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REVIEW ARTICLE

A Review: The Utilization of Indigofera Zollingeriana as Animal Feed Additional Supplements

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ABSTRACT - This review explores the possibility of Indigofera Zollingeriana as an animal feed supplement. With the increasing price of the ingredients for animal feed, we need to find alternative food source for the livestock. It examines the environmental and economic considerations of cultivating this plant specifically for animal consumption. Additionally, the review delves into the potential nutritional value of Indigofera Zollingeriana, assessing its suitability as a feed supplement to enhance animal health and productivity. The core focus lies in determining the feasibility of incorporating Indigofera Zollingeriana into animal feed production systems in a way that is both environmentally responsible and economically viable. By evaluating its potential as a sustainable feed source, this review contributes to the ongoing search for innovative and eco-friendly solutions to meet the growing demand for animal feed to solve the food security issues.

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1. INTRODUCTION

A plant belonging to the family Fabaceae, the genus Indigofera contains 700 species that are distributed throughout Africa, Asia, Australia, and North America. The indigofera species is very promising as a ruminant forage [1]. A relatively recent tree legume species to be realize as a potential animal feed supplements in Indonesia is called Indigofera zollingeriana (IZ) [2]**.** The genus Indigofera belongs to the Fabaceae family, which was formerly known as Leguminosae. The Fabaceae family has three sub-families: Mimosoideae, Faboideae, and Caesalpinioideae. It is found in tropical and subtropical regions of the world [3]**.**This indigofera plant can withstand acidic soils, dry seasons, floods, and salinity. Indigofera is a good plant to grow in Indonesia, Malaysia and other tropical countries [4]. Indigofera zollingeriana grows quickly, is tolerant of poor soil conditions, responds well to fertiliser, and requires little upkeep [1], [2], [5].

In addition to having good growth, high production, and nutritional value, IZ is a highly potent and high-quality forage. Eight months is when IZ can be harvested; its mean wet biomass total production is roughly 53 tons/ha/harvest, and its herbage's protein content is 29.56% [5]. About 65 chemical compounds, including alkaloids, steroids, fatty acids with amino groups, lignin and cellulose contents, utilisable fibre (NDF and ADF), high dry matter digestibility, and flavonoids glycosides are present in this plant [6]. There have been reports of using indigofera as a source for forage crops, natural dyes, cosmetics, and medications [4]. By considering the above, this paper focusing on the the utilization of the IZ for the livestock and determine its sustainability, as prove by the research, for the production of animal feed.

2. INDIGOFERA NUTRIONAL PROFILE

The proximate analysis of Indigofera zollingeriana (Table 1) showed that the plant parts have a significant impact on the nutritional value. In Indonesia, the soil fertility might be important. The dry matter content of the plant was comparatively high overall. The inclusion of the stem and branches in the sample is most likely what caused this. The stem itself contains >90% DM, with the exception of samples collected in East Java, which had a slightly lower Dry Matter (DM) content. Whole plant samples also have comparatively high ash contents. The amount of ash in the stems and leaves was comparable. Samples collected in East Java had a low ash content which are 3%, 9% & 10%, which contributed to their high variety. IZ has a 30% Crude Protein (CP) content on a DM basis. Some areas have over thirty percent of CP contain in plant was present in the samples in Table 1. There was minimal variation in IZ's crude fibre content. Regardless of the plant parts utilised, the percentage of Crude Fibre (CF) varied between 12 and 16%. The reason for this was that the samples were taken at comparatively particular stages of maturation.The difference is probably due to the age at which the tree legumes were harvested. Because of its low CF content, the legume is expected to have a high DM digestibility. Therefore, IZ could replace concentrate feed in the diet. IZ exhibited a high content of total digestible nutrients (TDN) (>69%) in every part of the plants. This is necessary for raising animals for meat or milk production. IZ

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exhibited a variation in neutral detergent fibre (NDF) content based on the sampling location. The NDF content of the South Kalimantan samples, which came from IZ trees planted in peatlands with extremely acidic soil, was 36-38% [7].

