



Increased Protein Consumption and Nitrogen Retention of Sheep Fed Sodium Bicarbonate and Fermented Concentrate

Wafiq Siti Nur Pajriyah¹, Wardhana Suryapratama^{1*}, F.M. Suhartati¹, Sri Rahayu¹,
Efka Aris Rimbawanto¹

¹Faculty of Animal Science, Jenderal Soedirman University, Purwokerto, Indonesia

ABSTRACT. This study aimed to evaluate the effects of sodium bicarbonate and fermented concentrate feed on protein consumption and nitrogen retention in sheep. The experiment utilized 18 male local sheep, aged 7–8 months, with an average body weight of 19.44±2.37 kg. The animals were fed a diet consisting of ammoniated rice straw (25%) and concentrate (75%). The study employed an in vivo experimental approach using a Randomized Complete Block Design (RCBD), with initial body weight as the blocking factor and six replicates per treatment group. The treatments were as follows: P1= ammoniated rice straw (25%) + concentrate (75%); P2= ammoniated rice straw (25%) + concentrate (75%) + sodium bicarbonate; and P3= ammoniated rice straw (25%) + concentrate (75%) fermented with *Saccharomyces cerevisiae* (3%) + sodium bicarbonate. The measured variables were protein consumption and nitrogen retention. Data were analyzed using analysis of variance (ANOVA), followed by the Honestly Significant Difference (HSD) test. The mean protein consumption was 129.58±10.84 g/head/day (P1), 127.38±15.46 g/head/day (P2), and 161.11±5.32 g/head/day (P3). The mean nitrogen retention was 84.51±5.50 g/head/day (P1), 83.65±7.59 g/head/day (P2), and 117.16±12.46 g/head/day (P3). HSD analysis revealed that the combination of sodium bicarbonate and fermented concentrate feed (*Saccharomyces cerevisiae*) resulted in the highest protein consumption and nitrogen retention, with increases of 24.33% and 38.64%, respectively, compared to other treatments.

Keywords: fermentation concentrate, nitrogen retention, protein consumption, sheep, sodium bicarbonate

INTRODUCTION

Sheep are an important source of meat production, particularly in smallholder farming systems. However, their productivity is often limited by the provision of low-quality forage, such as field grass or rice straw. To enhance the nutritional value of rice straw, ammoniation is a widely used technique. While ammoniated rice straw improves feed quality, it remains insufficient to meet the nutritional requirements of sheep. Therefore, supplementation with a high-quality concentrate feed is essential to support optimal rumen microbial growth and overall livestock performance.

Despite its benefits, a high-concentrate diet can increase the risk of acidosis due to excessive acidification of rumen fluid. To mitigate this risk, the inclusion of buffer agents is necessary to maintain rumen pH stability. One such buffering agent is sodium bicarbonate, which has been shown to regulate rumen pH and improve fiber digestion (Tripathi et al., 2004; Kawas et al., 2007). According to Wittayakun et al. (2015), sodium bicarbonate supplementation helps establish a suitable rumen environment, thereby enhancing the fermentation of fibrous feed.

While concentrate supplementation is crucial for sheep nutrition, its composition often includes agricultural byproducts that contain anti-nutritional factors, reducing digestibility by rumen microbes. This issue can be addressed through fermentation. Jalali et al. (2012) reported that fermented complete feed enhances feeding frequency, increases intake rates, reduces crude fiber content, and improves crude protein levels. Fermentation is facilitated by yeast, which accelerates the process and enhances anaerobic conditions in the rumen (Pantaya et al., 2016). Additionally, fermented concentrates promote the growth of lactic acid-utilizing bacteria, further stabilizing the rumen environment (Septian et al., 2022).

One of the most commonly used yeasts in feed fermentation is *Saccharomyces cerevisiae* (Umaiya et al., 2014). Chaucheyras-Durand et al. (2008) demonstrated that *Saccharomyces cerevisiae* supplementation increases rumen pH, while Suryapratama and Suhartati (2012) found that its inclusion in fermented concentrates enhances microbial protein synthesis by 9.42% compared to non-fermented concentrates. Higher protein consumption improves microbial protein synthesis, leading to better nutrient absorption and utilization in sheep (Adi et al., 2020).

Protein consumption is influenced by the crude protein content of the feed, including contributions from microbial protein synthesis in the rumen. Therefore, evaluating the total protein

*Corresponding author: wardhanaunsod@gmail.com

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available for utilization is essential. The combined addition of sodium bicarbonate and fermented concentrate feed is expected to positively impact protein consumption and nitrogen retention in sheep. Based on these considerations, this study aims to examine the effects of sodium bicarbonate and fermented concentrate supplementation on protein consumption and nitrogen retention in sheep.

