Utilization of Water Hyacinth Leaves for Protein Protection in Goat Diets: Impacts on Production Performance and Meat Quality

Erwin Hubert Barton Sondakh*, Jerry Kalele, Rahmawaty Hadju

Faculty of Animal Science, Universitas Sam Ratulangi, Manado, Indonesia
***Corresponding author's email: erwin_sondakh@yahoo.com**

Abstract. This study aimed to evaluate the effect of using water hyacinth (Eichhornia crassipes) leaves as a natural feed protein protector on production performance and meat quality in goats. A total of 16 male goats (±15 kg body weight) were used in a completely randomized design with four dietary treatments: R1 (15% tofu dregs + 15% concentrate + 70% forage), R2 (15% tofu dregs + 1% water hyacinth leaves + 14% concentrate + 70% forage), R3 (15% tofu dregs + 2% water hyacinth leaves + 13% concentrate + 70% forage), and R4 (15% tofu dregs + 3% water hyacinth leaves + 12% concentrate + 70% forage). The goats were reared for 10 weeks to measure feed intake and average daily gain (ADG), followed by slaughter to evaluate carcass characteristics and meat chemical composition. Data were analyzed using analysis of variance (ANOVA), and treatment differences were assessed using Duncan's multiple range test. Results showed that inclusion of water hyacinth leaves significantly increased feed intake, ADG, hot and cold carcass weight, carcass percentage, and meat protein content ($P<0.05$). Supplementing goat diets with 1–3% (dry matter basis) water hyacinth (Eichhornia crassipes) leaves as a natural protein protection strategy significantly improves feed intake, average daily gain, carcass traits, and meat protein content. These findings demonstrate the potential of water hyacinth leaves as a functional feed additive to enhance the productivity and meat quality of goats.

Keywords: water hyacinth leaves, feed protein, carcass, goat

Abstrak. Penelitian ini bertujuan untuk menguji pengaruh penggunaan daun eceng gondok sebagai protektan protein pakan terhadap performa produksi dan kualitas daging kambing. Materi yang digunakan berupa 16 ekor kambing jantan dengan bobot badan awal sekitar 15 kg. Perlakuan terdiri atas empat ransum, yaitu: R1 = 15% ampas tahu + 15% konsentrat + 70% hijauan; R2 = 15% ampas tahu + 1% daun eceng gondok + 14% konsentrat + 70% hijauan; R3 = 15% ampas tahu + 2% daun eceng gondok + 13% konsentrat + 70% hijauan; dan R4 = 15% ampas tahu + 3% daun eceng gondok + 12% konsentrat + 70% hijauan. Ternak dipelihara selama 10 minggu untuk mengamati konsumsi pakan dan pertambahan bobot badan harian. Selanjutnya, ternak dipotong untuk dianalisis persentase karkas dan kualitas kimia daging. Parameter yang diamati meliputi konsumsi pakan, pertambahan bobot badan harian, persentase karkas, serta kandungan kimia daging. Data dianalisis menggunakan analisis ragam, dan perbedaan antar perlakuan diuji dengan uji Duncan. Hasil penelitian menunjukkan bahwa penggunaan daun eceng gondok sebagai protektan protein pakan meningkatkan konsumsi pakan dan pertambahan bobot badan harian ($P<0,05$), bobot karkas panas dan dingin, persentase karkas ($P<0,05$), serta kandungan protein daging ($P<0,05$). Disimpulkan bahwa suplementasi daun eceng gondok sebanyak 1–3% dari bahan kering dalam ransum berperan sebagai protektan protein pakan yang efektif, sehingga mampu meningkatkan konsumsi pakan, pertambahan bobot badan harian, persentase karkas, serta kandungan protein daging kambing. Temuan ini menunjukkan bahwa daun eceng gondok berpotensi digunakan sebagai bahan pakan alternatif untuk meningkatkan performa produksi dan kualitas daging pada ternak kambing.

Kata kunci: daun eceng gondok, protein pakan, karkas, kambing

Introduction

Feed is a critical factor in meat production, particularly in determining the quality of the resulting protein. Tannins, which are polyphenolic compounds found in various plants, have gained attention in animal nutrition research. These compounds can influence protein digestibility and improve the quality of meat produced by ruminants such as goats and cattle.

