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# COMPARATIVE ANALYSIS OF NUTRIENT CONTENT AND IN VITRO GAS PRODUCTION DIGESTIBILITY BETWEEN CORN AND SORGHUM PLANTS DURING DIFFERENT GROWTH STAGES

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## SUMMARY

Many countries, at arid and semi-arid regions, face challenges in providing corn (*Zea mays L.*) as animal feed due to water and land limitations. In contrast, sorghum (*Sorghum bicolor L.*) can be grown on the same land, as it is more tolerant to saline conditions and requires less water. This study aimed to compare the in-vitro gas production, ruminal digestibility, and nutrient content of sorghum and corn plants at different vegetative parts and two growth stages. Significant differences in digestibility were observed between the two plants. The highest in vitro dry matter digestibility (IVDMD) was found in corn flag leaves at the dough stage. Notable differences were also found among some vegetative parts in both plants concerning gas production and in vitro organic matter digestibility (IVOMD), with the highest crude protein (CP) content found in corn flag leaves at the dough stage. The findings suggest that sorghum can serve as a viable alternative to corn without negatively impacting in-vitro digestibility. However, further studies are needed to assess its performance at the in-vivo level.

***Keywords:*** *corn, sorghum, replacement, in-vitro digestibility, and nutrient content,*

## INTRODUCTION

More than 90% of the water resources in the world's arid and semi-arid regions are consumed by agriculture (FAO, 2017a). However, these regions lose a significant portion of their water annually due to global climate change and population growth (Belesky and Malinowski, 2016; FAO, 2017b). These conditions necessitate the development of management strategies and practices, including deficit irrigation, to improve water use efficiency and stabilize agricultural yields (González-Trinidad *et al..,* 2020; Pang *et al..,* 2018).

Refining irrigation water demands and improving water management for crop production could lead to sustainable water use and enhance the economic livelihood of the people. Numerous studies have measured irrigation water requirements based on cropping systems, current irrigation technology, and irrigation practices (Lamm *et al.,* 2006; Rogers and Lamm, 2012; Klocke *et al.,* 2014; Kisekka *et al.,* 2016; Area *et al.,* 2021). For example, Schlegel *et al.* (2016) found that the water requirements for grain yield initiation were higher for corn (~277 mm) compared to grain sorghum (~176 mm). Therefore, one approach to optimize irrigation water use is to produce more sorghum than corn for animal feed.

Recent studies have further emphasized the importance of evaluating alternative crops like sorghum under water-limited conditions. For instance, research by Smith *et al.* (2023) demonstrated that sorghum exhibits superior drought tolerance and water use efficiency compared to corn, making it a promising candidate for arid regions. Additionally, Getachew *et al.* (2023) highlighted the potential of sorghum to maintain high nutrient content and digestibility even under reduced irrigation scenarios. These findings underscore the necessity to reassess crop choices in the context of sustainable agriculture and resource conservation.

This study aims to provide the literature with comprehensive data on the nutrient composition and digestibility of six different vegetative parts of corn plants and six corresponding parts of sorghum plants at two growth stages. This information will help in understanding the potential of sorghum as a viable alternative to corn in regions with limited water resources.

## MATERIAL AND METHODS

The present study was conducted at the farm and laboratory of the Animal Research Department of the Agriculture Research Center, Ministry of Agriculture, Giza, Egypt. Two plant species, corn and sorghum, were evaluated at two different stages of growth. Six parts of each plant were assessed.

***Plant parts:***

For corn plants, the evaluated parts included lower leaves, central leaves, upper leaves, corn leaf sheaths, ear husk, and flag leaves at two different growth stages (i.e., milk stage and dough stage). For sorghum plants, the evaluated parts included lower leaves, central leaves, upper leaves, lower stalks, central stalks, and upper stalks at two different growth stages (i.e., soft dough stage and hard dough stage). Table 1 shows the abbreviations of the plant part names at the two different stages.

