Research Article

The Effect of Including Indigofera (*Indigofera zollingeriana*) Leaf Meal in the Ration on the Productivity of Growing Male Rabbits

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Abstract | The increasing price of soybean meal (SBM) has driven the search for new protein sources for feed ingredients. This study aimed to evaluate the effects of dietary inclusion of Indigofera leaf meal (ILM) on the performance, diet digestibility, and feed efficiency of growing male rabbits. A total of 28 New Zealand White (NZW) male rabbits, aged 9–10 weeks (body weight = 1.45 ± 0.45 kg), were used in a completely randomized design. The rabbits were divided into four treatment groups (seven replications per treatment): basal feed (T0), and basal feed with 4% (T1), 8% (T2), and 12% (T3) ILM inclusion. As the level of ILM inclusion increased, the level of SBM in the ration decreased accordingly. The results indicated that nutrient intakes were not significantly different among treatments ($p > 0.05$), and ILM inclusion did not affect nutrient digestibility ($p > 0.05$), retained nutrients, growth performance, or feed efficiency ($p > 0.05$). In conclusion, the inclusion of ILM up to 12% in the ration did not negatively affect the productivity of growing NZW rabbits. Therefore, ILM can be considered a viable protein source to replace SBM in the ration for growing NZW rabbits.

Keywords | Feed, Inclusion, Indigofera, Productivity, Rabbit

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INTRODUCTION

Corn and soybean meal (SBM) are the most common primary feedstuffs used in rabbit diets. These ingredients have a high commercial value and can significantly impact the economic viability of production (Gidenne et al., 2017). However, livestock growth performance is influenced by the nutrients in feed intake (Migdal et al., 2019; Luthfi et al., 2022). The high cost of conventional feed ingredients has necessitated the exploration of alternative feedstuffs to reduce feed costs and promote ecological sustainability (Yang et al., 2021; Besharati et al., 2021).

Indigofera (*Indigofera zollingeriana*) is important pasture legumes and has high-quality nutrients (Schrire, 2013). The indigo leaf contains 24.17% crude protein (CP) and 75.47% total digestible nutrients (Evitayani et al., 2021), 2.4% ether extract (EE), 19.0% crude fibre (Cfi) and 36.6% carbohydrate (Alagbe, 2020) as well as condensed tannins, saponins and flavonoids (Bhatta et al., 2013; Muda et al., 2021). In addition, Indigofera has unique qualities that make it a safe feed ingredient. It contains antioxidant and anti-inflammatory properties, which can enhance the growth performance of animals (Kumar et al., 2013; Elmi et al., 2018; Karakousi et al., 2020; Gunun et al., 2022).

Based on these properties, Indigofera is a suitable and effective feed substitute.

Several studies have found that Indigofera could be used to be fed for animal (Evitayani et al., 2021; Muda et al., 2021; Gunun et al., 2022). A previous study by Evitayani et al. (2021) showed that the use of 30% *Indigofera zollingeriana* as a substitute for concentrate in the diet of the Etawa goat giving the highest digestibility value of the fibre fractions. The result of Gunun et al. (2022) showed that the inclusion of indigo waste at 10% in a concentrate diet did not have a negative effect on feed intake, nutrient digestibility, rumen fermentation, haematology, immune function or growth performance in growing beef cattle. Despite the benefits, there is limited information regarding utilisation of ILM in rabbits' diets. Therefore, this study aimed to evaluate the effects of dietary inclusion of ILM for male growing rabbits on performance, diet digestibility and feed efficiency.

MATERIALS AND METHODS

Animals and diet

The rearing and handling of livestock in this study has followed the procedures listed in the standard procedures of rearing and treating of farm animals stated in the law of the Republic of Indonesia (Number 18 of 2009, Animals' husbandry and health laws).

This study used 28 New Zealand white (NZW) male rabbit aged 9–10 weeks (body weight (BW) = 1.45 ± 0.45 kg; CV = 9.79%). This study was conducted using a completely randomised design. The animals were divided into four experimental groups, each with seven replications: basal feed (T0), and basal feed with ILM included at 4% (T1), 8% (T2), and 12% (T3). In this experiment, as the level of ILM inclusion in the ration increased, the level of SBM was reduced by the same ratio (Table 1). The animals were individually housed in similar digestibility cages (wire mesh with bamboo slats, 40 × 60 × 40 cm). All animals were kept under the same environmental conditions throughout the experimental period.

