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Development of Production Technology and Effective Utilization of Maize Silage by Analyzing Chemical Characteristics, Aerobic Stability and Microbial Counts

[1]Tasmim Sultana, [2]Shahanur Alam, [3]Muhammad Fakhrul Islam and [4]Masud Rana

[1]Department of Dairy Science, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh
[2]Department of Fisheries Management, Hajee Mohammad Danesh Science and Technology University, Dinajpur, Bangladesh
[3]Department of Agricultural Economics, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh
[4]Department of Fishing and Post-Harvest Technology, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh

Abstract: The main goals of the research were to establish a method for producing high-quality maize silage, analyze its nutritional content using chemical analysis, aerobic stability and microbial assessments, compare its FCR to commercial silage and evaluate the quality of ruminant meat. A total of 25 grams of silage was mixed with 225 mL of 0.1% peptone water and then a series of dilutions (ranging from 10-2 to 10-6) was carried out using 0.1% peptone solution for each sample. The percentage values for protein, lipid, ash, moisture, fiber and starch content of the prepared silage were found significantly ($p<0.01$) in 10.4, 3.6, 6, 60, 22 and 27 whereas the silage collected from the market was found 6.7, 2.8, 5, 72, 25 and 30 respectively. The results revealed that the market price of silage produced from corn plants is about 32% lower than the silage available in the market yet 3 times the nutritious content. Analysis of microbial counts showed that inoculant-treated silage had higher levels of lactic acid bacteria (*Lactobacillus plantarum*), which are beneficial for fermentation and overall silage quality. In visual evaluation of the produced silage indicates that the produced silage possesses better features and exhibits high-quality characteristics than the marketed silage. However, the daily weight gain (715±1.32g/day) and feed conversion ratio of prepared silage were significantly ($p<0.01$) higher than that of silage purchased from the market (594±0.95g /day) in the whole period. By adopting the findings from this study, farmers and livestock producers can potentially enhance the nutritional value and longevity of maize silage as a feed source, ultimately benefiting the health and productivity of their animals.

Key words: Maize Silage · Proximate Composition · Growth Performance · Microbial Mounts · Sensory Analysis

INTRODUCTION

The agronomic qualities of maize silage, which includes robust crop insolubility, high productivity, high nutritional value and adaptation to certain conditions, make it one of the most prevalent forages used in dairy cow diets in farms in the United States of America, Asia and Europe [1, 2]. When there isn't any natural pasture, such as during the dry season, this technique is used to keep the pasture intact so that cows and sheep may consume it later [3]. In an effort to preserve as many nutrients as possible, the grasses are chopped and then fermented. Microorganisms that grow in the grass carry out the fermentation process [4]. By use of a natural "pickling" process, fodder that has been cultivated while still green and nutritious may be preserved. Fermentation of plant sugars by microbes in an oxygen-free environment (a "silo") results in lactic acid. Forage that is preserved in this manner is referred to be "ensiled forage" or "silage, " and it may be stored for up to three years without beginning to deteriorate [5]. For animals, silage is a very appetizing food that can be provided at any time of

Corresponding Author: Tasmim Sultana, Department of Dairy Science, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh.

the day. Before the nutrients, particularly protein, in the plant begin to deplete, it is possible to convert forages into plants to preserve them.

However, due to the fact that it is often too wet to dry properly, specialized technology is required to aid the forage in drying out as rapidly as possible [6]. Forage crops with thick stems, like maize, cannot be adequately dried into hay. The conservation of forage crops is commonly achieved through the use of silage. To achieve successful ensiling, a forage crop can be harvested at an early stage when it contains only 30% dry matter [7]. Silage production has long been a part of the wider agricultural industry, but smaller farmers are unable to produce silage since the process requires enormous production volumes and heavy machinery to dig or design storage pits and compress the green mass [8]. In dairy and beef cattle dietary requirements, maize silage serves as a major source of energy and fiber [9] and it is also often used as a key roughage component in total mixed rations [10]. There is very little work on maize silage processing and utilization in Bangladesh, especially FCR estimation, microbial counting and gut content analysis, my work revealed the nutritional quality of the produced silage and meat quality after feeding the ruminants which will play an effective role in small-scale producers. The primary objectives of the research were to develop a methodology for best quality silage production from maize; to evaluate the nutrient content of produced silage; to compare the FCR of the produced silage and other commercial silage and to compare the meat quality of ruminants, feeding with prepared silage and commercial silage.

