# Effects of Baled Forage Sweet Sorghum Silage on Production Performance and Serum Parameters in Meat Sheep (Postprint)

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## Abstract

This experiment aimed to investigate the effects of forage sweet sorghum wrapped silage on the production performance and serum indices of meat sheep, in order to evaluate the feeding efficacy of forage sweet sorghum wrapped silage for meat sheep. The trial selected 14 Small-tailed Han sheep [(25.70±1.50) kg] and 14 Dorper sheep [(33.40±1.68) kg] ewes aged 3-4 months as experimental animals, which were divided into Dorper sheep sweet sorghum silage group (DG group, n=7), Dorper sheep corn silage group (DY group, n=7), Small-tailed Han sheep sweet sorghum silage group (HG group, n=7), and Small-tailed Han sheep corn silage group (HY group, n=7) based on different roughage sources in the diet. The feeding trial lasted for 3 months, with body weight measurement and blood collection conducted on the mornings of days 30, 60, and 90 of the trial. The results showed: 1) The average daily feed intake (ADFI) and average daily gain (ADG) of the corn silage group (DY group + HY group, n=14) were extremely significantly higher than those of the sweet sorghum silage group (DG group + HG group, n=14) ($P<0.01$). 2) During the trial period, the serum total antioxidant capacity (T-AOC) of the Dorper sheep group (DG group + DY group, n=14) was significantly higher than that of the Small-tailed Han sheep group (HG group + HY group, n=14) ($P<0.05$); on day 60 of the trial, the serum malondialdehyde (MDA) content of the Dorper sheep group was significantly lower than that of the Small-tailed Han sheep group ($P<0.05$); on day 90 of the trial, the serum superoxide dismutase (SOD) activity of the sweet sorghum silage group was significantly higher than that of the corn silage group ($P<0.05$); on day 90 of the trial, the serum MDA content of the HY group was significantly higher than that of the DY group and HG group ($P<0.05$); the serum SOD activity of the sweet sorghum silage group on days 60 and 90 of the trial was significantly higher than that on day 30 of the trial ($P<0.05$). 3) Serum urea nitrogen (UN) content and glutamic-pyruvic transaminase (GPT)

and alkaline phosphatase (AKP) activities showed significant breed effects on days 60, 90, and 60 of the trial, respectively (P<0.05); serum -hydroxybutyric acid (BHBA) content and glutamic-oxaloacetic transaminase (GOT) and AKP activities showed significant treatment effects on day 90, days 30 and 90, and day 60 of the trial, respectively (P<0.05); the serum GOT and AKP activities of the HY group on day 90 of the trial were significantly higher than those on day 30 of the trial (P<0.05). In conclusion, the production performance of meat sheep fed diets containing corn wrapped silage was superior to that of meat sheep fed diets containing forage sweet sorghum wrapped silage; however, long-term fattening of meat sheep with silage poses safety risks, whereas forage sweet sorghum wrapped silage compared with corn wrapped silage is beneficial for improving liver health and reducing the incidence of diseases such as hyperlipidemia and systemic ketosis acidosis, thereby reducing safety risks.

## Full Text

# Effects of Packaged Forage Sweet Sorghum Silage on Growth Performance and Serum Indices of Mutton Sheep

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### Abstract

This study investigated the effects of packaged forage sweet sorghum silage on growth performance and serum indices of mutton sheep to evaluate its feeding efficacy. Twenty-eight female sheep—fourteen 3- to 4-month-old Small-tailed Han sheep [(25.70±1.50) kg] and fourteen 3- to 4-month-old Dorper sheep [(33.40±1.68) kg]—were allocated to four groups based on dietary roughage: Dorper sheep with sweet sorghum silage (DG group, n=7), Dorper sheep with corn silage (DY group, n=7), Small-tailed Han sheep with sweet sorghum silage (HG group, n=7), and Small-tailed Han sheep with corn silage (HY group, n=7). The feeding trial lasted 90 days, with body weight measurements and blood sampling conducted on days 30, 60, and 90. The results showed: (1) The corn silage group (DY + HY, n=14) exhibited significantly higher average daily feed intake (ADFI) and average daily gain (ADG) compared to the sweet sorghum silage

