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Supplementation of Dragon Fruit Peel Waste (Hylocereus Polyrhizus) in Goat Ration on Digestibility and Fermentability in Vitro

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ABSTRACT

This study aims to evaluate the effect of adding dragon fruit peel (Hylocereus polyrhizus) to goat rations on digestibility and fermentability in vitro. Dragon fruit peel is known to contain antioxidants and nutrients that can improve the quality of animal feed. This study used a completely randomized design (CRD) consisting of 5 treatments and 6 replicates with the addition of different dragon fruit peel (R0 or control) rations without the addition of dragon peel, 5%, 10%, 15% and 20%. The observed variables include dry matter digestibility, organic matter digestibility, total volatile fatty acid production, and ammonia (NH_3) production. The results of variance analysis (ANOVA) showed that dragon fruit peel supplementation can significantly increase digestibility and fermentability in vitro. The treatment with the addition of 20% dragon fruit peel (R4) showed the highest performance of DMD of 71.55%, OMD of 81.61% and total VFA production of 195.16 mM while in the production of ammonia (NH_3) the treatment with the addition of 10% dragon fruit peel (R2) showed the highest performance with the production value of NH_3 as 10.14 mM. This study concluded that supplementation of dragon fruit peel in goat rations can increase the digestibility and fermentability of feed in vitro, as well as provide an efficient and environmentally friendly feed alternative.

Keywords: Agro-Industry, Digestibility, Dragon Fruit Peel, Fermentability

INTRODUCTION

Goats are a widespread livestock commodity, especially in developing countries such as Indonesia, where the demand for goat meat, milk, and other processed products continues to increase. Goat farming depends on the provision of high-quality feed that not only meets nutritional needs but also improves productivity and digestive health, but the high cost of feed is one of the main problems in the livestock business. The biggest cost incurred in a livestock business is the cost of feed, reaching 60-70% [1]. Currently, efforts to procure feed raw materials have undergone changes as seen in efforts to shift the use of commercial feed ingredients to alternative feed ingredients sourced from fishery waste, plantations and agro-industry by-products.

Indonesia is a tropical country with abundant flora resources and fruits available throughout the year. One of the popular fruits cultivated in Indonesia is dragon fruit, especially red dragon fruit (*Hylocereus polyrhizus).* During 2023, dragon fruit production reached 317.406.8 tons with East Java as the largest dragon fruit producing province [2]. The increasing production of dragon fruit and the fruit processing industry (chips, juice, jam, food coloring, flour) causes the waste produced to also increase, especially the peel waste, 30-35% of dragon fruit parts are peel, the percentage of dragon fruit peel [3] components is quite large when compared to the percentage of other tropical fruit components such as mango, pineapple and avocado. Peel waste from the production process of the processing industry can cause environmental problems if large amounts of waste are wasted and not managed properly. This peel waste can be utilized as an alternative feed ingredient to reduce feed costs while reducing the impact of environmental damage due to the accumulation of agro-

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industrial waste.

Dragon fruit consists of three main components, fruit flesh (47.40-73.76%), peel (36.70- 37.60%) and seeds (2.70-14.67%) [4]. Dragon fruit peel waste has the potential to be utilized as alternative feed and alternative ruminant feed additives because there are several phytonutrient components that have the potential to be utilized in ruminant nutrition, namely flavonoids, tannins, saponins. In the other research, it was mentioned that dragon fruit peels are a good source of phytonutrients (tannins and saponins) for modifying rumen fermentation (pH, NH_3-N, VFA and Digestibility) and reducing protozoa populations and methane gas production in in vitro and in vivo studies [5]. Dragon fruit peel has great potential as a feed source of crude fiber, energy and other nutrients. In general, dragon fruit peel contains nutrients almost the same as the nutritional content in the pulp. Nutrients contained in dragon fruit include carotene, protein, fiber, phosphorus, potassium, iron, sodium, calcium, fiber and vitamins [6]. The vitamin content in dragon fruit peel is vitamin C, vitamin E, vitamin A, B1, B2 and B3 [7].