**Table (1): Abbreviations of the plant's parts names at two different stages of growth.**

| **No.** | **Abbreviations for corn** | **Corn (name of the plant parts)** | **Stage for corn** | **Abbreviation for sorghum** | **Sorghum (name of the plant parts)** | **Stage for sorghum** |
|---|---|---|---|---|---|---|
| 1 | C1M | Corn lower leaves | Milk stage | S1S | Sorghum lower leaves | soft dough stage |
| 2 | C2M | Corn central leaves | Milk stage | S2S | Sorghum central leaves | soft dough stage |
| 3 | C3M | Corn upper leaves | Milk stage | S3S | Sorghum upper leaves | soft dough stage |
| 4 | C4M | Corn leaves sheaths | Milk stage | S4S | Sorghum lower stalks | soft dough stage |
| 5 | C5M | Corn ear husk | Milk stage | S5S | Sorghum central stalks | soft dough stage |
| 6 | C6M | Corn flag leaves | Milk stage | S6S | Sorghum upper stalks | soft dough stage |
| 7 | C1D | Corn lower leaves | Dough stage | S1H | Sorghum lower leaves | hard dough stage |
| 8 | C2D | Corn central leaves | Dough stage | S2H | Sorghum central leaves | hard dough stage |
| 9 | C3D | Corn upper leaves | Dough stage | S3H | Sorghum upper leaves | hard dough stage |
| 10 | C4D | Corn leaves sheaths | Dough stage | S4H | Sorghum lower stalks | hard dough stage |
| 11 | C5D | Corn ear husk | Dough stage | S5H | Sorghum central stalks | hard dough stage |
| 12 | C6D | Corn flag leaves | Dough stage | S6H | Sorghum upper stalks | hard dough stage |

***Chemical analysis of plants:***

Plant ingredients were analyzed for dry matter (DM) by drying the samples at 135 ºC for 2 hours (AOAC 1997, ID 930.15). Organic matter (OM) was calculated as the weight lost at sample ignition at 600 ºC (AOAC 1997, ID 942.05). Neutral detergent fiber (NDF), acid detergent fiber (ADF), and acid detergent lignin (ADL) were determined using the ANKOM fiber technology technique (Robinson *et al.*., 1999) without using alpha-amylase. Crude protein (CP) was determined by the Kjeldahl method (AOAC 1997, ID 984.13). Tables 2 and 3 show the chemical composition of the plants at the first and second stages of growth, respectively.

***In vitro gas production:***

Two days before the beginning of the experiment, 0.2 grams of sample from each plant part were weighed into 125 ml glass bottles. A buffer solution was prepared before the addition of rumen fluid as described by Theodorou *et al.* (1994) and continuously flushed with $CO_2$ at 39°C during sample inoculation. Sheep rumen fluid was obtained from four adult male sheep that were fed a basal diet of alfalfa hay and sourced from a local slaughterhouse, then mixed into a 2-liter bottle with an O2-free headspace and immediately transported to the laboratory at 39°C. Upon arrival at the laboratory, the rumen fluid was filtered through four layers of cheesecloth to eliminate large feed particles. The buffer solution was added to the rumen fluid at a 4:1 ratio. Each vessel was filled with 50 ml of the incubation medium, dispensed anaerobically in the vessels, and sealed. The samples were incubated at 39°C for 24 hours. After 24 hours of incubation, each plant part was replicated six times in six bottles. Three of the six replicates were used to determine the total gas production, and the other three were used to determine basic rumen fermentation parameters and microbial population. The initial pH value of the inoculums ranged between 6.8 and 6.9.

***Total gas production:***

After 24 hours of incubation, the total gas production (GP) was estimated according to Blümmel *et al.* (1997b) by the displacement of the syringe piston connected to the serum flasks. The gas produced due to substrate fermentation was calculated by subtracting the gas produced in blank vessels (without substrate) from the total gas produced in the vessels containing buffered rumen fluid and substrate.

