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Effects of fermentation time of natural-pasture-based total mixed ration on slaughter performance and organ development of sheep

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Abstract

Fermenting total mixed rations (FTMR) is an important method for changing traditional extensive livestock farming practices, improving animal health, and enhancing the quality of livestock products. It offers several advantages, including a wide source of feed raw materials, a long and safe storage time, labour and time savings and providing nutritionally balanced feed for pastoralists throughout the year. However, the existing data are insufficient about how FTMR with different fermentation durations affect animal performance and health. Therefore, this study aims to evaluate the effect of natural forage silage-based FTMR with different fermentation durations on production and health of sheep. In Hulunbuir, total mixed rations were formulated with natural forage silage on a fresh weight basis, and fermented for 0 day, 10 days and 20 days respectively. Eighteen sheep were selected and randomly divided into three groups of six sheep. The three groups were fed TMR (CK), FTMR fermented for 10 days (FTMR1) and FTMR fermented for 20 days (FTMR2) over a period of 75 days, respectively. Results showed no significant differences in carcass weight, carcass yield, longissimus dorsi muscle (LDM) area and GR value among the groups (P>0.05). The FTMR2 group had a significantly higher spleen weight and proportions to carcass weight than the other groups, with no significantly differences between CK and FTMR1. Other organ weights and proportions to carcass weight showed no significant differences (P>0.05). In conclusion, FTMR provides similar effects to TMR without harming organs. FTMR fermented for 20 days promotes spleen development and immune function, benefiting livestock health.

Introduction

In the Mongolian Plateau, native grass serves as the primary fodder source for livestock production. Apart from making hay, ensiling native grass is seen as an emerging new trend (Hou et al., 2023; Y. Li et al., 2022). Total mixed ration is an ideal method for meeting the growth requirements of livestock by combining native grass silage with other roughage, concentrates, vitamins, and minerals. It can reduce selective feeding, increase dry matter intake, and stabilize the rumen internal environment, compared with the traditional feeding model (Beigh et al., 2016; Bharanidharan et al., 2021). However, TMR is susceptible to aerobic spoilage (Seppälä et al., 2013), and requires a high level of mechanization in the production process (Bueno et al., 2020). These factors limit the circulation and promotion of TMR, especially in some Asian countries. Currently, in Asian countries, livestock farming operates at a household or small-scale farm basis is typical. Due to constraints in funds, technical knowledge, and production equipment, farmers find it is challenging to adopt TMR for livestock feeding.

Nevertheless, fermented total mixed ration (FTMR) can save labour in the TMR preparation process, enabling long-term storage and distant distribution of TMR (Weinberg et al., 2011). Compared with TMR, FTMR improves the aerobic stability (Wang et al., 2016) and nutrient digestibility of the diet (Miyaji et al., 2017), while reducing methane emissions (Cao et al., 2010).

Throughout the FTMR distribution process, farmers often purchase and store large quantities of FTMR at once. In this process, the nutritional composition of FTMR could be influenced by factors such as raw material composition, storage time, and storage conditions. Studies indicate obvious changes in the soluble protein and soluble sugar fractions in FTMR; solubilization of the protein fraction in FTMR is enhanced with prolonged storage and higher storage temperatures, while most soluble sugars are lost during the fermentation process (Weinberg et al., 2011). However, the existing data are insufficient about how FTMR with different fermentation durations affect animal performance and health. Therefore, this study aims to evaluates the effects of natural forage silage-based FTMR with different fermentation durations on production and health of sheep.

Methods

Animals, diets, and experimental design

Eighteen sheep of similar weight (33.55 ± 0.86 kg) were randomly divided into three groups of six head. The groups were fed either a total mixed ration (CK), a short term fermented total mixed ration (FTMR1, fermentation time for 10 days), or a long-term fermented total mixed ration (FTMR2, fermentation time is 20 days). Total mixed rations were formulated according to the nutrient requirement of a meat-type sheep (NY/T816-2021). The main components of the native pasture species are *Leymus chinensis*, *Bromus inermis*, *Potentilla bifurca*, *Astragalus laxmannii*, and *Artemisia argy*i. The experiment lasted for 75 days, including a 14-day pre-feeding period and a 60-day formal study period. The pre-feeding period was the same as the test period in terms of feeding management and formula composition. The animals were fed twice a day at 08:00 and 18:00, with free access to water.