group (DG + HG, n=14) (P<0.01). (2) Throughout the trial, the Dorper sheep group (DG + DY, n=14) showed significantly higher serum total antioxidant capacity (T-AOC) than the Small-tailed Han sheep group (HG + HY, n=14) (P<0.05). On day 60, serum malondialdehyde (MDA) content in Dorper sheep was significantly lower than in Small-tailed Han sheep (P<0.05). On day 90, serum superoxide dismutase (SOD) activity in the sweet sorghum silage group was significantly higher than in the corn silage group (P<0.05), while serum MDA content in the HY group was significantly higher than in both DY and HG groups (P<0.05). Additionally, serum SOD activity in the sweet sorghum silage group on day 90 was significantly higher than on day 30 (P<0.05). (3) Significant breed effects were observed for serum urea nitrogen (UN) content on day 60, glutamic-pyruvic transaminase (GPT) activity on day 90, and alkaline phosphatase (AKP) activity on day 60 (P<0.05). Significant treatment effects were found for serum  -hydroxybutyrate (BHBA) content on day 90, glutamic-oxaloacetic transaminase (GOT) activity on days 30 and 90, and AKP activity on day 60 (P<0.05). On day 90, serum GOT and AKP activities in the HY group were significantly higher than on day 30 (P<0.05). In conclusion, mutton sheep fed diets containing packaged corn silage demonstrated superior growth performance compared to those fed packaged forage sweet sorghum silage. However, long-term fattening with silage-based diets poses potential health risks. Packaged forage sweet sorghum silage appears more beneficial for liver health, reducing the incidence of hyperlipidemia and ketosis, thereby mitigating safety risks compared to corn silage.

**Keywords:** forage sweet sorghum; corn; packaged silage; mutton sheep; growth performance; serum indices

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## Introduction

Forage sweet sorghum (*Sorghum bicolor* L. Moench) is recognized as a high-energy crop due to its drought resistance, waterlogging tolerance, salinity adaptation, rapid growth, efficient sugar accumulation, and high biomass yield. Under drought conditions, its biomass production exceeds that of corn silage by 0.5–1.0 times, making it particularly suitable for semi-arid regions. In recent years, sweet sorghum has been widely cultivated in northwestern China' s arid zones and partially utilized in animal production. However, occasional poisoning incidents during consumption of young sweet sorghum plants have negatively impacted its application, despite these cases being related to variety selection, processing methods, and feeding techniques. In grassland-livestock production, silage technology is extensively employed to alleviate forage supply pressure, extend storage duration, and reduce harmful components. Stretch film wrapping represents the world' s most advanced silage technology, offering convenient transportation and rapid market circulation, and has been widely adopted globally. As a novel forage resource, packaged forage sweet sorghum silage is mass-produced by some forage enterprises, yet its safety and scientific feeding

protocols for mutton sheep fattening remain unstudied, limiting its application in sheep farming.

The Loess Plateau hilly-gully region of central Gansu has vigorously developed its mutton sheep industry, introducing breeds such as Small-tailed Han sheep and Dorper sheep. These breeds exhibit distinct adaptive characteristics: Dorper sheep feature high lambing rates, rapid early growth, and superior carcass quality, while Small-tailed Han sheep are known for high fecundity, roughage tolerance, and adaptation to dry climates. However, systematic research on the fattening effects and health status of these breeds when fed novel forage sweet sorghum silage is lacking. Therefore, this study utilized packaged forage sweet sorghum silage and corn silage as primary roughage sources, supplemented with concentrate, to investigate the health status and growth performance of fattening mutton sheep through performance measurements and serum index analysis, thereby providing data for the scientific application of forage sweet sorghum in sheep production.