***Digestibility:***

Dry matter digestibility (%DMD) was calculated as the difference between the sample DM content and the residual DM content after 24 hours of incubation, divided by the sample DM content and multiplied by 100. NDF and ADF of the residuals after fermentation were analyzed using the same methods as for feed ingredient analysis. Digestibility of NDF (NDFD) and ADF (ADFD) was calculated as the difference between the content in the sample before and after incubation, divided by the content in the sample before incubation, and multiplied by 100. Metabolizable energy (ME, Mcal/g DM), in vitro organic matter digestibility (% IVOMD) were estimated according to Menke and Steingass (1988). Short-chain fatty acid (SCFA) concentrations were calculated according to Getachew *et al.* (2002). Microbial protein (MP) was calculated according to Blümmel *et al.* (1997a).

***Statistical analysis:***

he experimental data were statistically analyzed using the statistical analysis system (SAS) User's Guide (SAS 1998). Separation among means was carried out using Duncan's multiple range test (Duncan 1955). The following general linear model (GLM) was used:

$$Y_{ij} = \mu + T_i + e_{ij}$$

Where: $Y_{ij}$ is the observation of individual at in the treatment, $\mu$ = is the overall mean, $T_i$ is the fixed effect in the treatment (i = 1,2,3…...,14), $e_{ij}$ is the error, normally independently distributed (NID) (0, $\sigma^2_e$).

## RESULTS AND DISCUSSION

The results of this study highlight significant differences in the chemical composition, in vitro gas production, and digestibility between different parts of corn and sorghum plants at two stages of growth. The findings are critical for understanding the potential of sorghum as an alternative to corn, especially in arid and semi-arid regions where water availability is limited.

***Chemical composition:***

Table 2 presents the chemical composition of different parts of corn and sorghum at the first stage of growth, i.e., milk stage for corn and soft dough stage for sorghum. The highest crude protein (CP) content was found in corn upper leaves (C3M), while sorghum lower stalks (S4S) had the lowest CP content. Also, Table 2 shows the chemical composition of the plant parts at the second stage of growth, i.e., dough stage for corn and hard dough stage for sorghum. The highest CP content was observed in corn flag leaves (C6D), whereas sorghum lower stalks (S4H) had the lowest CP content.

**Table (2): Chemical composition (%) of the plant's parts at the first stage and second stage of growth**

| Sample | Stage | Type | CP | EE | CF | ASH | DM |
|---|---|---|---|---|---|---|---|
| ***First stage of growth** | | | | | | | |
| C1M | Milk stage | corn | 8.2 | 3.6 | 24.9 | 11.8 | 91.7 |
| C2M | | | 9.6 | 3.6 | 25.4 | 11.6 | 92.4 |
| C3M | | | 11.6 | 3.5 | 26 | 8.9 | 93 |
| C4M | | | 8.4 | 3.3 | 27 | 15 | 92.2 |
| C5M | | | 9.3 | 3.6 | 22.6 | 8.9 | 92.7 |
| C6M | | | 7.6 | 3 | 28.4 | 15 | 92 |
| S1S | Soft dough stage | Sorghum | 6.4 | 2.9 | 20.1 | 7.1 | 92.4 |
| S2S | | | 11.4 | 2.8 | 24.2 | 6.2 | 93.1 |
| S3S | | | 8.7 | 2.9 | 25.2 | 6.4 | 94.3 |
| S4S | | | 2.4 | 2.4 | 26.5 | 10.9 | 91.9 |
| S5S | | | 4 | 2.4 | 25.5 | 10.9 | 91.8 |
| S6S | | | 2.6 | 2.5 | 22.7 | 7.5 | 93.7 |
| ****Second stage the first stage** | | | | | | | |
| C1D | Dough stage | corn | 9 | 3.3 | 34.3 | 11.3 | 93.3 |
| C2D | | | 7.6 | 2.9 | 38 | 10.2 | 91.8 |
| C3D | | | 9.3 | 3.1 | 34.4 | 12.9 | 91.8 |
| C4D | | | 13.3 | 2.8 | 35.4 | 14 | 90.9 |
| C5D | | | 8.5 | 3.3 | 32.9 | 8.4 | 91.5 |
| C6D | | | 14.8 | 3 | 32.8 | 9.5 | 92 |
| S1H | Hard dough stage | Sorghum | 5 | 2.6 | 26.9 | 8.3 | 93.4 |
| S2H | | | 6.9 | 3.4 | 25.6 | 8.9 | 93.5 |
| S3H | | | 7.8 | 3.2 | 25.4 | 7.6 | 93.9 |
| S4H | | | 2.3 | 2.1 | 26.8 | 6.2 | 94.3 |
| S5H | | | 2.8 | 2.5 | 26.1 | 7.1 | 94.1 |
| S6H | | | 2.7 | 2.5 | 24.4 | 7.3 | 93.9 |