MATERIALS AND METHODS

Study Area: The first part of this experiment involved processing silage at ARMA Agriculture Limited, Bangabandhu Road, Ashulia, Savar, Dhaka, where a silo pit was already established. The analysis was carried out at the Bangladesh Livestock Research Institute (BLRI), Savar, Dhaka and the Sher-e-Bangla Agricultural University's Dairy Science Laboratory.

Collection and Chopping of Maize: As part of the present study, whole maize was collected from Singair, Manikgang. The entire maize plant ought to be obtained by cutting it 10-12 centimeters from the surface of the ground. The collected maize is chopped into small pieces ranging between 2-3 cm. The sliced maize pieces were utilized for the preparation of silage.

Silage Processing and Storage: The chopped maize was mixed thoroughly with probiotics and molasses juice (50 gm/1000L) and placed inside the silo pit. Silo pits were loaded with the help of high pressing from the top in such a manner that one feet maize was placed then pressed and again placed one feet maize layer and pressed again finally from top. The total silo pit was covered with plastic sheets in such a way to make it completely airtight. Silo pits were locked for 18-22 days after that packed with 3-layer plastic bag and sealed tightly. The silo bags were stored in a room where no chance of rat's entry.

Determination of Nutrient Content: The nutrient content, including moisture, crude protein, crude fiber, crude lipid and ash was analyzed in the Dairy Science laboratory at Sher-e-Bangla Agricultural University in Dhaka. The nutrient composition of the samples was examined in triplicate using the standard procedure provided by the association of analysis chemist [11].

Silage Utilization: Ten beef was selected to feed commercial silage and ten beef were fed with prepared silage.

Growth Performance Analysis: Growth parameters of the feeding animals (cross-variety) were measured twice per month. Length and width were measured with the help of measuring tape and weight was calculated with the help of electric balance.

Gut Microbes Analysis: A conventional dispersion plate technique [12] was used to count microbiological species (yeasts, fungi and aerobic bacteria) according to the following described procedures. A total of 25 grams of silage was mixed with 225 mL of 0.1% peptone water and then a series of dilutions (ranging from 10^{-2} to 10^{-6}) were carried out using 0.1% peptone solution for each sample. Bacterial counts were conducted under controlled aerobic conditions, using plate count agar (PCA). The samples were incubated at 36±1°C for 24-48 hours to determine the total bacterial counts. Yeast counts were conducted using tryptone glucose yeast extract agar (TGY) following aerobic incubation for 24-72 hours at 30±1°C. The fungal count was determined using dichloro rose bengal chloramphenicol agar (DRBC) and incubated aerobically for 5-7 days at 25±1°C. Colony forming units per gram (CFU g^{-1}) were used to represent the total microbiological counts, which would then be translated into log10 to arrive at the lognormal distribution.

Meet Quality Analysis: Meet of the experimental animals was collected for sensory and biochemical analysis for both feeding trials.

Statistical Analysis: The data was analyzed and visually displayed using SPSS version 20.0 and Microsoft Office Excel 2010 software.

RESULTS AND DISCUSSION

The silage produced in the current study is of a much higher grade than the silage available in the market. The yield of silage produced is shown in the table below:

Estimation of Production Cost: The present study shows that the market price of silage produced from corn plants is about 32% lower than the silage available in the market but the nutritional value is about 3 times. The calculation of the materials used in the study and the production cost are shown in Table 2.

Evaluation of Physical Quality of the Prepared and Marketed Silage: The quality of the silage was assessed by individuals with expertise in evaluating its physical characteristics, including color, flavor, general appearance and overall acceptance. Visual evaluation of produced silage showed that the quality of color, smell and acceptability of the produced product was 8.5-8.7, 8.6-8.8 and 8.3-8.6, respectively on a 9-point scale [13] whereas the quality of marketed silage was 6-6.5, 5.5-6 and 5-5.5 respectively for color, flavor and acceptability (Fig. 01). Therefore, the results indicate that the produced silage possesses better features and exhibited high-quality characteristics than the marketed silage [14, 15] have shown that addition of molasses produced a strong sweet and alcoholic fragrance that is a sign of higher-quality silage. The presence of bacteria that produce acetate and lactate as well as water-soluble carbohydrates in sufficient amounts is likely responsible for the additions' improved anaerobic fermentative qualities [16].