The feed consisted of rice bran, corn, coffee peal, wheat and pollard, coconut meal, molasses, mineral, salt, SBM, ILM and *Synedrella nodiflora*. The ILM was obtained from local farm in Salatiga regency. The ration contained about 16% CP (iso-protein) and was given in pellet form. Table 1 presents the composition and chemical analysis of the ration.

The *Synedrella nodiflora* contained 36.60% dry matter (DM), 14.70% ash, 16.35% CP, 2.38% EE and 14.40% CFi. The pellets were administered at a rate of 125 g per day, split into two feedings at 7:30 am and 4:00 pm. *Synedrella nodiflora* was provided at 10 g per day, once at 4:00 pm, with any remaining amount recorded the following day. Water was available at all times through an automatic nipple drinker.

Table 1: The composition and chemical analysis of the ration (Sutaryo *et al*., 2022).

Feed stuff	Composition (%)			
	T0	T1	T2	T3
Rice bran	30	25	25	20
Corn	20	20	20	17
Soybean meal	20	16	12	8
Indigofera leaf meal	0	4	8	12
Coffee peal	17	5	2	1
Pollard	5	15	11	15
Coconut meal	1	12	19	24
Molasses	1	1	1	1
Salt	1	1	1	1
Minerals	1	1	1	1
Nutrient content	**(%)**			
Dry matter	93.39	93.91	92.91	93.91
Ash	6.19	6.01	6.74	5.98
Organic matter	87.20	87.90	86.17	87.93
Crude protein	16.18	16.17	16.11	16.10
Ether extract	4.63	4.39	4.88	4.21
Crude fibre	15.50	18.19	16.53	19.91
Neutral detergent fibre	50.48	51.72	48.92	48.91
Acid detergent fibre	39.98	38.99	36.19	37.28
Acid detergent lignin	10.80	10.10	11.74	12.46
Hemicellulose	10.50	12.74	12.73	11.63
Cellulose	29.18	28.89	24.45	24.82
GE (kcal/kg)	4,125.93	4,224.20	4,251.65	4,274.59

Experimental procedure

This study was carried out in 3 stages. At first, the animals were adapted and were fed basal ration for 2 weeks. The animals were then fed treatment ration during preliminary stage for 1 week, which aimed to eliminate the influence of the previous ration. The last stage was collection data for 9 weeks.

The BW gain of each animal was calculated by weighing the live BW at the beginning of each study week from the live BW at the end of the same week. Each rabbit's average weekly feed intake was obtained by calculating the difference between the weekly feed offered and the residual at the end of each week (Kamal et al., 2023).

The animals were reared in metabolism cage and its faeces were collected for 7 days (Perez et al., 1995). Faeces and urine were collected using individual tray located under the metabolic cage. A net was placed over the tray so that the faeces are separated from the urine. The tray was tilted in such a way so that the urine flows directly into a plastic bottle containing a 10% of sulfuric acid solution. The collected faeces were weighed, sprayed with the same solution and stored in the freezer using polyethylene bags until chemical composition analysis was carried out (Sutaryo et al., 2022). This step was also applied on the collected urine samples.

Analytical procedures

Nutrient intake, nutrient digestibility, average daily gain and feed conversion ratio (FCR) were the variables observed in this study. Nutrient intake (NI) (g/day) = nutrients in the feed given minus remaining nutrients in faeces; total NI (g) = total nutrient intake during rearing period; nutrient digestibility = the difference between nutrient intake and nutrients in faeces per nutrient intake in percent; body weight gain (BWG) (g/day) = difference between initial body weight and final body weight per length of rearing period; and feed conversion ratio (FCR) = dry matter intake (DMI) (g) per BWG (g).

Chemical analysis was carried out for diets and faecal samples according to AOAC (AOAC, 2005) methods to assess ash, CP, Cfi and EE content. Acid detergent fibre (ADF), neutral detergent fibre (NDF) and lignin concentration of samples were measured according to Van Soest et al. (1991).

Data analysis

All data were statistically analysed using variance analysis with 95% confidence level manually using Microsoft Excel. Duncan's multiple range tests were performed to detect significant differences among means.