Every IZ seedpod contains five to seven tiny, highly dormant seeds. As time goes on, these seeds become more and more dormant, until just 28–35% of the seeds remain viable after two months of storage [8]. As a ground cover plant, IZ can stop the movement of organic matter and the loss of nutrients on the surface of the soil [9]. [6] reported the top leaf meal of IZ contain 28.98% crude protein, 3.30% crude fat, 8.49% crude fiber, 0.52% calcium and 0.34% phosphorus while [5] stated that leaf flour of IZ contained crude protein 27,89%, Ether extract (EE) 3,70% and CF as much as 14,96%. Leaf flour Indigofera sp. contained crude protein 27.9%, crude fiber 15.25%, Ca 0.22%, and P 0.18% as reported by [1]. The best way to increase Indigofera forage production is to increase the number of plants. Narrow row spacing increased β-carotene and NDF but did not harm fodder output and nutritional value, such as crude protein, crude fat, crude fibre, ADF, and TDN [10].

Table 1. The nutritive contents of Indigofera zollingeriana (as per cent of DM except for DM which is on air'dry basis)

Samples	Topography	Provinces	DM	Ash	CP	EE	CF	TDN	NDF	ADF
Leaves	Wet	S. Kalimantan*	89	10	29	3	15	70	38	29
Leaves	Dry	S. Kalimantan*	90	9	30	3	12	69	36	25
Stems	Upland	East Java**	92	10	31	3	14	72	31	27
Leaves	Upland	East Java**	91	9	29	3	13	71	36	25
Whole Plant	Low Land	North Sumatera*	92	9	30	4	13	72	31	39
Whole Plant	Middle Land	North Sumatera*	94	11	33	2	15	69	33	29
Whole Plant	Upland	North Sumatera*	93	11	34	3	13	70	33	29
Leaves	Low Land	East Java**	88	3	30	0.6	14	72	34	30
Stems	Low Land	East Java**	88	3	28	1	16	69	32	27

Figure 1. Indigofera Zollingeriana

3. INDIGOFERA ZOLLINGERIANA AS VALUABLE NUTRITIONAL ANIMAL FEED

3.1 For Ruminant

There is only one published report [7] that includes data on the effects of feeding IZ to cattle that has been statistically analysed and includes responses from herbivores to its inclusion in the diet. Twelve castrated male cattle were used in a small study in south Sulawesi, where growth rates of 0.36 kg per day were supported by an elephant grass basal diet of 65 g CP/kg DM. The growth rate was increased by approximately 30% when IZ was substituted for grass in the diet at 40 or 60% (DM basis). Goat feeding studies are used to further assess the feeding value of IZ in the absence of additional reports pertaining to cattle. Growth rate increased in goat diets where IZ gradually replaced low-quality tropical grass (65–81 g CP/ kg DM), but responses seemed to peak at roughly 30–40% legume inclusion (DM basis) in the diet. Goat feeding studies served as the foundation for IZ.

[7] found no differences in the growth rates of male Boerka goats when IZ was substituted for 25, 50, or 75% of Ottochloa nodusa (slender panicgrass; 93 g CP/kg DM) in the basal diet. Since the total feed offered to all groups was limited to approximately 3.5% BW/day DM (based on average BW), it's possible that this limited the expression of intake and weight gain differences between diets. However, DM intakes did not differ between treatments (mean 3.1% BW/day). Further tests have demonstrated that IZ can substitute concentrate in goat rations, at least in part. When IZ -prepared

wafers were added to a mixed soybean husk-commercial concentrate diet (35:65, DM basis; 129 g CP/kg DM), the growth rate of the female Etawah × Kacang goats increased from 47 g/day to 73 g/day [7]. The total CP concentration (144 g/kg DM) was barely affected. When L. leucocephala or C. calothyrsus wafers were prepared to present similar total diet CP concentration, their growth responses were similar. As would be expected, goats fed the high-protein concentrate showed higher rumen ammonia-N concentration and N retention than goats fed the high-carbohydrate concentrate. The goats were able to absorb and make use of the extra nitrogen from the higher protein diet because the energy in the soybean meal may have broken down in the rumen more easily than that in maize. To better absorb excess nitrogen from legumes like IZ, a highly fermentable energy source like cassava might be more appropriate.