Dragon fruit peel waste is quite high in fiber and other content such as vitamins and minerals so that it can be used as a feed source. Dragon fruit peel contains 8.98% protein, 0.70% fat, 18.76% ash and 23.39% fiber [8]. The highest nutritional content of dragon fruit peel is crude fiber as much as 23.39% and ash 18.76%. High ash content in dragon fruit peel indicates the high minerals contained in dragon fruit peel [9]. In the research [10] supplementation of dragon fruit peel as a ration additive of 10% in goat rearing showed a positive effect in rumen fermentation and in its use dragon fruit peel can be used as a feed component. The results of other studies on the addition of 0, 2, 4% dragon fruit to Holstein cross bulls showed an increase in ruminal ecology, increased VFA production, especially propionate, microbial protein synthesis and reduced rumen methane production [11]. Dragon fruit peel waste has the potential to be an alternative feed for ruminants, especially goats. The study aimed to determine the effect of supplementation of dragon fruit peel waste in goat rations on fermentability, digestibility of dry and organic matter in vitro

MATERIAL AND METHODS

This research was conducted at the Laboratory of Ruminant Animal Nutrition and Animal Feed, Faculty of Animal Husbandry at Padjadjaran University, Indonesia for 4 months.

Preparation of Rumen Fluid and Artificial Saliva

Rumen fluid came from four male goats slaughtered at a slaughterhouse. The goat's rumen fluid was placed into a water thermos that had previously been filled with hot water, this aims to maintain the thermos temperature of 39ºC. Before the rumen fluid was put into the thermos, the hot water was removed. Next, the thermos was filled with goat rumen liquid, and goat rumen liquid came from squeezing the contents of the rumen using muslin cloth. Each flask was filled by one goat's rumen fluid. The rumen fluid was filtered using thin gauze as many as four layers into the flask, under anaerobic conditions, and then taken immediately to the laboratory.

The preparation of artificial saliva refers to McDougall's instructions (1947). The chemicals used were 9.8 g $NaHCO_3$; 9.3 g $Na_2HPO_4.7H_2O$; 0.57 g KCL; 0.47 g NaCI; 0.06 g $MgSO_4$, and 0.04 g $CaCl_2$. All of these chemicals were put into beaker glass and then added to aquadest until it reached a volume of 1000ml, which was stirred until homogeneous using a magnetic stirrer.

Preparation of Dragon Fruit Peel and Basal Ration

Fresh dragon fruit peels were obtained from a one-liter juice home industry, the peels were first cut into pieces using a chopper to speed up the drying process. The peel was dried under direct sunlight to reduce its moisture content for 3-4 days. After drying, the ingredients were ground using a hammermill, into flour. Dragon fruit peel flour is ready to be mixed with other ration ingredients.

The basal ration was prepared in the proportion of 60: 40 (%), 60% Taiwan elephant grass (*Pennisetum purpureum cv. Taiwan*) and 40% concentrate formulated using WinFeed Feed Formulation Software program.

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Proximate analysis of the raw materials that make up the ration was then carried out in duplicate and also that of the experimental ration and fruit leather. The results of the analysis can be seen in tables 1 and 2.

Table I Basal Ration Feed Ingredients and Chemical Composition

Feed Ingredients	Food Substances				
	Moisture	Ash	Crude Fat	Crude protein	Crude Fiber
	---------- % ----------				
Tofu Dregs	5.615	3.31	2.585	20.53	14.38
Soy Bean Meal	8.175	7.715	1.175	47.08	2.45
Cassava Dregs	9.695	3.395	0.445	2.26	13.545
Taiwan Elephant Grass	6.98	17.295	1.57	13.24	27.115
Palm Kernel Meal	7.29	5.42	9.84	11.875	17.995
Rice Bran	8.305	11.26	9.09	15.225	10.98
Coconut Meal	8.485	8.245	1.365	24.36	6.37

Source: Proximate Analysis Results of Biotechnology Center, Bogor Agricultural University (2024)

Table II Result of Proximate Analysis of Ration and Dragon Fruit Peels

Parameter	Ration	Dragon fruit Peel
	---------- % ----------	
Moisture	8.18	9.09
Ash	17.29	15.59
Fat	1.57	0.81
Crude Protein	13.24	9.44
Crude Fiber	27.11	18.91

Source: Results of Proximate Analysis of Biotechnology Center, Bogor Agricultural University (2024)

RESEARCH METHODS

The research design used was a completely randomized design (CRD) consisting of 5 treatments and 6 replicates and 4 goats were used for this research. The experimental treatment consisted of ration control without the addition of dragon fruit peel and four levels of dragon fruit peel addition (5, 10, 15 and 20%).