****First stage of growth:*** *C1M=Corn lower leaves at Milk stage, C2M=Corn central leaves at Milke stage, C3M=Corn upper leaves at Milke stage, C4M=Corn leaves sheaths at Milke stage, C5M=Corn ear husk at Milke stage, C6M=Corn flag leaves at Milke stage, S1S=Sorghum lower leaves at soft dough stage, S2S=Sorghum center leaves at soft dough stage, S3S=Sorghum upper leaves at soft dough stage, S4S=Sorghum lower stalks at soft dough, S5S=Sorghum central stalks at soft dough stage, S6S= Sorghum upper stalks at soft dough stage.*

*****Second stage the first stage:*** *C1D=Corn lower leaves at Dough stage, C2D=Corn central leaves at Dough stage, C3D=Corn upper leaves at Dough stage, C4D=Corn leaves sheaths at Dough stage, C5D=Corn ear husk at Dough stage, C6D=Corn flag leaves at Dough stage, S1H=Sorghum lower leaves at hard dough stage, S2H=Sorghum center leaves at hard dough stage, S3H=Sorghum upper leaves at hard dough stage, S4H=Sorghum lower stalks at hard dough, S5H=Sorghum central stalks at hard dough stage, S6H= Sorghum upper stalks at hard dough stage.*

The chemical composition analysis revealed that corn generally exhibited higher crude protein (CP) content compared to sorghum. Specifically, corn upper leaves (C3M) and corn flag leaves (C6D) had the highest CP content at their respective growth stages, which is consistent with previous studies indicating higher nutritional value in corn leaves (Farran *et al.,* 2002). Sorghum, on the other hand, showed lower CP values, particularly in the lower stalks (S4S and S4H). This difference in CP content underscores the importance of selecting specific plant parts and stages of growth to optimize the nutritional intake of ruminants (Ding *et al.,* 2020).

### *In vitro gas production and digestibility:*

Table 3 displays the results of gas production at 24 and 48 hours of incubation, IVDMD and IVOMD after 48 hours of incubation for the plant parts at the first stage of growth. Corn ear husk (C5M) exhibited the highest gas production at 24 and 48 hours, as well as the highest IVDMD and IVOMD ($P \leq 0.05$). In contrast, corn flag leaves (C6M) showed the lowest gas production at 24 and 48 hours, along with the lowest IVDMD and IVOMD ($P \leq 0.05$). Table 3 shows the gas production at 24 and 48 hours of incubationIVDMD), and (IVOMD) after 48 hours of incubation for the plant parts at the second stage of growth. Corn ear husk (C5D) exhibited the highest gas production at 24 and 48 hours ($P \leq 0.05$). Corn flag leaves (C6D) also showed the highest gas production at 48 hours, as well as the highest IVDMD and IVOMD ($P \leq 0.05$). Conversely, corn central leaves (C2D) displayed the lowest gas production at 24 and 48 hours, along with the lowest IVOMD ($P \leq 0.05$).

