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Development and evaluation of three sorghum varieties under different fermentation period for silage production

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Abstract

Silage is a crucial source of nourishment for livestock, especially during dry periods or poor-quality grass. The simple random and ranking technique was used, and it was conducted at Cagayan State -University at Piat Campus to investigate the nutritional value of three sorghum cultivars when turned into silage with varying fermentation durations. Generally, the study aimed to determine the most suitable sorghum variety for optimal silage production based on nutritional quality. The results showed that all three sorghum varieties exhibited an increase in crude protein content from 14 to 21 days of fermentation. Additionally, higher fiber content was observed after 28 days of fermentation. Extended fermentation led to a reduction in moisture content due to microbial activity during the ensiling process. The presence of calcium and phosphorus in the fermentation substrate influenced the proliferation and activity of fermentative microorganisms. Based on the study, the 21-day fermentation period for sorghum silage is recommended for local livestock farmers. Furthermore, considering their nutritional content, the SV2 and SV3 sorghum varieties are suitable for silage production. It is recommended that a wider range of sorghum cultivars and varying fermentation durations be considered to identify the best options for high-quality silage production.

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Introduction

The demand for needs like food, clothing, and housing is rising as a result of the planet's ongoing rapid population growth. Regrettably, the amount of land accessible for crop production has significantly decreased as a result of this demand, which is negatively affecting the agricultural sector. The livestock business also faces difficulties as a result of the loss of pasture lands and natural vegetation brought on by the conversion of land for commercial use.

Because they have few resources, livestock farmers in the surrounding farming villages feed their animals by using naturally occurring weeds and agricultural waste materials. However, the lack of sufficient nourishment from these sources frequently results in low animal productivity.

The Department of Agriculture is trying to address this problem by introducing new technology and ways to give cattle greater nutrition. Planting sorghum, a significant fodder crop that does well in a range of environmental circumstances, is one such alternative. Because of its morpho-physiological responses to water stress, sorghum can thrive in arid and semi-arid environments and produce high dry matter yields while adjusting to variable rainfall patterns.

Because of their high nutritional value, limited buffering capacity, and high concentration of soluble carbohydrates, sorghum plants are also good for making silage. In tropical areas, silage production is a vital technique for conserving fodder and is frequently employed to keep livestock fed during dry spells.

Crop health and productivity are also influenced by the methods used in their upbringing, care, and nursing. Due to its environmental adaptability, sorghum is a significant feed crop that is utilized in livestock systems in many parts of the world (Sanchez *et al.*, 2002). Due to its morpho-physiological responses to water stress, which result in a high dry matter yield (DMY) and resilience in places with irregular rainfall distribution, sorghum is a significant source of roughage in arid and semi-arid regions (Sankarapandian *et al.*, 2013).

In addition to these traits, sorghum plants are good for making silage (Brocke *et al.*, 2014). This is due to their high soluble carbohydrate content (Sankarapandian *et al.*, 2013), low buffering capacity, and high nutritional value (Kumar *et al.*, 2015), all of which are necessary for sufficient lactic acid fermentation (Santos *et al.*, 2013).

It is significant because, in tropical countries, silage production is a primary means of conserving fodder, which gives animals something to eat during dry spells.

Sorghum leaves and stalks can be used as silage, green feed, or fodder for animals, especially cattle and ruminants. Silage is made by fermentation and gives animals a high-quality diet at times when feed is in short supply. However, several variables, including the crop's age, the length of the fermented period, and the crop itself, might impact the nutrient composition of sorghum silage. Consequently, a study was carried out to ascertain the nutrient composition of sorghum silage by counting the number of days throughout the fermentation process. Generally, the study aimed to develop and evaluate the three sorghum cultivars for silage as affected by the number of days in the fermentation period. Specifically, it aimed to: (1) evaluate the nutritional quality of the silage produced from the three sorghum varieties under different fermentation periods and (2) identify the most suitable sorghum variety for optimal silage production based on nutritional quality.

Materials and methods

Selection of Sorghum Varieties

The three sorghum varieties were collected at the Department of Agriculture – Region 2 at Southern Cagayan Research Center at Maguirig, Cagayan based on their availability, adaptability to local conditions, and potential for silage production.

Field Preparation and Planting

The area was prepared by two (2) alternate plowing and harrowing with seven (7) days intervals. Sorghum seeds of the selected varieties were sown at the recommended spacing and depth.

Establishment of Sorghum

The three (3) sorghum varieties were established at the Cagayan State University – Piat Campus experimental area from December 8, 2022 to February 2023. Seeds were planted following a distance of 50 cm in between plants and 75 cm in between furrows.

Crop Management

Standard agronomic practices such as irrigation, fertilization, and pest control were implemented throughout the growing season.

Harvesting and Preparation of Materials for Silage

Sorghum plants were harvested at exactly seventy-five (75) days which is the optimal stage for silage production. Sorghum was cut before the silage making. Sorghum was chopped using a forage chopper separately to maintain the purity of the materials. Chopped materials were placed in the clean plastic pail to serve as silage material.

Packing and Fermentation

Chopped materials were packed properly to eliminate excess air. Packing was done by pressing the material upon filling in the silage bags and continually repeating the same process until the pail was loaded with enough forage mixture. Fermentation was based on the treatment combinations. In addition, packaging material was used to tie the packed product to minimize the entry of air. The forage mixture was stored in a clean, cool, and dry place.

Nutritional Analysis

Samples of the silage produced from each sorghum variety were collected and analyzed for nutritional content, crude protein, fiber, fat, ash, moisture, calcium, and phosphorous. The samples were submitted to Cagayan Valley Integrated Agricultural Laboratory for analysis.