According to research [11], the availability of macrominerals (Ca, P, Mg, and S) in elephant grass-based rations was found to be optimal when IZ was used as a concentrate substitute in kacang goats. Twelve kacang goats, weighing between eleven and twelve kilogrammes, were examined in this study. Three treatments and four replications were included in the completely randomised design (CRD) experiment that was used to gather the data. P1 consisted of 60% elephant grass plus 30% concentrates plus 10% IZ; P2 consisted of 60% elephant grass plus 20% concentrates plus 20% IZ; and P3 consisted of 60% elephant grass plus 10% concentrates plus 30% IZ. According to the study's findings, replacing concentrate with 30% IZ may improve the availability of minerals like calcium (Ca) and phosphorus (P), but it won't have an impact on the availability of minerals like magnesium (Mg) and sulphur (S).

The Pure IZ Feed (PIF) was found to have higher DM digestibility (17 to 73%), feed efficiency (8 to 17%), protein use efficiency (1 to 2.5%), average milk production (121 to 383 mL/day), lower feed costs (USD 0.10 to 0.39), and feed conversion values when used in rations compared to commercial concentrate [12]. According to his research, the k-value showed a significant decline in the daily milk production of the does fed the commercial feed. When commercial feed was fed to Saanen goats, their milk production drastically decreased. Towards the end of the lactation period, both groups of goats' daily milk production stabilised when PIF was added to the ration. The Saanen goats appeared to respond more to PIF in the ration than the EC does, based on feed DM digestibility, feed, and protein use efficiency. In a study, goat milk production, feed efficiency, and nutritional efficiency all rose by roughly 26%, 15–23%, and 5-9%, respectively, when pure pelletized IZ leaves were used [13].

According to [14], the results of controlling of 60% basal feed (20% corn straw, 20% gamal leaves, and 20% Panicum maximum) and 40% IZ could improve the goat's performance. The researchers evaluated the potential and basal feed introduction (corn stover, gliricidia leaves, Panicum maximum) with the inclusion of IZ. [14] conducted an analysis and discovered that the treatment had a significant ($p<0.05$) impact on DWG, with mean daily weight gain (DWG) ranging from 33.28 to 65.62 g/day. The P1 treatment (basal 60% + 40% IZ) differed significantly from the P2 and P3 treatments (basal 70% + 30% IZ and basal 80% + 20% IZ), according to post hoc analysis. An ANOVA test revealed a significant ($p<0.05$) effect of the treatment on feed efficiency. The P1 treatment was significantly ($p<0.05$) higher than the P2 and P3 treatments, according to post hoc analysis. The range of mean feed efficiency was 0.12 to 0.17%. Ruminant self-sufficiency remains below thirty per cent because of high local ruminant demand. For catering the Malaysia's half of the local market's demands, livestock production need to be increase [15].

3.2 For poultry- Native Chicken

According to studies on feed consumption conducted during the study [16], the average consumption of native chickens during the rearing phase was used. Treatment P0 (control group) had a higher feed consumption rate during the starter phase of native chicken (18.32 grams/bird/day) compared to treatments P1 (5% IZ & 25% BSF) and P2 (10% IZ & 20% BSF). That is, 13.11 and 11.41 grammes per bird per day. Subsequent experiments revealed feed consumption during the initial phase; specifically, P0 Vs P1 and P2 and P1 Vs P2 both demonstrated a significant effect. This occurred as a result of the presence of BSF mangosteen and IZ syn. in the P1 and P2 feed, which had higher crude fibre contents than the P0 treatment (control feed). Many nutrients are transferred to faces or excreta as a result of the digestive tract's shorter digestion period resulting from a higher crude fibre content. This is consistent with the findings of [17], who observed that feed high in crude fibre inhibits chicks from utilising nutritious feed appropriately and that crude fibre that hasn't been digested will transfer nutrients out of the body with excrement or faeces. High crude fibre feeds are difficult to fully digest and result in a full fast cache, which limits the amount of feed that can be consumed. Because crude fibre is bulky and expands when exposed to water, the high content of crude fibre in the ration will cause the chickens to feel fuller faster [18]. Because BSF flour has a high fibre content, feed may become clumped. As a result, birds quickly reach fullness and consume less food [19].

