultry farming. This situation is caused by greenhouse emissions, the production of carbon dioxide (CO₂) and methane (CH₄). The consequences are high fluctuations in rainfall and rising sea levels. These conditions pose challenges to open-housed poultry egg production. Therefore, genetic selection for poultry that is resistant to weather stress is necessary. Closed-house farm management and improved feed quality with extra supplementation.

Efforts to increase egg production and quality can be achieved with high-quality feed. Good-quality feed will impact production because some of the feed's nutrients are used for maintenance/health and meat and bone productivity. The remaining nutrients are then used for reproduction. Low-quality poultry feed will reduce reproductive capacity in laying hens. Quality feed plus additional feed supplements are urgently needed. Poultry supplements should not compete with humans, thus preventing competition between humans and livestock for food and feed.

Supplementation for poultry production has been carried out several times by previous researchers, including using turmeric, ginger, moringa, azzola, aloe vera, lemongrass and onions. The results of the study showed a positive influence on poultry reproductive activity. Another plant with potential as a feed ingredient and poultry feed supplement is *indigofera* leaves. This plant is considered a green contentrate in ruminant feed. This condition is due to the nutrient content contained in *indigofera* leaves which is extraordinary. This plant contains all the micro and macro nutrients found in commercial concentrate feed. Until now, *indigofera* leaves have only been widely used in ruminant livestock. *Indigofera* leaves have potential for use in waterfowl due to their relatively low crude fiber content. The crude fiber content of *indigofera* is only 6-14% depending on

the age of the leaves (Aprillia *et al.*, 2022). This is a positive finding when given to poultry because it can be optimally digested. *Indigofera zollingeriana* also contains high levels of vitamins and minerals to support poultry egg production. *Indigofera zollingeriana* has a complete amino acid content, including histidine (0.67%); threonine (1.14%); arginine (1.67%); tyrosine (1.05%); methionine (0.43%); valine (1.56%); phenylalanine (1.60%); isoleucine (1.35%); leucine (2.26%); and lysine (1.57%). (Palupi *et al.*, 2014a).

Criteria for included research articles

The journals used as references in this article review are experiments on the addition of *indigofera* leaves in poultry feed to increase egg production and quality. The experimental journals used are those that have been published in journals with last fifteen years. To obtain these journals, the research was conducted using Science Direct and Google Scholar. National and international research articles were selected based on topics that might support the current article. The experimental journals used only match the topics discussed in this article, such as feed consumption, egg production, egg weight, feed conversion, shell thickness, yolk index, egg index, and egg fertility.

Indigofera content

Indigofera zollingeriana is a perennial shrub or small tree. It can grow up to 12 m tall and it's native from tropical regions of Asia (Cook *et al.*, 2020). The dry matter production of IZ leaves cut at 60 days old with a cutting height of 1.0 m was 31.2 tons/ha/year, which was the highest production compared to older or younger cutting ages (Tarigan *et al.*, 2010). The results of the tannin analysis in the study showed that IZ top leaf meal contained 0.29%. The tolerance limit for tannin in chicken rations is 2.6 g/kg (Kumar *et al.*, 2005). The results of the analysis of the saponin

content of IZ top leaf meal in the study were 0.036 ppm. The tolerance limit for saponins in chicken rations is 0.37%, which is equivalent to 3.7 g/kg of ration (Brugaletta *et al.*, 2020). The anti-nutrient content is lower when compared to other types of legumes such as *Moringa oleifera* leaves which have a tannin content of 0.3% and saponin of 6.4% (Astuti *et al.*, 2005). Therefore, IZ top leaf is non-toxic and can be used as a feed ingredient in poultry rations. *Indigofera zollingeriana* is a type of legume with significant potential as an alternative protein source to complement other feed ingredients in efforts to develop poultry production (Palupi *et al.*, 2014b).

Indigofera zollingeriana has excellent nutritional value as a leaf crop. Its nutrient content even better than Indonesian National Standard (SNI) for feed requirements for layer in Indonesia. The IZ nutrient content of IZ according to research by Akbarillah *et al.* (2017) and Aprillia *et al.* (2022) when compared to the nutritional requirements according to SNI for laying ducks, laying hens and broiler chickens in Indonesia. Water content 12.00%, crude protein 27.08, crude fat 5.94%, crude fiber 6.61, Ash 12.22, calcium 1.78-2.04, posphor 0.34-0.46, lysine 1.75% and methionin 0.43%.