RESULTS AND DISCUSSION

Table 2 presents the NI of this study. The study showed that the NI had no differences among treatments (p > 0.05). Thus, the same DMI also did not result in increased NI such as organic matter (OM), CP and Cfi (p > 0.05). The average of OM, CP and Cfi was 78.35 g/d, 15.21 g/d and 17.27 g/d, respectively.

Table 3 presents the nutrient digestibility in this study. There was no significant effect on nutrient digestibility (p > 0.05). The average digestibility of DM, CP, Cfi, NDF, ADF, cellulose and hemicellulose in this study were 67.59%, 71.20%, 44.07%, 66.80%, 67.72%, 63.77% and 58.89%, respectively.

Table 4 presents the retained protein and growth performance in this study. The study showed that the retained protein in rabbits has no significant difference among treatments (p > 0.05). The average of retained protein was 8.85 g/d (58.19%). The productivity of male rabbits was the same for all the treatments. The average of ADG was 19.31 (g/d). The inclusion of ILM in rabbits' diet did not affect (p > 0.05) the feed efficiency. The average of FCR was 5.04.

Table 2: Nutrient intake of rabbits fed indigofera leaf meal as substitution in ration.

Nutrients	T0	T1	T2	T3	Average
	(g/d)				
Dry matter	93.62	96.38	97.28	87.86	93.78
Organic matter	77.30	80.30	80.71	75.08	78.35
Crude Protein	15.21	15.64	15.67	14.18	15.21
Ether Extract	4.10	4.15	4.24	3.82	4.08
Crude fibre	17.48	17.7	16.23	17.59	17.27
Neutral detergent fibre	47.44	50.00	47.63	43.11	47.04
Acid detergent fibre	37.56	37.73	35.30	32.89	35.87
Acid detergent lignin	10.19	9.83	11.43	10.96	10.60
Cellulose	27.37	27.91	23.87	21.93	25.27
Hemicellulose	2.81	2.85	2.94	2.59	2.80

Table 3: Nutrients digestibility of rabbits fed indigofera leaf meal as substitution in ration.

Variables	T0	T1	T2	T3	Average
	(%)				
Dry matter	66.92	69.80	66.65	67.00	67.59
Organic matter	67.76	69.73	67.50	69.50	68.62
Crude Protein	70.65	73.72	68.75	71.68	71.20
Ether Extract	66.70	69.84	66.89	72.86	69.58
Crude fibre	42.82	46.79	40.03	46.65	44.07
Neutral detergent fibre	66.89	68.67	63.85	67.81	66.80
Acid detergent fibre	66.54	70.55	63.34	70.47	67.72
Acid detergent lignin	42.95	46.42	40.33	47.30	44.25
Cellulose	68.23	62.89	64.74	59.24	63.77
Hemicellulose	63.85	61.17	50.41	60.13	58.89

Table 4: Retained protein and productivity of rabbits fed Indigofera leaf meal as substitution in ration.

Variables	T0	T1	T2	T3	Average
Retained protein (g/d)	8.57	9.00	8.43	9.41	8.85
Retained protein (%)	56.34	57.54	53.80	66.36	58.19
Average daily gain (g/d)	19.81	19.52	20.70	17.20	19.31
Feed conversion ratio	4.78	5.19	4.78	5.40	5.04

The experiment results showed that the increase inclusion level of ILM in the ration up to 12% did not enhance the ability of the rabbits to consume feed. It was because high level of Indigofera inclusion in ration did not change the nutrient content in the ration (Table 1). Haryati et al. (2021) reported that the use of Indigofera meal up to 30% as a supplementation feed ingredient did not affect feed consumption of rabbits. Haryati et al. (2021) claimed that supplementation of Indigofera leaves in feed up to 20% did not enhance feed palatability and antinutrient content so did not result in a decrease in feed consumption. Gunun et al. (2022) reported that the addition of indigo waste at 10% in a concentrate has no negative effect on DMI of growing beef cattle.

The NI in this study was similar to Yulianto et al. (2019) study that NZW rabbits fed different feeding of fibre source consumed about 94.97 g/d DMI and 16.51 g/d CP. Sikiru et al. (2019) reported that feed intake of NZW fed *Chlorella vulgaris* as supplementation was 90.60–110.26 g. The rabbit performances and feed efficiency were relatively the same among all treatments (Table 3); therefore, ILM had potential to replace SBM in the rabbit ration at least up to 12%. Previous study by Haryati et al. (2021) showed that NZW rabbit productivity decreased from 119 g/d on the control diet (without supplementation) to 70.80 g/d on the Indigofera supplemented diet at 30%.