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### 1.1 Experimental Diets

Packaged forage sweet sorghum silage was purchased from the Gansu Provincial Academy of Mechanical Sciences, while packaged corn silage and alfalfa pellets were obtained from Gansu Minxiang Forage Co., Ltd. The corn silage was processed by shredding, whereas the sweet sorghum silage was chopped transversely. Nutrient compositions of these three roughage sources are presented in . The composition and nutrient levels of the concentrate supplement are shown in .

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### 1.2 Experimental Animals and Management

The feeding trial was conducted from July to October 2016 at Xiangtai Farm in Dingxi City, Gansu Province. Twenty-eight female sheep—fourteen 3- to 4-month-old Small-tailed Han sheep [(25.70±1.50) kg] and fourteen 3- to 4-month-old Dorper sheep [(33.40±1.68) kg]—were selected and divided into four groups based on dietary roughage: Dorper sheep with sweet sorghum silage (DG group, n=7), Dorper sheep with corn silage (DY group, n=7), Small-tailed Han sheep with sweet sorghum silage (HG group, n=7), and Small-tailed Han sheep with corn silage (HY group, n=7). For breed comparisons, DG and HG groups were combined as the sweet sorghum silage group (n=14), while DY and HY groups formed the corn silage group (n=14). For treatment comparisons (silage type), DG and DY groups were combined as the Dorper sheep group (n=14), while HG and HY groups formed the Small-tailed Han sheep group (n=14).

Sheep were housed individually with ad libitum water access. The 90-day trial included blood sampling and weighing on days 30, 60, and 90. The diet consisted of silage (offered ad libitum), alfalfa pellets (1.0% of body weight), and

concentrate supplement (0.5% of body weight). Alfalfa pellets and concentrate were mixed and fed in equal portions at 07:30 and 17:30 daily.

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#### 1.3.1 Performance Metrics

**Average Daily Gain (ADG):** Sheep were weighed at the trial' s onset and on days 30, 60, and 90 to calculate ADG for each group.

**Average Daily Feed Intake (ADFI):** Feed offered and refusals were recorded daily at 07:30 to calculate ADFI.

**Feed-to-Gain Ratio (F/G):** Calculated as the ratio of ADFI to ADG.

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#### 1.3.2 Serum Indices

Blood samples (10 mL) were collected via jugular venipuncture before morning feeding on days 30, 60, and 90. Samples were centrifuged at 3,000 rpm for 15 minutes, and serum was aliquoted into 1.5 mL tubes and stored at -20°C for analysis. Serum urea nitrogen (UN), total cholesterol (T-CHO), -hydroxybutyrate (BHBA), creatinine (CR), glutamic-oxaloacetic transaminase (GOT), glutamic-pyruvic transaminase (GPT), alkaline phosphatase (AKP), superoxide dismutase (SOD), malondialdehyde (MDA), and total antioxidant capacity (T-AOC) were measured using a Gen5 microplate reader according to kit instructions (Nanjing Jiancheng Bioengineering Institute).

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### 1.4 Statistical Analysis

Data were preliminarily processed using Excel 2010 and analyzed via SPSS 19.0 software. One-way ANOVA was performed, with LSD post-hoc tests for multiple comparisons. Results are expressed as mean ± standard deviation, with P 0.05 considered significant and $P<0.01$ considered highly significant.

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### 2.1 Effects of Packaged Forage Sweet Sorghum Silage on Growth Performance

As shown in , the corn silage group exhibited significantly higher ADFI than the sweet sorghum silage group at all trial stages ($P<0.01$), with Dorper sheep showing significantly higher ADFI than Small-tailed Han sheep ($P<0.01$). ADG was also significantly higher in the corn silage group throughout the trial ($P<0.01$). The feed-to-gain ratio was significantly lower for the corn silage group on days 30

and 90 (P<0.05). On days 60 and 90, the DY group had the highest ADFI, significantly exceeding all other groups (P<0.05), followed by DG and HY groups, which were significantly higher than the HG group (P<0.05).