MATERIALS AND METHODS

This study utilized 18 male local sheep, aged 7–8 months, with an average initial body weight of 19.44 ± 2.37 kg. The experimental diet consisted of ammoniated rice straw (25%) and concentrate (75%) fermented with *S. cerevisiae* (3%). Feed was provided at 4% dry matter (DM) based on body weight. The concentrate was formulated using the following ingredients: rice bran (18%), onggok (32%), corn flour (10.7%), full-fat soybean (26.7%), and soybean meal (10.7%). Additionally, sodium bicarbonate was incorporated at 0.75% of the total feed DM to serve as a buffer agent. The

study was conducted using a Randomized Complete Block Design (RCBD), with initial body weight as the blocking factor. The nutritional composition of the treatment diets is presented in Table 1. The treatments tested consisted of 3 kinds with 6 groups and as replicates:

- P1 = Ammoniated rice straw (25%) + Concentrate feed (75%)
- P2 = Ammoniated rice straw (25%) + Concentrate feed (75%) + sodium bicarbonate 0.75%
- P3 = Ammoniated rice straw (25%) + Concentrate feed (75%) fermented with *Saccharomyces cerevisiae* 3% + sodium bicarbonate 0.75%

The measured variables are protein consumption (PC) and nitrogen retention (NR) of sheep which can be calculated as follows:

$$\text{Protein Consumption} = (\% \text{CP fed} \times \text{DM fed}) - (\% \text{CP leftover feed} \times \text{DM leftover feed})$$

$$\text{Nitrogen Retention} = \text{N consumption} - (\text{N feces} + \text{N urine})$$

Table 1. Nutrient content of feed treatment

Treatment	%Dry Matter	Organic Matter	Crude Protein	Crude Fiber	Crude Fat	Ash Content	NNFE
----- (%DM) -----							
P ₁	60.54	85.23	13.28	25.71	3.92	14.77	42.31
P ₂	61.99	85.64	13.49	25.36	4.02	14.36	42.77
P ₃	47.90	86.68	18.68	24.94	4.91	13.32	38.15

Note: Calculation based on proximate analysis of Animal Nutrition and Diet Science Laboratory, Faculty of Animal Science, Jenderal Soedirman University in 2022. NNFE: non nitrogen free extract; P₁= Ammoniated rice straw + Concentrate feed; P₂= Ammoniated rice straw + Concentrate feed + Sodium bicarbonate; P₃= Ammoniated rice straw + Concentrate feed fermented with *S. cerevisiae* + Sodium bicarbonate

RESULTS AND DISCUSSION

Protein consumption

The nutritional composition of feed plays a crucial role in determining its quality and digestibility, which directly impacts livestock productivity. The proportion of feed ingredients provided to sheep influences the balance of protein and energy sources (Winarti et al., 2017). In addition to meeting nutrient requirements, sheep productivity is also affected by feed intake (Saputro et al., 2016). In this study, the average dry matter feed intake was 767 ± 83.00 g/head/day (Table 2). According to Wijaya et al. (2016), dry matter intake is closely related to the consumption of essential nutrients, including protein, which contributes to overall growth and performance. Protein consumption in sheep is influenced by both the protein content of the feed and overall feed intake (Muktiani et al., 2013). In this study, the average protein consumption ranged from 127.38 to 161.11

g/head/day (Table 2, Figure 1). This value is higher than the findings of Sauri et al. (2022), who reported that sheep fed a basal diet (80%) supplemented with fermented concentrate (20%) had an average crude protein intake of 76.26 ± 19.32 g/head/day.

The highest average protein consumption was observed in P₃, which received ammoniated rice straw, fermented concentrate, and sodium bicarbonate. In contrast, the average protein consumption in P₁ was not significantly different from that in P₂. These results align with the protein consumption standards for sheep set by the National Research Council (NRC, 1985), which indicate that to achieve a daily weight gain of 200–250 g/head/day, sheep require 127–167 g of protein per day. The average protein consumption in this study was higher than that reported by Sauri et al. (2022), where sheep fed a diet consisting of 80% basal feed and 20% fermented concentrate

consumed an average of 100.82 g of crude protein per head per day.