The treatments were given as follows:

a) R0 = 60% Taiwan elephant grass + 40% concentrate

b) R1 = 55% Taiwan elephant grass + 40% concentrate + 5% dragon fruit peel

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c) R2 = 50% Taiwan elephant grass + 40% concentrate + 10% dragon fruit peel

d) R3 = 45% Taiwan elephant grass + 40% concentrate + 15% dragon fruit peel

e) R3 = 40% Taiwan elephant grass + 40% concentrate + 20% dragon fruit peel

Observed variables:

Digestibility of Dry Matter (DM) and Digestibility of Organic Matter (OM)

Measurement of digestibility of dry matter and organic matter using the method [12] which is divided into 2 stages. The first stage of fermentative digestion, by entering the sample into the fermenter tube as much as 0.5 g then the McDougall solution and rumen fluid in a ratio of 4:1 were added to the fermenter tube and closed, and then put into a waterbath to incubate for 48 hours. Upon completion of the incubation period was complete, centrifugation was carried out at a speed of 4,000 rpm for 10 minutes, then the supernatant resulting from centrifugation was discarded and the residue was taken. The sample was then added with 50ml pepsin solution and incubated again for 48 hours with stirring every 6 hours.

The incubation process lasted for 48 hours, after which the fermenter tube was opened and filtered using Whatman No. 41 filter paper (which had previously been weighed and recorded its weight) to separate the residue and reduction solution. The fermenter tube was rinsed using distilled water until there was no residue left in it. The filter paper containing the residue was then put into an aluminum cup that was already known by weight for further ovens. The aluminum cup containing the filter paper and residue was oven dried at 105ºC for 24 hours, then put into an applicator for 15 minutes. The aluminum cup containing filter paper and residue was weighed to determine the final weight of dry material. The results of the filtration were then put into a porcelain crucible (known weight) and oven dried at 105ºC for 24 hours, let stand in an applicator for at least 15 minutes to cool then weighed to get the weight of the sample after the oven and calculate the dry matter digestibility. Samples that have been weighed of the dry matter were then fumigated using an electric furnace at 600ºC for 4 - 6 hours, allowed to stand in a dexicator, and weighed to determine the weight of organic matter.

Measurement of VFA Total Production

Measurement of total VFA concentration was carried out using Markham's steam distillation technique (1998). Supernatant as much as 5ml was put into a set of steam distillation equipment, then add H_2SO_4 was added as much as 1ml and then closed. This distillation process is connected to a flask tube containing boiling water, the distillation process ends when the solution contained in the erlenmeyer has reached 200ml. After that, drop the solution with a phenolphthalein indicator as much as 3 - 5 drops and then titrate using 0.5 N HCI until there is a color change from pink to colorless, then the volume of HCl used was calculated and recorded.

Total VFA production is calculated using the formula:

$$VFA\ total(mM) = (a - b)N\ HCL\ \times \frac{1000}{5}$$

Note: a = Volume of blank titrant (5ml NaOH)

b = Volume of sample titrant Ammonia (NH_3) production

In NH_3 analysis using the Conway method [13] by preparing a conway cup and lid. The lips of the conway cup and lid were greased with vaseline, then enter 1ml of supernatant on the left side of the conway cup then 1ml of Na_2CO_3 is inserted into the right side of the conway cup. After that, boric acid solution with methyl red indicator and bromocresol green 1ml were placed in a small cup in the middle. The conway cup was then tightly closed and shaken so that the Na_2CO_3 solution and supernatant are mixed. The conway cup was kept at room temperature for 24 hours, and thereafter titrated using 0.005 N H_2SO_4 until the color changed from blue to pink.

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NH_3 production is calculated by the formula:

$$NH_3(mM) = (V\ H_2SO_4 \times N\ H_2SO_4\ \times 1000)mM$$

Note = $V\ H_2SO_4$ = Volume of H_2SO_4 used for titration (ml)

$N\ H_2SO_4$ = Normality of H_2SO_4

Statistical Analysis

Statistical analysis was tested with ANOVA and if there was a significant effect (P0<0.05) followed by Duncan's Multiple Range Test (Steel and Torrie, 1980). Data processing was analyzed using the SPSS program.