Results and discussion

*Proximate Composition of the Sorghum Silage*Table 1 shows the results of the proximate analysis of the different varieties of sorghum investigated. The results of the crude protein content obtained from the samples ranged between 7.57 to 10.59 with a mean of 9.08. From the data, it can be observed that the crude protein content varies for each variety over the different fermentation periods. Samples from all treatments show an increase in crude protein content from 14 - 21 days before slightly decreasing to 28 days. This means that 21 days of fermentation is the best harvesting day for sorghum silage to be fed to animals. The variations in protein content of the various samples are primarily due to the nature and deficiency of essential elements required for plant life (Arnon, 1995).

The crude fiber column provides the percentage of crude fiber in each sample. It can be gleaned that as the number of days increases from 14 to 28 days of fermentation, the crude fiber decreases. This means that the decrease of crude fiber consists of indigestible plant materials and is often used as an indicator of the fiber content, which can affect the digestibility and nutritional value of the sorghum. In this sense, the lower the fiber content, the better the quality of the silage produced and the higher the dry matter intake by the animals (Santos *et al*,, 2010).

The percentage of crude fat present in each sorghum sample shows that 14 days of fermentation had a higher crude fat content compared to 21- and 28-day fermentation. Crude fat in silage contributes to energy, palatability, and fermentation quality. However, very high-fat silage can become unstable and prone to spoilage. This means that proper management ensures that fat levels enhance silage without compromising the overall nutritional balance. As to the percentage of ash content, it can be observed that as the number of days of fermentation increases there is a decrease of ash

content. This means that the fermentation process in silage involves the activity of lactic acid bacteria, which produce lactic acid as a byproduct. This acidic environment can lead to the breakdown of cell walls and the release of cellular contents, including minerals. As a result, some minerals may be lost during fermentation, contributing to the decrease in ash content (Kung, 2001).

Table 1. Proximate Composition of Sample Analyzed for Percentage Dry Basis.

Variety/Proximate Composition	14 days	21 days	28 ays
1. Crude Protein			
SV_1	8.26	8.79	7.57
SV_2	8.61	10.23	8.82
SV_3	10.58	10.59	9.00
2. Crude Fiber			
SV_1	26.87	24.92	24.90
SV_2	27.49	26.26	24.74
SV_3	26.15	25.48	24.70
3. Crude Fat			
SV_1	2.55	2.54	1.12
SV_2	3.53	2.85	2.66
SV_3	3.05	2.86	2.53
4. Ash			
SV_1	7.69	6.51	6.36
SV_2	7.97	7.45	6.31
SV_3	8.43	7.84	6.34
5. Moisture			
SV_1	83.88	77.67	77.43
SV_2	83.87	72.59	73.68
SV_3	82.09	76.43	75.03

The amount of ash in sorghum is a good measure of its inorganic mineral concentration. It can reveal details about the mineral makeup and possible contaminants in the samples. A 10% excess of ash lowers metabolizable energy (ME) and degrades silage quality.

Conversely, silage sorghum experiences a reduction in moisture content when exposed to extended fermentation because of the microbial activity that takes place throughout the ensiling procedure. Lactic acid bacteria and other microorganisms in the silage break down sugars during the fermentation process to form organic acids, mostly lactic acid. By lowering the pH, preventing the growth of rotting organisms, and encouraging the creation of stable silage, this acidification process aids in the preservation of the silage. McDonald *et al.* (1991) proved that the organic acids produced by microbial activity lower the water activity inside the silage bulk as fermentation progresses.

The silage loses moisture as a result of this drop-in water activity, which lowers the moisture content overall. Additionally, Kung Jr. *et al.* (2018) point out that longer fermentation times enable lactic acid bacteria to use sugars more completely, which results in a more effective conversion of sugars to organic acids. Over time, the moisture level decreases, and the silage is preserved in part because of this increased acid generation.

Mineral Composition

The mineral content of sorghum silage is shown in Table 2. According to the results, calcium levels vary from 0.33 to 0.83, with SV1 being the highest levels and SV2 having the lowest. Even though it isn't found in large amounts, calcium is essential for the growth of strong bones in animals.

In contrast, the range of phosphorous concentrations is 0.14 to 0.21%. Phosphorus is a mineral that is necessary for animal nutrition and aids in the formation and development of bones. The proliferation and activity of fermentative microorganisms can be influenced by the presence of calcium and phosphorus in the fermentation substrate.

Table 2. Mineral Composition of Three Sorghum Cultivars (Dry Basis).

Variety/Mineral Composition	Calcium (%)			Phosphorous (%)		
	14 days	*21 days*	*28 days*	*14 days*	*21 days*	*28 days*
SV_1	0.78	0.69	0.83	0.16	0.18	0.14
SV_2	0.63	0.33	0.44	0.21	0.17	0.15
SV_3	0.65	0.56	0.53	0.20	0.21	0.15

This can eventually affect the efficiency of fermentation and the quality of the fermented product (Gupta *et al.*, 2015). Therefore, the mineral content of sorghum cultivars, particularly the amounts of calcium and phosphorus, can affect both the fermentation process and the digested product's nutritional value.

Conclusions

Based on the above results, the followings were drawn: among the different duration of the fermentation period, 21 days is the best harvesting day for sorghum silage to be fed to animals for having higher nutrients and good quality; in terms of fiber content, the lower the fiber content, the better the quality of the silage produced, this means the higher the feed intake by the animals; and the SV2 and SV3 can be used for silage production for having been the highest in terms of crude protein.

Recommendations

Based on the above findings, the followings are recommended: the 21 days fermentation period of sorghum silage can be used by the livestock farmers in the locality; in terms of variety, the SV2 and SV3 varieties can be used for silage production considering their nutritional content and a wide range of sorghum cultivars and short-long long-term fermentation can be considered to identify the best choices for high silage production.

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