The analysis of variance indicated that the dietary treatment had a highly significant effect ($P<0.01$) on protein consumption. Furthermore, the Honestly Significant Difference (HSD) test revealed that the average protein consumption of sheep fed sodium bicarbonate and fermented concentrate (P3) was significantly higher ($P<0.01$) than that of sheep in the control group (P1), which did not receive sodium bicarbonate or fermented concentrate. The fermentation of concentrate and the addition of sodium bicarbonate increased protein consumption by 24.33%. *S. cerevisiae* used in concentrate fermentation modifies the feed structure, making it simpler and more accessible to rumen microbes, as evidenced by an increase in crude protein content and a reduction in crude fiber (Hernaman et al., 2017). Additionally, *S. cerevisiae* enhances the population of beneficial microbes in

the rumen, optimizing nutrient consumption and digestibility (Fallo et al., 2024).

Fermented concentrate has an appealing aroma that enhances palatability, leading to increased feed intake. According to Gultom et al. (2016), feed intake level influences overall consumption and, consequently, protein intake. The highest average dry matter feed intake was observed in P1 at 812.56 ± 58.15 g/head/day (Table 2). The analysis of variance showed that dietary treatment had a highly significant effect on dry matter intake ($P<0.01$). The HSD test further indicated that sheep in the control group (P1), which did not receive sodium bicarbonate or fermented concentrate, had significantly higher ($P<0.01$) dry matter intake compared to those in P3. The lower dry matter content in the fermented concentrate is attributed to the additional water required during the fermentation and steaming process.

Table 2. Table of research results

Treatment	pH	Feed Consumption (DM) (g/head/day)	Protein Consumption (g/head/day)	Nitrogen Retention (g/head/day)
P ₁	5.42 ± 0.15^a	812.56 ± 58.15^b	129.58 ± 10.84^a	84.51 ± 5.50^a
P ₂	5.74 ± 0.18^a	773.78 ± 113.90^a	127.38 ± 15.46^a	83.65 ± 7.59^a
P ₃	5.80 ± 0.09^b	715.64 ± 36.88^a	161.11 ± 5.32^b	117.16 ± 12.46^b
Average	5.65 ± 0.21	767.33 ± 83.00	139.36 ± 19.09	95.10 ± 18.14

Note: ^{ab} superscript with different letters in the same column indicates difference at ($P<0.01$) P₁= Ammoniated rice straw + concentrate; P₂= P₁ + Sodium Bicarbonate; P₃= Ammoniated rice straw + Concentrate fermented with *S. cerevisiae* + Sodium bicarbonate; DM: dry matter

Despite the lower dry matter intake, sheep fed fermented concentrate with *S. cerevisiae* exhibited higher protein consumption. This can be explained by the higher crude protein content in the fermented concentrate (18.68%) compared to the unfermented concentrate (13.28%) (Table 1). According to Sairullah et al. (2017), feed with high crude protein content enhances protein intake in sheep and maximizes nitrogen availability for rumen microbes. In addition to accelerating fermentation, *S. cerevisiae* is a facultative anaerobe that utilizes oxygen in the rumen, thereby promoting anaerobic conditions (Hanafi et al., 2015). This anaerobic environment facilitates the efficient utilization of ammonia and lactic acid, contributing to rumen pH stability (Puastuti, 2009). The inclusion of sodium bicarbonate in high-concentrate diets appears to be effective in maintaining optimal rumen pH, allowing rumen microbes to function more efficiently. The results showed that the average rumen fluid pH was 5.65 ± 0.21 (Table 2).

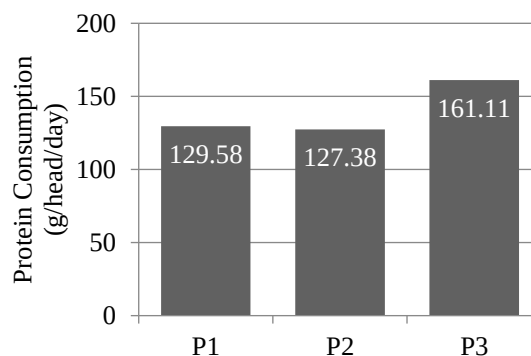


Figure 1. Average protein consumption

The analysis of variance demonstrated that sodium bicarbonate supplementation had a highly significant effect ($P<0.01$) on rumen fluid pH. The HSD test further confirmed that sheep supplemented with sodium bicarbonate exhibited a significant increase in rumen fluid pH ($P<0.01$). According to Widyaningtiyas et al. (2022), sodium bicarbonate is a key component of saliva that acts as a buffer, stabilizing rumen pH and creating favorable conditions for anaerobic microorganisms. Normal rumen pH ranges from

6.3 to 7 (Hernaman et al., 2017). At a pH of 5.5–6.2, cellulolytic and hemicellulolytic bacterial activity is inhibited, while amylolytic bacterial activity increases, leading to reduced fiber digestibility (Rahalus et al., 2014). Furthermore, amylolytic bacteria exhibit strong proteolytic activity, and an increase in their activity can be associated with enhanced protein digestibility and consumption (Suryani et al., 2015).