Proximate Composition of Prepared and Market Silage: The percentage values for protein, lipid, ash, moisture, fiber and starch content of the prepared silage were 10.4, 3.6, 6.0, 60.0, 22.0 and 27.0, respectively whereas the silage collected from the market was found 6.7, 2.8, 5.0, 72.0, 25.0 and 30.0, respectively (Table-3). A comparison of the approximate composition of several silages was conducted using many results from earlier research [17], [18]. Overall, this study's findings on the nutritional value of produced silage over commercially available silage coincided with those of [19] who examined the effects of silages generated from corn fodders on their physical quality, digestibility and nutritional value. There were no notable variations in the lipid and ash content between prepared and marketed silage. In contrast to the current findings, scientist [20] claimed that adding certain additives for varying fermentation times enhanced the ash content. The second cause may be that the additive was utilized with high mineral content or the addition was applied at a period when soil contamination was present, which would have increased the total ash contents.

Determination of Growth Performance: To observe the body growth of cows fed silage, 10 cows were fed with produced silage and 10 cows with market-purchased silage as 4.5% body weight for 120 days. The weight of cows was measured and recorded at regular 15-day intervals. It is demonstrated that the cows fed silage produced at 120 days noticed an average body weight gain of 715 grams, while those fed market-bought silage had an average body weight gain of 594 grams. These findings demonstrated that the produced silage's average daily growth was higher than the silage purchased from the market (Tables 4 & 5). These results align with those of Lin *et al.* [21] who reported that supplementation with fermented feed could increase the average daily growth, feed conservation ratio, as well as dietary intake of Hanwoo steers. It might be the result of silages that go through microbial fermentation and its taste and smell are enhanced by the presence of various organic acids [22].

Gut Microbes Analysis

Isolation and Identification of Probiotics: From the generated silage, three strains of *Lactobacillus plantarum* (P_1, S_{11} and M_7) were identified in this investigation that exhibited potent antibacterial activity against three pathogenic bacteria. Inhibiting three harmful bacteria is mostly dependent on five common organic acids that are created when strains ferment. The fermentation broth had more antibacterial action than organic acid alone against *Salmonella* and *Escherichia coli* at the same pH. Additionally, several hazardous bacteria may be inhibited by combining organic acid antibacterial treatments in different ratios. Based on this discovery, combining several organic acids might be a viable strategy to create new antimicrobial agents that are employed in food preservation. Zhao *et al.* [23] reported that some lactic acid bacteria have the ability to create chemicals that resemble antibiotics and inhibit infections,

Table 1: Production/Yield of the Silage

SL. No.	Pit-01		Pit-02		Pit-03	
01			1st Production (March 10, 2022 to April 2, 2022)			
	Raw Maize (Kg)	Yield/Silage (Kg)	Raw Maize (Kg)	Yield/Silage (Kg)	Raw Maize (Kg)	Yield/Silage (Kg)
	3000	2856	3000	2868	3000	2825
02			2nd Production (April 15, 2022 to May 08, 2022)			
	Raw Maize (Kg)	Yield/Silage (Kg)	Raw Maize (Kg)	Yield/Silage (Kg)	Raw Maize (Kg)	Yield/Silage (Kg)
	3000	2910	3000	2875	3000	2932
03			3rd Production (April 10, 2022 to May 29, 2022)			
	Raw Maize (Kg)	Yield/Silage (Kg)	Raw Maize (Kg)	Yield/Silage (Kg)	Raw Maize (Kg)	Yield/Silage (Kg)
	3000	2865	3000	2934	3000	2852

Table 2: Cost-Benefit Analysis of the Produced Silage

SL No.	Ingredients	Total Used gm	Cost BDT	Yield Kg (Average)	Unit Cost BDT/Kg	Market Price (BDT/Kg)	Cost Less (%)
01	Raw Maize	1000	6000	930	8.60	11.5	32%
02	Probiotics	150	480				
03	Water	1L	-				
04	Polythene	1 rill	960				
05	Labor Cost	-	500				

Table 3: Nutritional Quality of the silages under examination

Nutritional Parameters	Silage Prepared	Silage Collected from Market
Protein%	10.4±0.13	6.7±0.04
Lipid%	3.6±0.37	2.8±0.06
Ash%	6±0.06	5±0.12
Moisture%	60±0.23	72±0.21
Fiber%	22±0.56	25±0.23
Starch%	27±0.29	30±0.37