The vitamin and mineral content of IZ shows excellent results. According to Palupi *et al.* (2014a) and Alagbe (2020) as shown in Table 1. The mineral content of IZ is presented in Table 2 according to Ernawati *et al.* (2021) Previous researchers have conducted extensive research into the nutrient, vitamin, and mineral content of IZ. All findings demonstrate excellent data for IZ's use in feed. *Indigofera zollingeriana* is used as both a feed ingredient and a supplement for poultry in Indonesia. The search for plants suitable for poultry feed has been hampered by anti-nutritional compounds and high crude fiber content. These issues can be addressed with IZ leaves.

Table 1. Vitamin content of *Indigofera zollingeriana** and *Indigoera tinctoria***.

Parameter	<i>Indigofera zollingeriana</i> top leaf meal
Vitamin A*	3828,79 IU/100 g
Vitamin D*	42.46 mcg/100 g
Vitamin K*	1.149 ppm
Vitamin E (α -tokoperol) *	0.15 mg/100 g
B-carotene*	0.50 mg/100 g
	<i>Indigofera zollingeriana</i> leaf meal (mg/100g)
B-carotene**	8.45 $\pm$ 0,44
Vitamin B1 (Thiamine) **	1.94 $\pm$ 0,00
Vitamin B2 (Riboflavin) **	0.71 $\pm$ 0,01
Vitamin B3 (Niacin) **	0.66 $\pm$ 0,02
Vitamin B6 (Pyridoxine) **	0.32 $\pm$ 0,00
Vitamin B7 (Biotin) **	0.63 $\pm$ 0,01
Vitamin B9 (Folic acid) **	0.26 $\pm$ 0,04
Vitamin B12 (Cyanocabalamine) **	0.21 $\pm$ 0,00
Vitamin C (Ascorbic acid) **	14.0 $\pm$ 1,22

Use of indigofera in layer feed

Indigofera zollingeriana leaves have a high protein content. The leaves contain complete amino acids such as histidine (0.67%); threonine (1.14%); arginine (1.67%); tyrosine (1.05%); methionine (0.43%); valine (1.56%); phenylalanine (1.60%); isoleucine (1.35%); leucine (2.26%); lysine (1.57%) (Palupi *et al.*, 2014). The crude fiber content of IZ leaves is quite low if the leaves are selected at the right age. The crude fiber was around 6-16%. The calcium content of IZ leaves is four times that of *Moringa oelifera* (MO) leaves. The magnesium content of IZ is twice that of *Moringa oelifera*. The β -carotene content is so high that it can influence the color of egg yolks to become more orange.

Supplementation of fresh IZ leaves as a feed additive to KUB chickens

Table 2. Mineral content of *Indigofera* according to Ernawati, *et al.* (2021).

Macro Mineral	Contents (% BK)
Calsium (Ca)	0.80 $\pm$ 0,04
Phosphore (P)	0.25 $\pm$ 0,04
Kalium (K)	0.39 $\pm$ 0,06
Natrium (Na)	0.15 $\pm$ 0,02
Magnesium Mg)	0.47 $\pm$ 0,04
Micro Mineral	Contens (mg/ Kg BK)
Manganese (Mn)	395.88 $\pm$ 21,25
Zink (Zn)	16.97 $\pm$ 1,30
Copper (Cu)	22.52 $\pm$ 0,86
Iron (Fe)	129.36 $\pm$ 11,59
Chromium (Cr)	14.28 $\pm$ 0,27

(Table 3) significantly affected egg production and yolk score ($P < 0.05$). The addition of IZ flour did not significantly affect egg weight ($P > 0.05$). According to Kustiningsih and Retnawati (2020), Chicken egg production is greatly influenced by the protein and phosphorus content of the feed. Differences in feed protein content affect egg production. Feeds containing high protein will produce higher egg production due to the more complete amino acid content than feeds with lower protein. The color score of chicken egg yolk increases due to the effect of beta carotene which increases as the level of IZ leaves increases. Egg weights did not different significantly, thats meaning that providing fresh IZ leaves can maintain the amino acid content in the feed, especially the amino acids methionine and lysine, thus maintaining normal egg weight (Palupi *et al.*, 2014)