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### 2.2 Effects on Serum Antioxidant Indices

As presented in , serum SOD activity, T-AOC, and MDA content across all sheep ranged from 79.43–118.44 U/mL, 0.20–0.35 U/mL, and 4.07–5.17 nmol/mL, respectively. Significant breed effects were observed for serum T-AOC on days 30, 60, and 90 (P<0.05), and for MDA content on day 60 (P<0.05). A significant treatment effect was detected for serum SOD activity on day 90 (P<0.05). On day 30, serum MDA content in the HY group was significantly higher than in DY and HG groups (P<0.05). Serum SOD activity in DG and HG groups was significantly higher on days 60 and 90 compared to day 30 (P<0.05). Serum T-AOC in DG and HG groups was significantly higher on day 90 versus days 30 and 60 (P<0.05), whereas the HY group showed significantly higher T-AOC on days 30 and 90 compared to day 60 (P<0.05).

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### 2.3 Effects on Serum Biochemical Indices

As shown in , serum UN, T-CHO, BHBA, and CR contents, along with GOT, GPT, and AKP activities, ranged from 2.78–5.84 mmol/L, 1.74–2.68 mmol/L, 0.30–0.57 mmol/L, 567.37–575.11  mol/L, 5.12–13.89 U/L, 8.72–14.72 U/L, and 246.18–449.65 U/L, respectively. Significant breed effects were found for serum UN content on day 60, GPT activity on day 90, and AKP activity on day 60 (P<0.05). Significant treatment effects were observed for serum BHBA content on day 90, GOT activity on days 30 and 90, and AKP activity on day 60 (P<0.05). On day 30, serum BHBA content in the DY group was significantly higher than in all other groups (P<0.05). Serum UN content in all groups was significantly lower on day 90 compared to days 30 and 60 (P<0.05). Serum T-CHO content in the DY group was significantly higher on day 90 versus days 30 and 60 (P<0.05). Serum GOT activity in the HG group was significantly higher on day 60 compared to days 30 and 90 (P<0.05), while serum GOT and AKP activities in the HY group were significantly higher on day 90 than on day 30 (P<0.05).

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### 3.1 Impact on Growth Performance

Under our experimental conditions, the two silage types produced significantly different effects on growth performance across breeds. Beyond breed differences, this disparity relates closely to dietary composition and processing methods. As

shown in , the corn silage contained approximately four times the starch content of sweet sorghum silage, while sweet sorghum silage had about 1.2 times higher neutral detergent fiber and acid detergent fiber contents. This composition likely enhanced palatability and digestibility of corn silage, representing a primary reason for the lower intake and inferior fattening performance in the sweet sorghum group. Additionally, Dorper sheep exhibited higher intake than Small-tailed Han sheep during mid (days 31–60) and late (days 61–90) periods, possibly due to their faster development, larger body size, and superior digestive capacity. In summary, Dorper sheep outperformed Small-tailed Han sheep in both intake and weight gain, and corn silage diets yielded better growth performance than sweet sorghum silage diets.

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### 3.2 Impact on Antioxidant Capacity

Antioxidant defense system strength correlates directly with health status, comprising enzymatic and non-enzymatic components. SOD is a crucial antioxidant enzyme maintaining redox balance by preventing oxidative stress-induced cellular damage, making serum SOD activity an indirect indicator of free radical scavenging capacity. MDA, the final product of lipid peroxidation initiated by free radical attack on polyunsaturated fatty acids, can cross-link membrane lipids and proteins, impairing membrane protein function and causing cellular dysfunction. Thus, serum MDA content reflects lipid peroxidation extent and indirectly indicates cellular damage severity. T-AOC represents a comprehensive antioxidant capacity index reflecting combined enzymatic and non-enzymatic actions. Literature values for sheep serum SOD activity, T-AOC, and MDA content range from 56–136 U/mL, 0.1–0.7 U/mL, and 2.0–6.0 nmol/mL, respectively—all within our observed ranges. Notably, as feeding duration increased, both Dorper and Small-tailed Han sheep in the sweet sorghum groups showed significantly elevated serum SOD activity, while corn silage groups remained unchanged. A similar trend occurred for serum T-AOC in Dorper sheep fed sweet sorghum silage, indicating that sweet sorghum silage enhances antioxidant capacity, particularly in high-performance breeds. This effect may stem from sweet sorghum' s high flavonoid and vitamin C content in leaf mesophyll and strong SOD activity in leaf veins, with antioxidant compounds peaking during mid-to-late development stages.