Several in vitro studies using supplementation with ingredients containing tannin have been successfully carried out through rumen fermentation to suppress methane gas, increase propionic acid, (Aboagye and Beauchemin, 2019; Sondakh et al., 2024) and even protect rumen protein (Arisya et al.,

2019; Chen et al., 2021). However, previous studies have provided limited scientific evidence regarding the effects of tannins on livestock productivity and meat quality. Therefore, there are concerns that the use of tannins derived from water hyacinth for protein protection may negatively affect animal performance. Moreover, for ruminant livestock, the use of too much tannin should not disturb the digestive microbial conditions in the rumen. The effect of uncontrolled use of tannin will reduce the digestibility of dry matter and organic matter (Hoste et al., 2015). There are several mechanisms by which tannins are associated with protection against proteins. According to Tanuwiria and Hidayat (2019), tannins can bind to proteins and cause protein precipitation, preventing the protein from dissolving in the rumen. Protecting dietary protein in ruminants is essential, as the rumen is the primary site of digestion in these animals. Protein protection can be carried out in the rumen when livestock consume feed ingredients that contain high protein. Among the feed ingredients that have high protein are tofu dregs. According to recent research, tofu dregs contain around 20-30% protein, depending on the processing method and type of soybean used (Sari et al., 2022). Ramlan (2018), water hyacinth leaves and stems contain nutrients that can be used as alternative feed ingredients, this content consists of: 17.20% of dry matter, 3.55% of crude protein, 4.08% of crude fiber, 8.22% of carbohydrat, 1.50% of fat, and 3.93% of ash. Viomalini et al (2020), There was an increase in the average daily gain in goats, although not significant, when given water hyacinth leaves. Rorong dan Suryanto (2010) stated that water hyacinth leaves produced 26,327 mg/kg using aquades extraction. Tannins from water hyacinth are expected to protect the protein content in tofu dregs so that they are not digested in the rumen. In this way, protein utilization for ruminant livestock can be used as optimally as possible. Bhat et al. (2013) through his research shows that feed containing tannins can contribute to improving the quality of meat protein, but the mechanisms and effects still need to be studied further. The improvement in meat quality is believed to be associated with the portion of dietary protein that escapes ruminal degradation. However, Bhat et al. (2013) reported that high concentrations of tannins can inhibit protein availability and reduce the overall nutritional value of the feed. Therefore, an optimal dose of tannin is needed that can be used in feed formulation to protect protein

Based on this background, a study was conducted to evaluate the production performance of ruminants fed diets containing tofu dregs and supplemented with water hyacinth leaves, with a focus on productivity and meat quality in goats.

Materials and Methods

Research Materials

The study used 16 male goats with an average body weight of approximately 15 kg. The ration consisted of forage (elephant grass and water hyacinth leaves), concentrate (commercial ruminant concentrate and tofu dregs), and water was provided ad libitum. The proportion of each feed ingredient followed the respective treatment formulations.

Research Methods

This study used 16 local goats as experimental animals. A completely randomized design (CRD) was employed, consisting of four dietary treatments with four replications each. Treatment consists of:

R1: 15% tofu dregs + 15% concentrate + 70% forage

R2: tofu dregs 15% + water hyacinth leaves 1% + concentrate 14% + forage 70%

R3: tofu dregs 15% + water hyacinth leaves 2% + concentrate 13% + forage 70%

R4: tofu dregs 15% + water hyacinth leaves 3% + concentrate 12% + forage 70%.

Table 1. Nutrient composition of the experimental diets

Variables	Treatments			
	R0	R1	R2	R3
Feed Materials (%)				
Elephant grass	70	70	70	70
Concentrate	15	14	13	12
Tofu dregs	15	15	15	15
water hyacinth leaves	0	1	2	3
Nutrient composition (%)				
Crude protein	15.14	15.48	15.61	15.72
Crude fat	4.76	4.84	4.80	4.92
Crude fiber	22.76	23.04	23.22	23.64
Nitrogen-Free Extract (NFE)	44.56	44.25	44.62	44.00
Ash	10.03	9.86	9.93	10.12

Feed and drinking water were provided ad libitum. For a clearer treatment of the experiment can be seen in Table 1.