RESULT AND DISCUSSION

Table III Result of Dragon Fruit Peel Treatment on Ivdmd, Ivomd, Vfat and Ammonia

Parameter	Treatment				
	R0	R1	R2	R3	R4
IVDMD (%)	$50.185^{a} \pm 0.58$	$53.11^{b} \pm 0.73$	$59.125^{c} \pm 0.57$	$67.925^{d} \pm 0.97$	$71.553^{e} \pm 0.60$
IVOMD (%)	$54.073^{a} \pm 1.29$	$60.413^{a} \pm 3.21$	$67.980^{b} \pm 1.65$	$77.905^{c} \pm 1.76$	$81.605^{d} \pm 1.04$
VFAt (mM)	$97.421^{a} \pm 18.49$	$121.05^{b} \pm 6.01$	$148.518^{c} \pm 11.32$	$163.923^{d} \pm 2.61$	$195.165^{e} \pm 10.65$
Ammonia (mM)	$9.130^{ab} \pm 1.31$	$8.418^{a} \pm 1.34$	$10.141^{b} \pm 0.47$	$9.221^{ab} \pm 1.12$	$9.516^{ab} \pm 0.63$

*Different superscripts in the same row indicate significant differences (P<0.05) * Mean ± STD

Note: R0 = 60% Taiwan elephant grass + 40% concentrate; R1 = 55% Taiwan elephant grass + 40% concentrate + 5% dragon fruit peel; R2 = 50% Taiwan elephant grass + 40% concentrate + 10% dragon fruit peel; R3 = 45% Taiwan elephant grass + 40% concentrate + 15% dragon fruit peel; R4 = 40% Taiwan elephant grass + 40% concentrate + 20% dragon fruit peel.

Dry Matter Digestibility (DMD) and Organic Matter Digestibility (OMD)

The results regarding the effect of the addition of dragon peel waste in goat rations on DMD and OMD values can be seen in Table 3. Based on the results shown in Table 3, the average dry matter digestibility of goat rations treated with the addition of dragon fruit peel, the DMD values of R0, R1, R2, R3, and R4 are 50.18; 56.92; 67.43; 70.54; 72.95, respectively. Statistical results of variance analysis test (ANOVA) showed that the addition of dragon peel gave a significant effect (P<0.05) on the value of dry matter digestibility. The results of the Duncan test showed that the addition of dragon peel waste at the addition of 20% (R4) in the ration was significantly different (P<0.05), compared to other treatments (R4) produced the highest average value of dry matter digestibility of 71.55%.

There are various factors that can affect the digestibility value both internally and externally such as the nutrient content of feed ingredients and the condition of rumen microbes. Digestibility value is closely related to energy supply and feed nutrients, energy supply being one of the important factors in the process of microbial protein synthesis. High digestibility values are a sign of the availability of easily degradable proteins and available carbohydrates that can fulfill the survival of rumen microbes [14]. Fiber and betacyanin pigments contained in dragon fruit peels can help in livestock digestion. The study by [11] found that supplementation of dragon fruit peel in feed increased rumen fermentation activity and dry matter digestibility in Holstein-Friesian crossbred dairy cows. [15] in their research, high fiber contained in dragon fruit peels can affect the rate of

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fermentation in the rumen.

The effect of dragon fruit peel waste supplementation on OMD can be seen in Table 3. Based on Table 3, the average digestibility of organic matter of goat rations made by the addition of dragon fruit peel has increased with the value of OMD R0, R1, R2, R3 and R4 in sequence 54.07; 60.41; 67.98; 77.91; 81.61. The results of the variance analysis test (ANOVA) showed that the addition of dragon fruit peel gave a significant effect ($P<0.05$) on the digestibility value of organic matter. Further tests were conducted to determine differences in the OMD value of each treatment using Duncan's Multiple Range Test. The results of Duncan's test showed that the addition of dragon peel waste (R4) up to 20% in the ration was significantly different ($P<0.05$) compared to other treatments, (R4) produced the highest average OMD value of 81.61%.

Dry matter digestibility and organic matter digestibility are always aligned, this is because organic matter is part of dry matter. The crude protein content of feed can affect the high OMD value [16]. One of the nutrient components that are easily digested by rumen microbes is crude protein. The fairly low lignin content in dragon peel is 8.33%, causing an increase in the digestibility of organic matter.