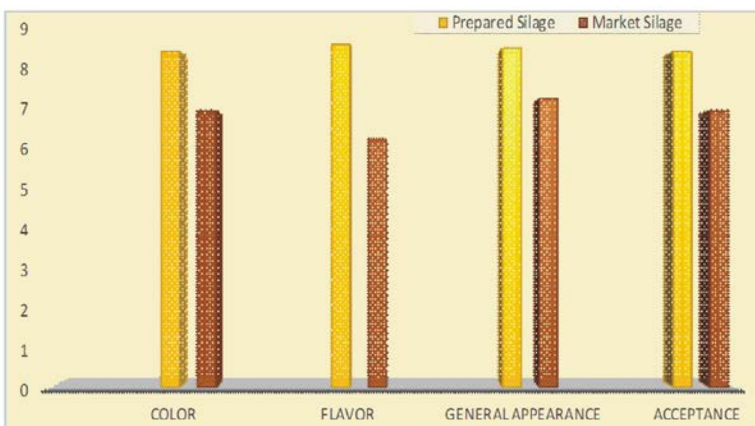

Fig. 1: Physical Quality of the Prepared and Marketed Silage

which is similar to the present study. The concentrations of *L. plantarum* sp. may suggest that this species, by its efficient promotion of lactic acid fermentation, plays a significant role in fermentation processes. Similar findings have been reported by Ennahar *et al.* [24], who found that the most often isolated microbe in paddy rice silage was *L. plantarum* sp. The findings of earlier research [25- 27] that found comparable LAB (Lactic acid bacteria) species composition in maize silage across areas of China, Japan and America are consistent with the findings. Selwet [28] and Kim *et al.* [29] also reported that by quickly inducing the fermentation process in ensiled conditions, LABs are regarded as crucial biological additions for the formation of silage. They may generate a variety of organic acids, especially those with high lactic acid concentrations, which cause silages to become more acidic. Silages kept with high nutritional content were kept from growing yeast or mold thanks to rapid acidification. When compared to commercial feed, it is an economical approach with excellent or identical outcomes.

Table 4: Growth Calculation (Feeding with Prepared Silage 4.5% Body Weight/Day)

Tag No.	Initial Wt. Kg	Day-15 Kg	Day-30 Kg	Day-45 Kg	Day-60 Kg	Day-75 Kg	Day-90 Kg	Day-105 Kg	Day-120 Kg
C-01	170	180	191.4	200	210	218	227.4	236	245
C-02	210	218	228.3	236	245	253.6	262	271	281.5
C-03	195	205.5	214	223.6	231	239.7	248	258	267.3
C-04	230	240	248.9	258.6	268.3	276.5	285	294.6	304
C-05	260	269.6	280	290	299.3	310	320	330.6	341.3
C-06	218	227	236.8	245	254	263	374.2	284.7	294
C-07	238	249	257.2	266	276.3	286	296	306.6	317
C-08	220	229.5	238	248.5	257.5	267	278	289	301
C-09	180	191	203	214	226	237.2	248.9	261	273
C-10	216	225.3	237	249	258	267.8	279	291	302
Average Growth Rate-715±1.32g/day									

Table 5: Growth Calculation (Feeding with Market Silage 4.5% Body Weight/Day)

Tag No.	Initial Wt. Kg	Day-15 Kg	Day-30 Kg	Day-45 Kg	Day-60 Kg	Day-75 Kg	Day-90 Kg	Day-105 Kg	Day-120 Kg
C-01	220	228.6	237	245	253.4	261.7	270	278	286.6
C-02	167	176	184	193.2	202	210	218.6	228	238
C-03	197	206	215	233.5	232	241	249	260	270
C-04	214.6	223	232.5	240	249.3	258.2	267	277	286
C-05	229	238	247	256.4	265.3	275.4	284	293.4	302
C-06	185.3	194.2	203	211	219.3	228	236	245	254
C-07	178.5	187	196.3	205	214	223	232.6	241.8	250
C-08	230	238	247	256.3	265	274.3	284	293	303.4
C-09	180	189	197.3	205	214.5	223	232	242	251
C-10	222	230	239	248	256.8	265	274	283.3	293
Average Growth Rate-594±0.95g /day									