The parameters observed included feed intake, average daily gain (ADG), and carcass quality. Observations were conducted over a period of 10 weeks. After the growth performance assessment, the goats were slaughtered, and meat samples were collected. Meat was taken from the longissimus dorsi muscle. The observed parameters included: (1) carcass percentage, calculated as the ratio of hot carcass weight to slaughter weight multiplied by 100%; and (2) meat quality, based on chemical composition (moisture, crude protein, fat, and ash content), which was analyzed using proximate analysis methods (AOAC, 2019).

Data analysis

Data were analyzed using analysis of variance (ANOVA) based on a completely randomized design (CRD), followed by Duncan's Multiple Range Test (DMRT) to determine significant differences among treatments.

Results and Discussion

Effect of Dietary Treatments on Feed Intake and Average Daily Gain (ADG)

Average daily gain (ADG) and feed intake of goats supplemented with water hyacinth leaves for protein protection are presented in Table 2. The results indicated that dietary treatments had a significant effect ($P<0.05$) on both daily weight gain and feed intake.

The results of this study also indicate that water hyacinth leaves do not negatively affect feed palatability in goats; in fact, feed intake increased starting from the R1 treatment. This increase in feed intake may be attributed to the inclusion of water hyacinth leaves. According to Pokharel et al. (2024), water hyacinth leaves can enhance the palatability of ruminant feed. Furthermore, Rorong and Suryanto (2010) reported that water hyacinth contains relatively high levels of tannins, approximately 25 g/kg.

Table 2. Average Daily Gain (ADG) and Feed Intake of Goats Fed Diets Supplemented with Water Hyacinth Leaves for Protein Protection

Variables	Treatments			
	R0	R1	R2	R3
Initial weight (kg)	16.95	17.68	16.43	18.25
Final weight (kg)	20.26	22.34	20.76	22.83
Average daily gain (g/day)	55.16[a]	77.66[b]	72.16[b]	76.33[b]
Feed intake (g/head/day)	526.00[a]	635.00[b]	598[b]	628.00[b]

It is presumed that these tannins help protect dietary protein from degradation in the rumen, thereby improving post-ruminal protein utilization. Containing tannin which can protect protein, so that protein utilization for livestock can be achieved. According to Jerónimo et al (2016) tannins can reduce protein digestibility, but at a certain level, tannins can also increase feed intake by stimulating livestock appetite. According to Hossain et al. (2018) that giving feed containing moderate amounts of tannin shows an increase in feed intake in goats compared to feed without tannin. Increased feed intake and body weight gain were studied by Mekuriaw et al. (2018) which states that the use of leaves water hyacinth in goat feed can increase feed intake and body weight gain significantly. Fitrihidajati dan Ratnasari (2017) stated that water hyacinth contains high fiber so it stimulates appetite. In a study conducted by Rahayu and Sari (2021), goats fed diets supplemented with water hyacinth leaves showed an increase in feed intake of up to 15% compared to those fed conventional diets. This finding suggests that water hyacinth leaves can serve not only as an alternative feed ingredient but also as a source of considerable nutritional value. As a high-fiber material, water hyacinth leaves may support digestive health in goats, thereby contributing to improved weight gain. Similarly, research by Fanta et al. (2024) reported that goats fed a mixture containing water hyacinth leaves experienced a significant increase in body weight compared to goats on conventional rations.

Effect of Dietary Treatments on Carcass Components

The average values of carcass components are presented in Table 3. Statistical analysis showed that carcass weight, dressing percentage, and the percentages of fat and bone differed significantly ($P<0.05$) among treatments.

The use of water hyacinth leaves as a source of tannin can increase carcass weight, dressing percentage and lean percentage. The results of this research are supported by several previous studies. Bai and Guo (2017) reported that the inclusion of water hyacinth in beef cattle diets increased carcass weight. This finding demonstrates that appropriate feed formulation can positively influence the quality and quantity of meat produced. Furthermore, this study provides evidence that water hyacinth leaves can serve as an effective alternative feed to enhance meat production and improve carcass yield.