Nitrogen Retention

The measurement of nitrogen retention is essential to determine the amount of nitrogen retained in the body. Additionally, nitrogen retention serves as an indicator of feed quality, particularly in assessing protein utilization (Hanun et al., 2018). In this study, the average nitrogen retention in sheep that did not receive sodium bicarbonate or fermented concentrate (P1) was 84.51 ± 5.50 g/head, which was slightly higher than that of sheep supplemented with sodium bicarbonate but fed unfermented concentrate (P2) at 83.65 ± 7.59 g/head. However, the highest nitrogen retention was observed in sheep receiving both sodium bicarbonate and fermented concentrate (P3), with an average of 117.16 ± 12.46 g/head (Table 2, Figure 2). The nitrogen retention values obtained in this study were significantly higher than those reported by Puastuti et al. (2012), where sheep fed fish meal exhibited an average nitrogen retention of 17.11 g/head. The substantial increase in nitrogen retention in P3 suggests that the combination of sodium bicarbonate and fermented concentrate enhances nitrogen utilization efficiency. This improvement can be attributed to the role of *S. cerevisiae* in breaking down complex feed components, making nutrients more accessible for rumen microbial synthesis and absorption.

Additionally, the buffering effect of sodium bicarbonate helps maintain an optimal rumen environment, further supporting efficient protein metabolism. The combination of fermented concentrate feed and sodium bicarbonate supplementation is believed to enhance the quality of sheep feed. This is reflected in the significantly higher nitrogen retention observed in sheep treated with sodium bicarbonate and fermented concentrate (P3), which aligns with the increased protein consumption in this group. A higher nitrogen retention value indicates improved efficiency in crude protein metabolism in sheep (Suharlina et al., 2019). Nitrogen retention is determined by the balance between nitrogen intake and nitrogen excretion. If a large amount of

nitrogen is retained in the body, it suggests a more efficient utilization of dietary nitrogen by livestock (Doko et al., 2024).

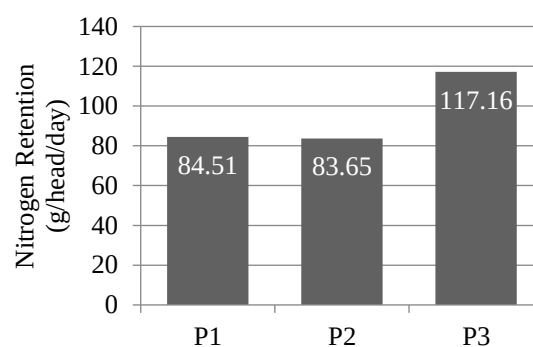


Figure 2. Mean nitrogen retention

The average nitrogen retention in sheep supplemented with sodium bicarbonate and fermented concentrate was significantly higher ($P < 0.01$) compared to sheep receiving unfermented concentrate without sodium bicarbonate. The increase in nitrogen retention in the P3 group was 38.64% higher than in the control group. However, the results of the Honestly Significant Difference (HSD) test showed no significant difference in nitrogen retention between sheep fed unfermented concentrate (P1) and those fed fermented concentrate with sodium bicarbonate (P2). This finding is consistent with Murniastuti et al. (2012), who stated that the absence of significant differences suggests similar efficiency in protein retention among treatments. Additionally, the nutrient composition of the feed in P1 and P2 was similar, leading to comparable protein intake levels (Table 1).

All treatments in this study resulted in positive nitrogen retention values, indicating that nitrogen utilization in the sheep's body was effective and that protein metabolism was efficient. According to Ndaru et al. (2014), a positive nitrogen retention value signifies that nitrogen intake exceeds nitrogen excretion. The retained nitrogen is utilized for growth and tissue formation. The level of protein consumption directly influences nitrogen retention, as undigested nitrogen excreted in feces represents protein that was not degraded in the rumen or absorbed in the small intestine (Rimbawanto et al., 2020). Another factor influencing nitrogen retention is the balance between dietary protein and energy availability in the body.

CONCLUSION

The supplementation of sodium bicarbonate and the use of concentrate feed fermented with *Saccharomyces cerevisiae* yielded the best results, increasing protein consumption by 24.33% and nitrogen retention by 38.64%.

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