**Table (3): Gas production and digestibility of the plant's parts at the first stage and second stage of growth.**

| Sample | Stage | Type | GP 24 h, 0.2 g | GP 48 h, 0.2 g | % IVDMD | % IVOMD | *P value* |
|---|---|---|---|---|---|---|---|
| $^{*}$**First stage f growth** | | | | | | | |
| C1M | Milk stage | Corn | $32.7^{bc}$ | $50.5^{a}$ | $37.6^{bc}$ | $48.4^{b}$ | 0.040 |
| C2M | | | $28.6^{d}$ | $47.2^{b}$ | $35.3^{d}$ | $45.3^{c}$ | 0.044 |
| C3M | | | $31.6^{c}$ | $48.5^{b}$ | $40.2^{ab}$ | $48.8^{b}$ | 0.035 |
| C4M | | | $23.9^{e}$ | $42.2^{c}$ | $32.5^{e}$ | $40.9^{e}$ | 0.043 |
| C5M | | | $39.6^{a}$ | $56.8^{a}$ | $43.2^{a}$ | $54.8^{a}$ | 0.047 |
| C6M | | | $18.3^{f}$ | $36.1^{c}$ | $27.1^{f}$ | $35.5^{f}$ | 0.043 |
| S1S | Soft dough stage | Sorghum | $33^{bc}$ | $56.9^{a}$ | $38.6^{b}$ | $47.5^{b}$ | 0.041 |
| S2S | | | $28.5^{d}$ | $49.3^{ab}$ | $32.7^{e}$ | $45.8^{c}$ | 0.042 |
| S3S | | | $30.6^{c}$ | $47.7^{b}$ | $41^{a}$ | $46.^{4bc}$ | 0.037 |
| S4S | | | $34.3^{b}$ | $49.7^{ab}$ | $38.6^{b}$ | $47.2^{b}$ | 0.047 |
| S5S | | | $37.3^{a}$ | $57.4^{a}$ | $37.2^{bc}$ | $50.5^{b}$ | 0.031 |
| S6S | | | $30.9^{c}$ | $48.9^{b}$ | $35^{d}$ | $44^{c}$ | 0.029 |
| SEM | | | 1.8 | 2.1 | 1.3 | 2.2 | |
| $^{**}$**Second stage of growth** | | | | | | | |
| C1D | Dough stage | corn | $34^{b}$ | $52.5^{b}$ | $40.2^{b}$ | $49.9^{b}$ | 0.045 |
| C2D | | | $24.1^{e}$ | $42.2^{e}$ | $35.2^{ce}$ | $40.4^{e}$ | 0.047 |
| C3D | | | $36.7^{b}$ | $53.7^{b}$ | $38.3^{c}$ | $52.5^{b}$ | 0.041 |
| C4D | | | $31.4^{c}$ | $51^{c}$ | $41^{b}$ | $49.7^{c}$ | 0.037 |
| C5D | | | $39.2^{a}$ | $58^{a}$ | $44.2^{a}$ | $54.1^{a}$ | 0.044 |
| C6D | | | $38.4^{a}$ | $58^{a}$ | $47.8^{a}$ | $56.3^{a}$ | 0.050 |
| S1H | Hard dough stage | Sorghum | $30.4^{c}$ | $51.2^{c}$ | $24.8^{g}$ | $44.7^{c}$ | 0.042 |
| S2H | | | $34.1^{b}$ | $53.5^{b}$ | $43.1^{ab}$ | $48.9^{bc}$ | 0.028 |
| S3H | | | $32.4^{c}$ | $50.6^{c}$ | $42^{b}$ | $47.7^{bc}$ | 0.041 |
| S4H | | | $32.6^{c}$ | $49.8^{c}$ | $29.5^{f}$ | $45.3^{c}$ | 0.038 |
| S5H | | | $33.9^{c}$ | $50.8^{c}$ | $32.3^{e}$ | $46.7^{c}$ | 0.050 |
| S6H | | | $32.4^{c}$ | $49.8^{c}$ | $33.6^{e}$ | $45.3^{c}$ | 0.041 |
| SEM | | | 1.3 | 2.4 | 1.5 | 2.5 | |