Plate 1: Project Activities (1-Raw Maize; 2-Maize Chopping; 3-Maize Piling; 4-Maize Setting at Pit; 5-Poly Rapping to prevent air Space; 6-Prepared Maize Silage; 7-Feeding with Cow; 8-Weightening of the experimental cow; 8-Meat from examined cow)

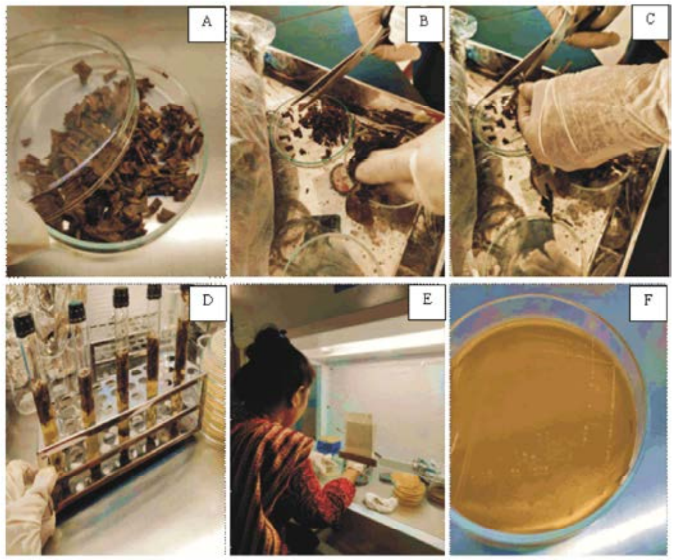

Plate 2: Determination of microflora (A. Silage in Petri plate; B. Smooth pieces; C. Sample preparation; D. Preparation of homogenate; E. Inoculation; F. Growth of *Lactobacilus* Spp.)

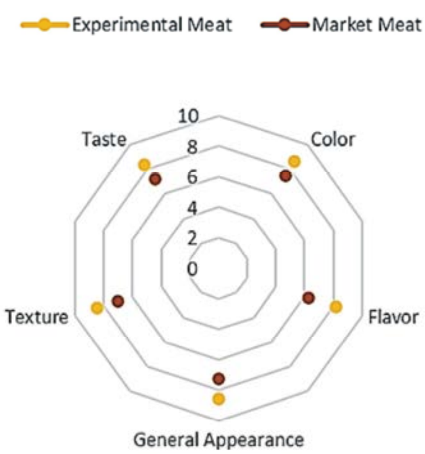

Fig. 2: Meat quality study by sensory test

Analysis of Meat Quality (Sample Collected from Experimental Animals and Collected from Slaughterhouse): The characteristics of meat that most strongly influence customers' purchase decisions and eating experiences include color, taste, flavor and texture. These characteristics are often referred to as sensory quality in the field of meat analysis. The primary criterion for selecting meat is its color, which has a significant influence on consumer purchases. In the present study, out of the cows that were fed the silage produced in this experiment, 1 cow was sacrificed and the meat was collected from the market and the quality of the two meats was evaluated. It can be seen that the external characteristics of silage-fed beef produced are of superior quality as shown in the diagram below (Fig.2). The results of the current study align with the research conducted by Kim *et al.* [29]. As for the color, softness, juiciness and general appearance of meat as well as its nutritional qualities. There were little differences across the varieties of silage [30] where a lower pH may have occurred as a result of starch consumption [31].

CONCLUSION

The present study demonstrated that damaging nitrates that build in plants during droughts and in over fertilized crops are reduced by the fermentation process in silage. It is possible to make best use of by-products (such as those obtained from the processing of sugar beets, maize straw and so on) and it takes ten times less storage space than hay requires. The nutritional value of maize silage is 30–50% more than that of maize grain and maize straw. This experiment will reveal a better and easier method of making silage, the ideal cattle feed that will contribute significantly to the nutritional needs of cattle of small and marginal farmers. The maximum amount of silage can be produced with the specific amount of maize. The nutritional value of the silage produced and the silage available in the market, as well as the FCR, will be determined, along with an understanding of the nutritional quality of their meat. One of the major costs of cattle rearing is the feed cost, which occupies the bulk of the total production cost. This study will show the way to meet the nutritional demands of cattle at a low cost and the researcher believes that reducing the cost of feed for farmers will play a role in making more profits, which will contribute significantly to the national economy.

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