# PRODUCTION AND QUALITY OF FORAGE SILAGES FROM DROUGHT-TOLERANT CROPS

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## ABSTRACT

The study focuses on the production and quality of forage silages from drought-tolerant crops, with emphasis on sorghum (cv. Tarzan). The aim was to evaluate fermentation characteristics and silage quality using a biological additive (soluble Lactobacillus paracasei DSM 16245, Lactococcus lactis NCIMB 30160, Pediococcus acidilactici DSM 16243, concentration $1.25 \times 10^{11}$, carrier lactose) applied at 1 mL/kg and a chemical additive (composed of propionic acid, formic acid, and glycerol) applied at 8 mL/kg in comparison with a control. The results showed that the highest dry matter losses occurred in the chemically treated silage (1.19%), while the control and biological variants had lower losses (0.64–0.74%). The biological additive enhanced lactic acid production, resulting in a lower pH and improved fermentation. All variants showed good silage quality with low proteolysis. Sorghum silages represent a suitable alternative roughage source, particularly under drought conditions, while appropriate ensiling practices and additive selection significantly influence their quality.

## INTRODUCTION

Climate change and global warming are increasingly forcing farmers to adapt crop production systems. The importance of drought-tolerant species is growing, as they can thrive under adverse conditions such as water deficiency, extreme temperatures, and poor soil quality. In drier regions, traditional crops (e.g., maize) are increasingly being replaced by sorghum, Sudan grass, and their hybrids, which provide stable biomass yields.

These crops have deep root systems, lower water requirements, and favourable nutritive value. Their silages are suitable for feed rations, support rumen function and digestion in ruminants, and contribute to the stability of livestock production even during drought periods.

Among the most promising species are sorghum, Sudan grass, and their hybrids (Hyso). They are primarily cultivated for silage and green forage production. Although they contain less starch than maize, they have higher fibre content and better drought tolerance.

Sorghum–Sudan grass hybrids combine high yield potential, good digestibility, and stress resistance. They allow multiple harvests, exhibit good fermentation stability, and are suitable for inclusion in Total Mixed Ration (TMR) diets in combination with protein supplements. Several studies (Lv *et al*., 2023; Cattani *et al*., 2017) have shown that, with a properly balanced ration, satisfactory milk production can be achieved without adverse effects on animal health.

The aim of this study was to evaluate the production and quality of forage silages from drought-tolerant crops, with a focus on sorghum (cv. Tarzan), which is suitable for ensiling and characterised by high biomass yield.

## MATERIAL AND METHODS

The experiment with the drought-tolerant sorghum variety Tarzan was conducted at the National Agricultural and Food Centre, Department of Animal Production, Division of Animal Nutrition and Small Livestock, Lužianky (Slovakia), in the Laboratory of Feed and Biological Material Analysis. The plant material originated from an agricultural cooperative in western Slovakia.

The experiment was conducted in laboratory silos with a working volume of 1.7 L, which were stored under controlled laboratory conditions in darkness at 20 ± 2 °C. The experiment was arranged in three treatments. The first treatment served as a control without silage additives. In the second treatment, a biological inoculant, containing soluble Lactobacillus paracasei DSM 16245, Lactococcus lactis NCIMB 30160, and Pediococcus acidilactici DSM 16243 (concentration $1.25 \times 10^{11}$, carrier: lactose), was applied at a dose of 1 mL·kg$^{-1}$.

In the third treatment, a chemical preservative, composed of propionic acid, formic acid, and glycerol, was applied at a dose of 8 mL·kg$^{-1}$. Each treatment was prepared in six replicates. During fermentation, dry matter losses were monitored on day 3 and subsequently at 21-day intervals using the gravimetric method.

After 90 days of ensiling, the experiment was terminated. The silages were removed from the laboratory silos and prepared for quality and nutritional analyses, including determination of nutrient composition.

Subsequently, the following parameters were determined in accordance with Commission Regulation (EC) No. 152/2009 of 27 January 2009: dry matter, crude protein, ash, crude fibre, acid detergent fibre (ADF), neutral detergent fibre (NDF), fat, and total sugars (Luff–Schoorl method).