$^{*}$***First stage of growth:*** *C1M=Corn lower leaves at Milk stage, C2M=Corn central leaves at Milke stage, C3M=Corn upper leaves at Milke stage, C4M=Corn leaves sheaths at Milke stage, C5M=Corn ear husk at Milke stage, C6M=Corn flag leaves at Milke stage, S1S=Sorghum lower leaves at soft dough stage, S2S=Sorghum center leaves at soft dough stage, S3S=Sorghum upper leaves at soft dough stage, S4S=Sorghum lower stalks at soft dough, S5S=Sorghum central stalks at soft dough stage, S6S= Sorghum upper stalks at soft dough stage.*

$^{**}$***Second stage the first stage:*** *C1D=Corn lower leaves at Dough stage, C2D=Corn central leaves at Dough stage, C3D=Corn upper leaves at Dough stage, C4D=Corn leaves sheaths at Dough stage, C5D=Corn ear husk at Dough stage, C6D=Corn flag leaves at Dough stage, S1H=Sorghum lower leaves at hard dough stage, S2H=Sorghum center leaves at hard dough stage, S3H=Sorghum upper leaves at hard dough stage, S4H=Sorghum lower stalks at hard dough, S5H=Sorghum central stalks at hard dough stage, S6H= Sorghum upper stalks at hard dough stage.*

The in vitro gas production and digestibility results showed notable differences between corn and sorghum parts. Corn ear husk (C5M) demonstrated the highest gas production and digestibility values at the milk stage, while corn flag leaves (C6D) performed best at the dough stage. These findings align with research by Blümmel *et al.* (1997b), who reported that corn plant parts, particularly the husks and leaves, are highly digestible and produce substantial amounts of gas during fermentation. Sorghum parts, while less digestible compared to corn, still exhibited reasonable gas production and digestibility, suggesting that sorghum could be a viable feed option under water-scarce conditions (Getachew *et al.,* 2004).

***Nutritive value of the plant parts as a ruminant feed:***

Table 4 presents the nutritive value for the plant parts at the first stage of growth, i.e., milk stage for corn and soft dough stage for sorghum. Corn ear husk (C5M) showed the highest microbial protein (MP) and short-chain fatty acids (SCFA), as well as the highest metabolizable energy (ME), net energy (NE), and total digestible nutrients (TDN) ($P \leq 0.05$). In contrast, corn flag leaves (C6M) exhibited the lowest MP, SCFA, ME, NE, and TDN ($P \leq 0.05$). Table 4 shows the nutritive value for the plant parts at the second stage of growth, i.e., dough stage for corn and hard dough stage for sorghum. Corn flag leaves (C6D) exhibited the highest MP, ME, NE, and TDN ($P \leq 0.05$). Conversely, corn central leaves (C2D) showed the lowest MP, SCFA, ME, and TDN ($P \leq 0.05$).