3.3 For poultry- Quail

The study by [20] examined the effects on Japanese quail egg quality of replacing soybean meal (SBM) in the diet with IZ top leaf meal (ILM). There were four replications (ten quails in each replication) and five treatments in this fully randomised experiment. Five combinations of SBM and ILM were present in the dietary treatment: R0 = diets with 18% SBM and no ILM; R1 = diets with 16.2% SBM and 2.66% ILM; R2 = diets with 14.4% SBM and 5.32% ILM; R3 = diets with 12.6% SBM and 7.98% ILM; R4 = diets with 9% SBM and 13.3% ILM. According to [20], using 13.3% ILM (R4) increased feed consumption, reduced malondialdehyde levels, and improved egg weight, yolk colour score, and cholesterol significantly ($P<0.05$). Egg weight and yolk colour score were significantly ($P<0.05$) increased when 13.3% (R4) ILM was substituted for soybean meal. The study's average egg weight ranged from 8.73 to 9.32 g, and the findings were within the typical 6–16 g range[20]. The amount of protein in the form of amino acids affects egg size. Nevertheless, the albumen, eggshell, haugh unit, or egg shape of quail eggs were unaffected by the inclusion of ILM in their diet. The width to length ratio of an entire egg determines its shape.

3.4 For poultry- Ducks

A study conducted in ducks by lowering plasma triglycerides, LDL, and cholesterol and raising plasma HDL, feeding IZ leaf meal at a rate of 5.5% and Sardinella Lemuru fish oil at a rate of 2% can help lay ducks maintain the balance of their blood lipid profiles. This is important because it helps the laying ducks of Magelang produce eggs and meat that are low in cholesterol [21]. The other study for Pegagan ducks' states that outcomes shown that adding top leaf meal from IZ to diets could enhance egg quality and provide antioxidants. The study conducted by [22] indicated that Pegagan duck slaughter weight, carcass percentage, and commercial carcass slices percentage were not adversely affected by the addition of up to 4% of IZ top leaf meal to diets. When 4% of IZ top leaf meal is added to rations, it can improve yolk colour by 43.40%, lower inhibition rate by 11.38%, raise β-carotene content by 75.23%, and keep cholesterol levels within normal ranges [23]. While in other study found that adding 6% of IZ leaf extract to drinking water can enhance the chemical quality of male Bali duck meat that has been stored for two to eight weeks [24].

4.0 FUTURE RESEARCH

Future research in Malaysia and other tropical nations, IZ may contribute to increased animal feed productivity. Malaysia has got to increase its livestock production to at least 50% of the local product market in order to get ready for the coming industrial revolution [25]. This review evaluated IZ's potential for use as a premium fodder for poultry in Malaysia, as well as how well-suited it is to the country's diverse growing conditions and what nutritional benefits it can provide to poultry over other forage tree legumes (FTL), which are already well-established in agro-ecological production systems there. When growing in ideal conditions, IZ yields an exceptionally high number of leaves and other edible components. However, it can also thrive and produce in less-than-ideal conditions, such as saline conditions, drought stress, and, most importantly, acidic soils [7]. It is more suited to these soils than other FTLs currently in use in the nation, IZ may occupy a significant ecological niche in Indonesia, where Al-toxic acidic soils make up a sizable portion of the entire landscape.

5.0 CONCLUSION

It is concluded that the result of studies that IZ plant is a potential protein and nutritional source for livestock animals. Its uses are widely range of animal which included poultry such as broiler, native chicken (Ayam Kampung), and quails, and ruminant such as goat and cattle. It is also recommended to process these plants to be infused in the animal feed pellets to enhanced the nutritional content for the livestock. Current and future research should tackle IZ plant risks on production and processing.

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DATA AVAILABILITY STATEMENT

The data used to support the findings of this study are included within the article.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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