These results showed that the NZW rabbits have the same ability to digest feed. It was because the nutrient consumption and nutrient content of feed in this study were relatively the same, so the length of retention time of feed in the gastrointestinal tract (GIT) also had no difference and resulted in the same digestibility. Ebeid et al. (2022) claimed that the high nutrient digestibility can be influenced by the longer retention time of feed in the GIT in rabbits. The longer retention time could stimulate the digestive enzymes and increase nutrient absorption. Haryati et al. (2021) reported that the higher feed intake, the higher Cfi that will induce the production of digestive enzymes so it can stimulate good digestive process and absorption. Evitayani et al. (2021) also reported that different nutrient content in feed will affect feed digestibility, thus giving different digestibility results.

In this study, inclusion of Indigofera in ratio up to 12% still well to be used because it did not decrease nutrient digestibility. Haryati et al. (2021) reported that rabbits fed supplementation of Indigofera reduced DM digestibility from 57.24% on control feed to 47.51% on feed with 30% supplementation of Indigofera. However, the higher supplementation did not decrease protein digestibility, i.e. 68.47%. Abdullah and Suharlina (2010) stated that the digestibility value of *Indigofera zollingeriana* ranged from 78% to 82%. The nutrient digestibility was similar among treatments in this study because the nutrient content of the feed was relatively consistent. Additionally, the digestibility of NDF and ADF was directly proportional to the digestibility of cellulose and hemicellulose. Hernaman et al. (2017) study reported that the digestibility of cellulose and hemicellulose is influenced by the digestibility of NDF and ADF because cellulose and hemicellulose are part of NDF and ADF. Gunun et al. (2022) stated that the greater NDF digestibility of the diet was mainly due to enhanced hemicellulose digestion.

This was because the NI and digestibility in this study were relatively same. This study indicated that the inclusion of Indigofera in ration did not have a negative impact on the nutrient retention so rabbits were able to provide the same body weight gain in all treatments. The average of ADG and FCR in this study was 19.31 g/d. Haryati et al. (2021) reported that supplementation of Indigofera in feed reduced the ADG of NZW rabbit from 23.82 g/d on control diet (without supplementation to 13.10 g/d on feed with 30% supplementation of Indigofera). This present result was higher than those of Yulianto et al. (2019) that NZW rabbits fed different fibre sources had an ADG of 14.28 g/d.

This result also led to the same FCR in all treatments. BWG is an essential component of growing animal production efficiency. Gunun et al. (2022) and Kamal et al. (2023) reported that good performance of animal was due to higher digestive feed digestibility, absorption and metabolism process resulting in high efficiency of feed and high BWG. A previous study by Yulianto et al. (2019) showed that rabbits fed different fibre source have an FCR of 5.13. The difference result in study was due to different feed content and DMI applied. Kamal et al. (2023) reported that growing rabbits fed different level of chitosan had an FCR range of 3.31–4.41.

CONCLUSIONS AND RECOMMENDATIONS

In conclusion, including ILM up to 12% in the ration, while decreasing the SBM level proportionally, did not affect nutrient intake, nutrient digestibility, productivity, or feed conversion ratio in growing NZW rabbits. Therefore, ILM can be used as an alternative feed ingredient to replace SBM in the ration, up to 12% substitution.

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NOVELTY STATEMENT

Indigofera leaf meal is a cheap and widely available feed ingredient, so it has great potential as an alternative feed source with high nutrient content. However, studies on the use of indigofera leaf meal as a substitute for SBM and its effect on the productivity of local rabbits in Indonesia are very limited.

AUTHOR'S CONTRIBUTION

Conceptualization: S.S., and A.P.; methodology: S.S., and A.P.; validation: R.A., and A.P.; formal analysis, N.U.; investigation: J.N., N.U., and I.S.; resources: S.S., and A.P.; data curation, S.S., and N.L; writing—original draft preparation: N.L. and S.S.; writing—review and editing: S.S., N.L.,; visualization, S.S.; supervision, A.P.; project administration: R.A.,.; funding acquisition: S.S. All authors have read and agreed to the published version of the manuscript.

Conflicts of interest

The authors have declared no conflict of interest.

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