**Table (4): Nutritive value of the plant's parts at the first stage and second stage of growth.**

| Sample | Stage | Type | MP (g/kg OMD) | SCFA mmol | ME-Mcal/kg | NE-Mcal/kg | %TDN | *P* value |
|---|---|---|---|---|---|---|---|---|
| **[8]First stage of growth** | | | | | | | | |
| C1M | | | $58.4^{b}$ | 0.72 | $1.7^{cd}$ | $3.6^{b}$ | $48.7^{b}$ | 0.047 |
| C2M | | | $54.7^{b}$ | 0.62 | $1.6^{d}$ | $3.6^{b}$ | $46.1^{bc}$ | 0.040 |
| C3M | Milk stage | corn | $58.8^{b}$ | 0.70 | $1.7^{cd}$ | $3.8^{a}$ | $48.9^{b}$ | 0.034 |
| C4M | | | $49.3^{bc}$ | 0.51 | $1.4^{e}$ | $3.4^{c}$ | $42.4^{c}$ | 0.046 |
| C5M | | | $66.1^{a}$ | 0.89 | $2^{a}$ | $3.8^{a}$ | $54^{a}$ | 0.044 |
| C6M | | | $42.9^{c}$ | 0.38 | $1.2^{f}$ | $3.2^{d}$ | $38^{d}$ | 0.048 |
| S1S | | | $57.3^{b}$ | 0.73 | $1.7^{cd}$ | $3.5^{c}$ | $48.3^{b}$ | 0.037 |
| S2S | | | $55.2^{b}$ | 0.62 | $1.6^{d}$ | $3.7^{b}$ | $46.6^{bc}$ | 0.039 |
| S3S | soft dough stage | Sorghum | $56^{b}$ | 0.67 | $1.7^{cd}$ | $3.6^{b}$ | $47.3^{b}$ | 0.050 |
| S4S | | | $56.9^{b}$ | 0.76 | $1.7^{cd}$ | $3.3^{d}$ | $48.1^{b}$ | 0.049 |
| S5S | | | $60.9^{b}$ | 0.83 | $1.8^{bc}$ | $3.5^{c}$ | $50.7^{ab}$ | 0.048 |
| S6S | | | $53^{b}$ | 0.68 | $1.6^{d}$ | $3.2^{d}$ | $45.6^{c}$ | 0.036 |
| SEM | | | 0.87 | 0.12 | 0.17 | 0.29 | 0.24 | |
| **[**]Second stage of growth.** | | | | | | | | |
| C1D | | | $60.1^{a}$ | 0.75 | $1.8^{bc}$ | $3.7^{bc}$ | $50^{b}$ | 0.041 |
| C2D | | | $48.7^{c}$ | 0.52 | $1.4^{e}$ | $3.3^{e}$ | $42.4^{e}$ | 0.045 |
| C3D | Dough stage | corn | $63.3^{a}$ | 0.82 | $1.9^{ab}$ | $3.8^{b}$ | $52.1^{a}$ | 0.042 |
| C4D | | | $60^{a}$ | 0.69 | $1.8^{bc}$ | $3.8^{b}$ | $49.5^{b}$ | 0.035 |
| C5D | | | $65.3^{a}$ | 0.87 | $1.9^{ab}$ | $3.8^{b}$ | $53.7^{a}$ | 0.045 |
| C6D | | | $67.9^{a}$ | 0.86 | $2^{a}$ | $4.1^{a}$ | $55^{a}$ | 0.050 |
| S1H | | | $53.9^{b}$ | 0.67 | $1.6^{d}$ | $3.3^{e}$ | $46^{d}$ | 0.038 |
| S2H | | | $58.7^{b}$ | 0.76 | $1.7^{cd}$ | $3.6^{c}$ | $49.3^{b}$ | 0.044 |
| S3H | Hard dough stage | Sorghum | $57.5^{b}$ | 0.71 | $1.7^{cd}$ | $3.6^{c}$ | $48.3^{bc}$ | 0.047 |
| S4H | | | $54.7^{b}$ | 0.72 | $1.6^{d}$ | $3.2^{e}$ | $46.8^{d}$ | 0.039 |
| S5H | | | $56.3^{b}$ | 0.75 | $1.7^{cd}$ | $3.3^{e}$ | $47.9^{bc}$ | 0.038 |
| S6H | | | $54.7^{b}$ | 0.71 | $1.6^{d}$ | $3.3^{e}$ | $46.7^{d}$ | 0.047 |
| SEM | | | 0.7 | 0.10 | 0.15 | 0.27 | 0.25 | 0.049 |

[*]***First stage of growth:*** *C1M=Corn lower leaves at Milk stage, C2M=Corn central leaves at Milke stage, C3M=Corn upper leaves at Milke stage, C4M=Corn leaves sheaths at Milke stage, C5M=Corn ear husk at Milke stage, C6M=Corn flag leaves at Milke stage, S1S=Sorghum lower leaves at soft dough stage, S2S=Sorghum center leaves at soft dough stage, S3S=Sorghum upper leaves at soft dough stage, S4S=Sorghum lower stalks at soft dough, S5S=Sorghum central stalks at soft dough stage, S6S= Sorghum upper stalks at soft dough stage.*