The utilization of fresh IZ leaves with levels T0= 0%, T1= 5%, T2= 10% and T3= 15% in the feed of Laying Ducks (*Anas platyrhynchos*) was significantly different ($P < 0.05$) in the parameters of feed consumption, egg production, egg weight and yolk color score. The highest feed consumption was at level 0%. The use of fresh IZ leaves tended to reduce total feed consumption, this is suspected because the use of fresh IZ leaves is bulky so that feed consumption significantly decreased from the control (Akbarillah *et al.*, 2010). Duck egg production peaked at the 10% level. Egg production trended upwards from 0% to 10%. Egg production declined at the 15% level. The decline in egg production at the 15% level was due to lower feed consumption compared to lower levels. Reduced nutrient intake due to decreased consumption will affect the raw materials for egg production within the duck's reproductive tract. High consumption is followed by high egg weights. Consequently, feed conversion will decrease. The best feed conversion was at the 10% level at 3.61, compared to the 15% level at 6.93. Consumption of IZ leaves, accompanied by high levels of β -carotene, resulted in a significantly different egg yolk color when given IZ leaves compared to the 0% level.

Further research on laying ducks with supplementation levels of T0= 0%, T1= 1%, T2= 2%, T3= 3% and T4= 4% in laying ducks found that supplementation of IZ top leaf meal up to 4% in the ration can improve egg yolk color, reduce the inhibition rate, increase egg β -carotene. Supplementation of IZ leaf flour increased the egg yolk color score of T1 (66.67%), T2 (70.00%), T3 (83.33%) and (T4) 76.67% compared to the control. This is due to the increased consumption of β -carotene derived from IZ leaf shoot flour 0.80 mg in T1 increased to 3.16 mg in T4 (Palupi *et al.*, 2014). Carotenoids are pigments widely known for their colors, particularly yellow, orange, and red. These pigments are absorbed in the chicken's digestive tract and stored in the egg yolk. The concentration of carotenoids in the yolk reflects the bird's diet (Nys and Guyot, 2011).

Supplementation of IZ leaf shoot meal in two different studies of laying hens aged 18-23 weeks vs. 32 weeks using IZ leaf shoot meal at up to 5% level did not significantly differ ($P > 0.05$) in feed consumption in the form of leaf meal. The results of the study had a significant effect ($P < 0.05$) on egg production, yolk color, egg weight, shell weight, shell

Table 3. Research on the use of IZ leaf meal in layer feed.

Sample	Parameter	Result	Reference
Free-range Laying Chicken	Egg Production Yolk color Egg weight	Supplementation of 10% fresh IZ leaves in the ration increased egg production and yolk color but had no effect on egg weight.	(Kustiningsih & Retnawati, 2020)
Laying duck	Feed intake Egg production Egg weight Feed conversion Yolk color	The use of fresh IZ leaves at 0%, 5%, 10%, and 15% in the basal ration affected parameters. Treatment up to the 10% level increased production, egg weight, feed conversion, and yolk color. Treatment at 15% tended to decrease production and egg weight.	(Akbarillah, <i>et al.</i> , 2010)
Laying Duck	Yolk color Inhibisi rate β -karoten contain	Supplementation of IZ meal shoot flour up to 4% in the ration can increase egg yolk color, decrease inhibition rate, increase egg β -carotene contain.	(Palupi, <i>et al.</i> , 2018)
Laying Hen	Egg weight Shell weight Shell thickness Albumen weight Yolk weight Yolk color	Supplementation of IZ leaf meal at 0%, 2%, 5% and 7.5% showed that the use of IZ leaf flour increased all egg quality parameters and the use of 5% was the best parameter in the study.	(Ivonne, <i>et al.</i> , 2023)
Laying Hen	Feed intake Egg production Feed conversion Yolk color β -karoten contain Cholesterol	The use of IZ leaf meal at 0%, 2.5% and 5% in young layer chickens did not affect feed intake and conversion but had an effect on increasing egg production, yolk color, beta carotene content and reducing cholesterol at a level of 5%.	(Sukarini, <i>et al.</i> , 2023)
Laying Quail	Sex maturity Number of follicles Fertility Hatchability	The use of IZ top leaf meal at 0%, 6%, 12%, and 18% levels showed no effect on age at sexual maturity, follicle count, fertility, and egg hatchability. The 6% level was the most optimal.	(Arum, <i>et al.</i> , 2017)
Laying Quail	Feed intake Egg production Egg weight Shell thickness Yolk color	The use of IZ leaf meal at 0%, 7.5%, 15%, and 22.5% showed no effect on egg consumption, production, and weight, but increased shell thickness and yolk color.	(Zakariya, <i>et al.</i> , 2024)