At the termination of the experiment, sheep were then slaughtered using commercial methods. The sheep were weighed (LWBS) after fasting for 12 h before being processed for slaughter. Carcase weight was recorded after removal of the hide, head, hooves and viscera. The heart, liver, spleen, lung and kidney were separated, and the proportion of each organ weighed. An organ weight to LWBS index was calculated. The GR value was measured by vernier caliper to measure the tissue thickness between the 12th and 13th ribs of sheep at the 110 mm from the midline of the dorsal spine. Eye muscle area (EMA) was the cross-sectional area of the LDM between the 12th and 13th ribs of the carcass.

Data were analyzed using Excel 2021 to calculate means and standard errors, and SPSS 25.0 software was employed for statistical analysis. Multiple comparisons of measured data were conducted using Tukey's method.

Results

The effects of TMR fermented for different durations on the slaughter performance of meat sheep are shown in Table 1. No statistically significant differences ($P > 0.05$) were observed among the three treatment groups for any of the indicators. However, the groups fed fermented total mixed rations (FTMR) showed higher live weight before slaughter, carcass weight, and slaughter yield compared to the group fed non-fermented TMR.

The effects of TMR fermented for different durations on the organ development of meat sheep are shown in Table 2. The FTMR2 group exhibited significantly greater spleen weight and spleen index when compared with CK and FTMR1, while no statistically significant differences were found between the TMR and FTMR1 groups. For the other organs, there were no significant differences in organ weight or their proportion to carcass weight among the three treatment groups ($P > 0.05$).

Table 1 Effects of FTMR with different fermentation duration on the slaughter performance of sheep

Item	CK	FTMR1	FTMR2	SEM	*P*-value
LWBS (kg)	41.45	42.10	43.83	1.53	0.711
Carcass weight (kg)	17.69	18.09	19.78	0.79	0.602
Carcass yield (%)	42.64	43.01	45.11	0.86	0.534
EMA (cm^2)	18.88	19.41	16.15	0.15	0.622
GR value (mm)	4.30	5.63	5.27	0.31	0.165

EMA = Eye muscle area of the longissimus dorsi.

In the same row, mean values with different superscripts were significantly different ($P < 0.05$).

Table 2 Effects of FTMR with different fermentation duration on organ development of sheep

Item	CK	FTMR1	FTMR2	SEM	*P*-value
Organ weight (g)					
Heart	229.50	231.75	269.33	4.84	0.366
Liver	495.00	564.00	535.33	18.21	0.365
Spleen	39.50b	45.75b	59.67a	21.86	0.010
Lung	419.50	427.75	510.00	19.55	0.082
Kidney	96.75	102.75	109.00	6.08	0.530
Percentage relative to empty BW[1], (g/kg)					
Heart	5.85	5.91	6.87	0.95	0.366
Liver	12.63	14.39	13.66	1.14	0.365
Spleen	1.01	1.17	1.52	0.25	0.010
Lung	10.70	10.91	13.01	1.02	0.082
Kidney	2.47	2.62	2.78	0.32	0.530

In the same row, mean values with different superscripts were significantly different ($P < 0.05$).

[1] Percentage relative to empty BW (%) = (the organ weight/empty BW) × 100%.

Discussion

Slaughter performance is a direct reflection of the production efficiency of livestock, serving as a key indicator of their economic value. Common metrics for assessing slaughter performance include carcass yield, EMA and the GR value. The EMA is an indicator of carcass quality, while the GR value serves as an indicator of carcass fat cover. In the present study, no significant differences were observed in slaughter yield, eye muscle area, or GR values across different treatment groups, suggesting that feeding meat sheep with fermented total mixed rations (TMR) yields results comparable to those achieved with non-fermented TMR.

Visceral organs play a fundamental role in an animal's metabolism. The weight and organ index of these organs reflect the animal's metabolic and developmental status. Under normal circumstances, organ development is closely coordinated with overall growth (Su et al., 2022). In this study, with the exception of the spleen, there were no significant differences in the weight and organ index of other organs between treatment groups, indicating that TMR fermented for varying durations does not adversely affect organ development. The spleen, a primary site for immune cell generation, differentiation, maturation, and immune responses, is crucial for immune function. Notably, the FTMR2 group exhibited a significant increase in both spleen weight and spleen index, suggesting that long-term fermentation of TMR promotes spleen development in sheep. Previous research has shown that lactic acid bacteria can significantly enhance spleen development in livestock (Sun et al., 2024), likely due to their proliferation during the fermentation process. As probiotics, lactic acid bacteria produce a range of bioactive

compounds, including organic acids, short-chain fatty acids, and extracellular polysaccharides(A. Li et al., 2024), which may modulate the immune system and bolster immune responses (Vieco-Saiz et al., 2019).

The study demonstrates that FTMR maintains comparable slaughter performance to TMR in meat sheep while enhancing spleen development.

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