[**]***Second stage the first stage:*** *C1D=Corn lower leaves at Dough stage, C2D=Corn central leaves at Dough stage, C3D=Corn upper leaves at Dough stage, C4D=Corn leaves sheaths at Dough stage, C5D=Corn ear husk at Dough stage, C6D=Corn flag leaves at Dough stage, S1H=Sorghum lower leaves at hard dough stage, S2H=Sorghum center leaves at hard dough*

*stage, S3H=Sorghum upper leaves at hard dough stage, S4H=Sorghum lower stalks at hard dough, S5H=Sorghum central stalks at hard dough stage, S6H= Sorghum upper stalks at hard dough stage.*

The nutritive value assessment further emphasized the superiority of corn ear husk (C5M) and flag leaves (C6D) in terms of microbial protein (MP), short-chain fatty acids (SCFA), metabolizable energy (ME), net energy (NE), and total digestible nutrients (TDN). These values are crucial for formulating balanced diets for ruminants, ensuring optimal growth and productivity (Hoffman *et al.*, 2001; Araya *et al.*, 2021). Sorghum parts, although generally lower in these nutritive parameters, still provide adequate nutrition, particularly when water availability restricts the cultivation of corn.

***implications for agricultural practices:***

The ability of sorghum to grow in saline and low-water conditions makes it an attractive crop for arid and semi-arid regions. The findings suggest that while corn provides superior nutritional value, sorghum can serve as a sustainable alternative, minimizing the impact of water scarcity on feed production (FAO 2017a). Future research should focus on enhancing the nutritional profile of sorghum through breeding and agronomic practices to further close the gap with corn (Schlegel *et al.,* 2016).

## CONCLUSION

This study concludes that sorghum can be effectively used as a feed alternative to corn without significantly compromising the nutritional intake of ruminants. However, corn remains superior in terms of CP content, gas production, and digestibility. More in vivo studies are required to confirm these findings and explore the long-term implications of substituting corn with sorghum in ruminant diets.

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## التحليل المقارن للمحتوى الغذائي والقيمة الهضمية المعملية بين نبات الذرة الشامية والذرة السكرية أثناء مراحل النمو المختلفة.

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العديد من الدول في المناطق الصحراوية وشبة صحراوية تواجه تحديات في توفير الذرة الشامية كعلف للحيوان نتيجة النقص في المياه والأرض المتاحة للزراعة. على الوجه الأخر، توجد الذرة السكرية التي لديها القدرة على النمو في نفس التربة للذرة الشامية ولكن مع قدرة الأكبر في تحمل ظروف الجفاف والملوحة. لذلك هدف هذه الدراسة إلى مقارنة المكونات الغذائية والقيمة الهضمية ومعدل إنتاج الغاز معمليا تحت ظروف تجربة هضم معلميه باستخدام سائل الكرش بين الأجزاء المختلفة لكل نوع على حدا على مرحلتين نمو لكل نبات.

وقد أوضحت النتائج أن هناك فروق معنوية في القيمة الهضمية بين الذرة الشامية والسكرية. وأرتفع معدل هضم المادة الجافة في في أجزاء اورق الذرة خلال الطور العجيني. بينما لم تشاهد أي فروق معنوية بين أجزاء نبات الذرة الشامية والسكرية على معدل إنتاج الغاز ومعامل هضم المادة العضوية. ولكن ارتفعت نسبة البروتين في أوراق الذرة خلال مرحلة الطور العجيني. بناءاً على هذه النتائج تقترح الدراسة الحالية أن نبات الذرة السكرية يمكن أن بديل حيوي للذرة الشامية بدون أي تأثير سلبي على معامائل الهضم. وزيادة العمل والبحث والدراسة لتقييمها على المستوى المزرعى في تغذية الحيوان.