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### 3.3 Impact on Serum Biochemical Indices

Serum biochemical indices comprehensively reflect nutrient metabolism, internal homeostasis, and health status. These parameters, primarily enzymes and proteins, indicate changes in cell permeability and organ function. All measured indices in this study fell within reported normal ranges.

Serum UN, the main product of protein metabolism, reflects protein metabolic

function. Lower UN content typically indicates better amino acid balance and higher protein synthesis efficiency. UN content correlates negatively with nitrogen deposition rate and crude protein utilization. The significant time effect observed for serum UN suggests that extended feeding improved protein synthesis rates. On day 60, Small-tailed Han sheep showed lower UN content than Dorper sheep, consistent with their reduced intake and potentially insufficient protein intake.

Serum T-CHO content reflects lipid metabolism status. Hepatocellular damage elevates blood cholesterol, causing hyperlipidemia. While no significant breed or treatment effects were observed, all groups exhibited increased T-CHO by trial' s end, with the DY group showing a significant time effect. This indicates that long-term silage-based fattening carries hyperlipidemia risks, particularly with corn silage.

BHBA, comprising 78% of blood ketone bodies, reflects ketogenesis and serves as a sensitive marker for ketoacidosis. The significant treatment effect on day 90, with lower BHBA in sweet sorghum groups, suggests that sweet sorghum silage reduces ketoacidosis risk.

Serum CR, a muscle metabolism product, remains relatively constant and depends primarily on renal excretion. All groups maintained normal CR levels with no significant effects, consistent with literature reports.

GOT and GPT are crucial transaminases mediating non-essential amino acid and protein catabolism, serving as important indicators of hepatic protein synthesis capacity and liver function. Elevated serum transaminase activity signals liver damage, while healthy animals show no dietary nutrient level-induced changes. The significantly lower serum GOT activity in sweet sorghum groups, coupled with the increasing-then-decreasing pattern in HG group and the late-period elevation in HY group, indicates that sweet sorghum silage better supports liver health compared to corn silage.

AKP, a non-specific phosphomonoesterase isoenzyme, catalyzes phosphate hydrolysis and transfer reactions. Serum AKP originates primarily from liver and bone, serving diagnostic value for obstructive jaundice, hepatic carcinoma, and cholestatic hepatitis. Elevated AKP activity also indicates bone development and calcium-phosphorus metabolism. The linear increase in serum AKP activity over time, with significant late-period elevation in the HY group, suggests that long-term corn silage feeding more sensitively impacts liver health and bone metabolism.

In conclusion, compared to corn silage, packaged forage sweet sorghum silage benefits liver health, reduces hyperlipidemia and ketoacidosis incidence, and thereby decreases safety risks. While suitable for mutton sheep fattening, further research is needed on its effects on rumen function, meat quality, and synergistic relationships with variety breeding and feed processing.

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## 4 Conclusions

1. Mutton sheep fed diets containing packaged corn silage exhibited superior growth performance compared to those fed packaged forage sweet sorghum silage.
2. Long-term silage-based fattening poses safety risks. However, packaged forage sweet sorghum silage promotes better liver health and reduces the incidence of hyperlipidemia and ketoacidosis compared to corn silage, thereby mitigating safety risks.

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*Note: Figure translations are in progress. See original paper for figures.*