Volatile Fatty Acid (VFA) and Ammonia (NH_3)

The results of the study on the effect of the addition of dragon peel waste in goat rations on VFA concentration are presented in Table 3. Based on the table, the average concentration of VFA in the treatment of the addition of dragon fruit peel R0, R1, R2, R3 and R4 are 584.53; 726.30; 891.11; 983.54; 1170.99, respectively. The results of the variance analysis test (ANOVA) showed that the addition of dragon fruit peel had a significant effect ($P<0.05$) on VFA concentration. Further tests were conducted to determine differences in VFA concentration of each treatment using Duncan's Multiple Range Test, the results of Duncan's Test showed differences in treatment of VFA levels. The effect of adding dragon peel waste (R4) was significantly ($P<0.05$) higher than the treatments R0, R1, R2 and R3. The addition of dragon peel waste (R4) produces the highest concentration of 195.16 and the lowest VFA concentration in (R0) which is 97.42.

Volatile fatty acid (VFA) is the end result of carbohydrate fermentation, the main products of VFA are acetic, propionic and butyric acids. The range of VFA levels varies between 70-150 mM, this depends on the type of ration and time after feeding [17][18]. VFA production in this study ranged from 97.42 - 195.16 mM, the values of R1, R2, and R3 were in the recommended ideal range, but in R4 the addition of dragon peel 20% VFA levels were higher than the range of total VFA production. Research reported that the high production of total VFA exceeded the ideal range presumably due to the provision of rations containing easily fermentable carbohydrates and other nutrients such as sulfur and nitrogen that form sulfurized amino acids (methionine, cystine, and cysteine) as important nutrients for rumen bacteria [19]. The high level of VFA is caused by the high carbohydrates and proteins that can be fermented in the rumen, explained that in agro-industrial by-product waste the carbohydrates contained are easily fermented so that the average propionic acid produced is high [20]. The addition of dragon fruit peel increases VFA production, especially propionate concentration up to 3-4% [11].

The effect of the addition of dragon fruit peel waste on NH_3 levels can be seen in Table 3. Based on the table, the average NH_3 levels in the treatment of the addition of dragon fruit peel R0, R1, R2, R3 and R4 are sequentially 9.13; 8.42; 10.14; 9.22; 9.52. The results of the variance analysis test (ANOVA) showed that the addition of dragon fruit peel gave a significant effect ($P<0.05$) on NH_3 levels. Further tests were conducted to determine differences in NH_3 levels of each treatment using Duncan's Multiple Range Test. The results of Duncan's test showed that there were treatment differences in NH_3 levels. The effect of the addition of dragon peel waste (R2) was significantly ($P<0.05$) higher than the treatments P0, P1, P3 and P4. The addition of dragon peel (R2) produced the highest average value of NH_3 which is 10.14% and the lowest in (R1) which is 8.41. The addition of dragon fruit peel can increase rumen digestibility, and ammonia concentration (NH_3) [11].

The efficiency of feed protein synthesis in the rumen can be seen from the level of ammonia (NH_3) produced, the production of NH_3 in the rumen is related to the use of feed ingredients containing protein [21]. The results of the variance analysis test (ANOVA) showed that the addition of dragon peel in the ration gave a significant

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effect (P <0.05) on NH_3 levels with the highest NH_3 levels in the addition of dragon fruit peel 10% (R2). NH_3 levels of all treatments ranged from 8.41 - 10.14 mM, the NH_3 levels are in the ideal conditions needed by rumen microbes to degrade feed optimally in the range of 3.57-14.28 mM. Optimal NH_3 production results in faster rumen microbial growth and maximum carbohydrate degradation, but if NH_3 levels exceed the ideal range, it can cause accumulation in the rumen fluid so that livestock are poisoned, especially in low energy rations [22].

CONCLUSIONS

From the results of the study, it can be concluded that the addition of dragon fruit peel as much as 20% in goat rations can increase the digestibility of dry matter, digestibility of organic matter and production of volatile fatty acid (VFA) this can be influenced by the presence of easily digestible carbohydrates in the rumen. The effect of the addition of 20% dragon peel does not cause negative effects on NH_3 production, NH_3 levels are still in the ideal range of 9.51 mM.

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