Similarly, Yusuf et al. (2021) reported that feeding goats with rations containing water hyacinth leaves significantly increased carcass weight. In their study, goats receiving diets with higher levels of water hyacinth showed a significant increase in carcass weight compared to those fed conventional diets ($P<0.05$). The increase in dressing percentage and carcass weight in experimental livestock was caused by the tannins in water hyacinth plants. Water hyacinth leaves can act as a feed supplement that can protect protein in the rumen.

Table 3. Average Carcass Quality of Goats Fed Diets Supplemented with Water Hyacinth Leaves for Protein Protection

Variables	Treatments			
	R0	R1	R2	R3
Carcass Weight (kg)	8,91[a]	10.25[b]	9.59[ab]	10.39[b]
Dressing Percentage (%)	44.68[a]	45.75[b]	46.23[b]	45.37[b]
Lean Meat Percentage (%)	67.37[a]	68.53[b]	68.28[b]	68.97[b]
Fat Percentage (%)	10.89	10.46	10.24	9.66
Bone Percentage (%)	20.65	20.44	20.04	19.71

Table 4. Average meat chemical quality of goats given water hyacinth leaves to protect protein

Variables	Treatments			
	R0	R1	R2	R3
Moisture (%)	75.68	74.27	75.52	74.54
Protein (%)	7.26[a]	7.84[ab]	7.99[ab]	8.24[b]
Lipid (%)	44.68	45.75	46.23	45.37
Ash (%)	2.13	2.04	1.98	2.30

The presence of rumen-undegradable protein (RUP) allows a greater proportion of dietary protein to bypass ruminal degradation, enabling enhanced post-ruminal absorption and utilization for muscle accretion. According to Lee et al. (2020), increasing the fraction of protein that escapes ruminal digestion is associated with improved carcass quality, as it provides more amino acids available for tissue synthesis.

Effect of Dietary Treatments on the Chemical Composition of Meat

As presented in Table 4, the inclusion of water hyacinth leaves as a natural source of protein protection significantly improved the chemical composition of the meat, particularly its crude protein content. Goats receiving diets supplemented with water hyacinth leaves exhibited higher meat protein levels compared to those not receiving the supplementation.

Fitrihidajati and Ratnasari (2017) reported that the inclusion of water hyacinth leaves in goat diets can enhance meat protein content. Their study demonstrated that goats fed diets containing 30% water hyacinth leaves exhibited a 15% increase in meat protein levels compared to those fed conventional diets. Similarly, Atti et al. (2004) showed that high-protein diets positively influence the protein content of goat meat. Vatanparast et al. (2020) emphasized that the quality of meat protein can be supported through the inclusion of plant-based feed ingredients. Furthermore, Salami et al. (2019) noted that tannin-containing feed not only enhances protein quality but also contributes to the overall nutritional value of the meat.

Conclusion

Inclusion of 1–3% water hyacinth (Eichhornia crassipes) leaves (dry matter basis) in goat diets as a natural feed protein protector significantly improves growth performance and enhances meat quality, particularly by increasing average daily gain and meat protein content. These findings suggest that water hyacinth leaves are a promising alternative feed additive for improving the productivity and nutritional value of goat meat.

Acknowledgement

We express our gratitude to Sam Ratulangi University for funding the research in project of RDUU-K1 2024.

References

Aboagye, IA, and KA Beauchemin. 2019. Potential of molecular weight and structure of tannins to reduce methane emissions from ruminants: A review. Animals, 9(11), 856.

Arisya, W, R Ridwan, M Ridla, and A Jayanegara. 2019. Tannin treatment for protecting feed protein degradation in the rumen in vitro. In Journal of Physics: Conference Series (Vol. 1360, No. 1, p. 012022). IOP Publishing.