Fermentation quality parameters were also analysed. The pH of silage extract was measured electrometrically, while lactic acid and volatile fatty acids were determined by gas chromatography. From these data, total volatile fatty acids (VFA) and total acid content were calculated.

## RESULTS AND DISCUSSION

The fermentation process of sorghum silage production was evaluated. During fermentation, dry matter losses were monitored on day 3 and subsequently at regular 21-day intervals using the gravimetric method. After 90 days of ensiling, the experiment was terminated, and the silages were removed from the laboratory silos and prepared for quality and nutritional analyses, including determination of nutrient composition.

Both the control silage and the silage treated with a biological additive showed no signs of spoilage (colour or smell changes) after 90 days, which was confirmed by nutrient composition and fermentation parameters. In contrast, silages treated with the chemical additive showed reduced quality in two replicates.

In the fresh sorghum material as well as in the differently treated silage samples, nutrient composition and fermentation parameters were analysed. The highest average dry matter losses were recorded in silage treated with the chemical preservative (1.19% after 90 days), whereas the control and biologically treated silages showed lower losses (0.64–0.74%). Dry matter content decreased by 7.5% during ensiling.

The contents of ADF, NDF, lignin, hemicellulose, and cellulose were higher in silage treated with the chemical preservative, as these additives rapidly suppress microbial activity. Consequently, no fermentation-driven degradation of hemicellulose or partial breakdown of cell walls occurred. In contrast, the use of a biological additive led to partial degradation of plant cell structures due to acidification, enzymatic activity,

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and plant-derived hydrolases, resulting in lower NDF and ADF fractions. Similar findings were reported by Xu et al. (2024), who observed a faster pH decline, higher lactic acid content, and improved fermentation stability in inoculated silages.

Total sugar content decreased markedly from 95.8 $g \cdot kg^{-1}$ dry matter to approximately 1–2 $g \cdot kg^{-1}$ dry matter due to its utilisation during fermentation. Lactic acid, produced by lactic acid bacteria, contributed to pH reduction in this experiment. The highest lactic acid content was found in the control variant (39 $g \cdot kg^{-1}$ dry matter). In the chemically treated silage, lactic acid content was lower; however, the proportion of propionic acid increased (3.7 $g \cdot kg^{-1}$ dry matter), which helps suppress the growth of yeasts and moulds. Ardiansyah *et al.* (2025) reported that chemical additives reduce lactic acid and ammonia content while improving aerobic stability and dry matter digestibility.

Butyric, isobutyric, valeric, and isovaleric acids are formed during proteolytic fermentation and protein degradation. Their low levels across all variants indicate minimal proteolysis and high fermentation quality.

Ammonia ($NH_3$-N) is an indicator of protein degradation during fermentation. In this experiment, $NH_3$-N levels were low in all variants, with the lowest value observed in chemically treated silage (5.28%), indicating effective protein preservation. Low $NH_3$-N values reflect efficient crude protein retention. Similarly, Diepersloot *et al.* (2021) reported that microbial inoculants improve fermentation profiles, enhance aerobic stability, and contribute to better nutrient preservation during storage.

## CONCLUSION

Sorghum silages are widely used as a major roughage component in Total Mixed Ration (TMR) diets, where they are combined with protein feeds, mineral supplements, and concentrates. Long-term drought conditions create significant challenges in ensuring sufficient production of roughage from both temporary and permanent grasslands.

Owing to climate change, which adversely affects the yield and quality of traditional crops, including grasslands, increasing attention is being paid to alternative drought-tolerant species such as sorghum, its hybrids, Sudan grass, and Hyso. These crops are capable of producing high biomass yields even under dry and less fertile conditions, thereby ensuring a more stable feed supply for dairy cows and other ruminants in years with low precipitation.

When appropriate agronomic practices are applied, including optimal harvest timing, suitable dry matter content, and proper silage management, sorghum silages can provide high-quality feed, contributing to good animal health and productive performance in dairy cattle.

Therefore, further research should focus on suitable varieties, optimisation of harvest timing, and improvement of ensiling techniques to ensure high-quality sorghum silage and a stable feed supply under changing climatic conditions.

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