thickness, albumen weight, yolk weight and beta-carotene content and were able to reduce egg cholesterol. Numerically, the 5% level was better than 2.5% or 7.5% of IZ leaf shoot meal administration. This means that consumption of IZ leaf shoot meal supplements is better given in the form of dry powder compared to wet leaves (Sukarini *et al.*, 2023). Feed consumption was not significantly different, possibly due to the dry feed provided. IZ leaf shoot powder production was more acceptable to layer hens because the SK content in IZ leaf shoots was <10%. According to (Akbarillah *et al.*, 2010) IZ top leaf has a SK content of 6.61%. This is what causes the effect of chickens consuming a balanced feed like basal feed. Shell weight and thickness are influenced by the calcium (Ca) and phosphorus (P) content of IZ leaf flour. According to Ernawati *et al.* (2021), indigofera leaves contain 0.25 ± 0.04 phosphorus and 0.80 ± 0.04 calcium. Carbonate ions and Ca ions are needed for the formation of CaCO_3 eggshells, the Ca and P content in IZ leaf meal affects eggshell quality. Egg yolk cholesterol has a decreasing trend in line with the increase in the use of IZ top leaf meal. This is possible because the antioxidant content in the feed increases with the increase in the level of IZ top leaf meal in the feed ratio. According to Atma and Kurnia (2021), It is known that IZ leaf flour contains active substances in the form of antioxidants that can play a role in controlling cholesterol in egg yolks. Antioxidants (such as vitamin E, vitamin C, flavonoids, and carotenoids) protect the liver from oxidative stress. This results in reduced endogenous cholesterol production, including that accumulated in egg yolks. Antioxidants help maintain healthy ovaries and oocytes (immature eggs), thus making lipid synthesis in egg yolks more efficient and healthier.

The use of IZ leaf meal in quail feed at levels T0= 0%, T1= 7.5%, T2= 15%, T3= 22.5% did not affect consumption, production, or egg weight, but did increase shell thickness and yolk color scores. Similar to research on ducks and chickens, IZ leaves consistently increased shell thickness and yolk color scores. This means that the calcium and phosphorus in IZ leaves can clearly help increase shell The increase in yolk color is due to

the β -carotene in IZ leaves, which increases the carotenoids in the yolk. On the other hand, providing IZ flour to quail has the same effect on feed consumption and quail egg production. This means that IZ leaves can maintain their function in the feed so that consumption and egg production are equivalent to the basal feed in quail. Another study on quail reproduction with IZ leaf flour levels of T0= 0%, T1= 6%, T2= 12%, T3= 18% showed that the treatment had no effect on age at sexual maturity, number of follicles, fertility, and egg hatchability. Numerically, the 6% level is the most optimal. The nature of fibrous feed is bulky so there is a tendency for very short transit times and an impact on reduced nutrient absorption (including fat and its components, including cholesterol). The estrogen hormone is synthesized from cholesterol, primarily in the ovaries and other glands, such as the adrenal cortex, testes, and placenta (Arum *et al.*, 2017). The result of study by Palupi *et al.* (2014) stated that the addition of indigofera leaf shoot flour had a very significant effect ($P < 0.01$) in reducing egg cholesterol levels in laying hens. One of the roles of cholesterol is to be the main one in the biosynthesis of steroid hormones, including estrogen, progesterone, and testosterone, all of which play a role in FSH regulation through a feedback mechanism. The impact of inhibited cholesterol absorption results in the inhibition of the anterior pituitary in synthesizing the FSH hormone for follicle formation in the ovaries. As a result, the hormone estrogen will be inhibited, ultimately affecting the age of sexual maturity.

Conclusion

Based on research conducted on the effects of adding IZ leaves to laying hen feed, it can be concluded that IZ leaves have potential as a feed ingredient and supplement that can increase poultry production and egg quality. The nutritional content of IZ leaves, such as amino acids, beta-carotene, calcium, and phosphorus, makes them a good choice as a feed supplement. IZ leaves can maintain fertility and hatchability in poul-

try. *Indigofera zollingeriana* top leaf are better used in layer feed than old leaves.

Future Research Recommendation

To unlock the potential of IZ leaves meal in poultry feed, future research should focus on the following:

Find the age and position of IZ leaves on the tree with the most suitable content for poultry.

Dose-response testing in various poultry species (broiler breeders, laying breeders, and native breeds) to determine optimal levels.

Comparative evaluation with other natural feed supplements (e.g., *Moringa oelifera*, *Leucaena luschepala*, *Azolla pinata*, *Glirichida sepium*, *Calianandra callothyrsus*, *Sesbania grandiflora*, *Mucuna pruriens*) to identify synergistic or complementary effects.

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Conflict of interest

The author declares that there is no conflict of interest.

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