Atti, N, H Rouissi, and M Mahouachi. 2004. The effect of dietary crude protein level on growth, carcass and meat composition of male goat kids in Tunisia. Small Ruminant Research, 54(1-2): 89-97

Bai, YF, and JY Guo. 2017. Utilization of water hyacinth biomass for animal feed. In *Water Hyacinth* (pp. 277-300). CRC Press

Bhat, TK, A Kannan, B Singh, and OP Sharma. 2013. Value addition of feed and fodder by alleviating the antinutritional effects of tannins. Agricultural Research. *2*: 189-206

Chen, L, X Bao, G Guo, W Huo, Q Xu, C Wang, and Q Liu. 2021. Effects of hydrolysable tannin with

or without condensed tannin on alfalfa silage fermentation characteristics and in vitro ruminal methane production, fermentation patterns, and microbiota. Animals. 11(7):

Fanta, YU, YK Kebede, and NY Asfaw. 2024. Effects of feeding water hyacinth (Eichhornia crassipes) fodder with or without commercial concentrate on zoo-technical performance and profitability in tropical goats and sheep. bioRxiv.

Fitrihidajati, H, and IE Ratnasari. 2017. Effectiveness of ruminant feed formula from the fermented water hyacinth (Eichhornia crassipes) to produce the high level protein of goat meat. Advanced Science Letters. 23(12): 11972-11975

Hoste, H, JFJ Torres-Acosta, CA Sandoval-Castro, I Mueller-Harvey, S Sotiraki, H Louvandini, and TH Terrill. 2015. Tannin containing legumes as a model for nutraceuticals against digestive parasites in livestock. Veterinary parasitology. 212(1-2): 5-17

Jerónimo, E, C Pinheiro, E Lamy, MT Dentinho, E Sales-Baptista, O Lopes, and F Silva. 2016. Tannins in ruminant nutrition: Impact on animal performance and quality of edible products)

Lee, YH, F. Ahmadi, M Lee, YK Oh, and WS Kwak. 2020. Effect of crude protein content and undegraded intake protein level on productivity, blood metabolites, carcass characteristics, and production economics of Hanwoo steers. *Asian-Australasian journal of animal sciences*, *33*(10): 1599.

Mekuriaw, S, F Tegegne, A Tsunekawa, and T Ichinohe. 2018. Effects of substituting concentrate mix with water hyacinth (Eichhornia crassipes) leaves on feed intake, digestibility and growth performance of Washera sheep fed rice straw-based diet. Tropical animal health and production. 50: 965-972

Pokharel, NP, K Dhakal, P Panth, dan R Koirala. 2024. Effect of different additives on nutrient parameter and palatability of ensiled water hyacinth (Eichhornia crassipes). Agriculture and Food Sciences Research, *11*(2): 36-42.

Ramlan, P, and AI Merita. 2018. Analisa potensi eceng gondok (Eichhornia Crassipes) Danau Limboto sebagai pakan ternak. Prosiding Seminar Nasional Integrated Farming System. Gorontalo, 108 – 110).

Rorong, JA, and E Suryanto. 2019. Analisis fitokimia enceng gondok (Eichhornia crassipes) dan efeknya sebagai agen photoreduksi Fe3+. Chemistry Progress, 3(1): 33-41.

Sondakh, EHB, J Kalele, and N Tuwaidan. 2024. The use of water hyacinth leaves supplementation in ruminant feed on methane, protozoa, VFAs, and fatty acids ruminal fluid in vitro. Animal Production, 26(2): 125-129.

Tanuwiria, UH, and R Hidayat. 2019. Efek level tanin pada proteksi protein tepung keong mas (Pomacea canaliculata) terhadap fermentabilitas dan kecernaan in vitro. Jurnal Ilmu Ternak Universitas Padjadjaran, *19*(2): 122-130.

Yusuf, AO, AJ Owolabi, KO Adebayo, ABJ Aina, OS Sowande, and TO Ajayi. 2021. Growth performance of goats fed diets containing varying levels of water hyacinth. Agricultura Tropica et Subtropica. 54(1): 228-237.

Vatanparast, H, N Islam, M Shafiee, and DD Ramdath. 2020. Increasing plant-based meat alternatives and decreasing red and processed meat in the diet differentially affect the diet quality and nutrient intakes of Canadians. Nutrients. 12(7): 20-34

Viomalini, SDE, and YLRE Nugrahini. 2020. Pemanfaatan Eceng Gondok (Eichhornia Crassipes) sebagai Pakan Alternatif untuk Meningkatkan Average Daily Gain, Konsumsi Serta Tingkat Kecernaan pada Ternak Ruminan*sia*. Doctoral dissertation. Sebelas Maret University.