DETERMINATION OF PHYSICAL AND NUTRITIONAL QUALITY OF SILAGES PREPARED FROM DIFFERENT SPECIES OF FODDER

A THESIS

BY

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A Thesis (Course No. AN-6104) Submitted to Agrotechnology Discipline in Partial Fulfilment of the Requirement for the Degree of Master of Science in Animal Nutrition

AGROTECHNOLOGY DISCIPLINE

KHULNA UNIVERSITY

KHULNA-9208

JUNE, 2023

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DEDICATED

TO

MY

BELOVED PARENTS

AND

YOUNGER BROTHER

ACKNOWLEDGEMENT

First and foremost, praise and gratitude are due to the Almighty Allah for the gifts He bestowed on the thesis-writing process in general.

I want to convey my sincere admiration, gratitude, and appreciation to my deserving supervisor, Professor Dr. Sardar Safiqul Islam, Agrotechnology Discipline, Khulna University, for giving me the chance to finish the thesis and for his invaluable guidance throughout the process. His warmth, genuineness, provision, and inspiration have immensely fueled my motivation. I appreciate his kind assistance, tolerance, adaptability, friendliness, tremendous, informed monitoring, and helpful criticism in getting the job done. Being able to work with him was a huge honor and blessing.

My sincere thanks go out to Professor Dr. Md. Shafiqul Islam, Agrotechnology Discipline, Khulna University, my esteemed teacher and co-supervisor, for his assistance, collaboration, and timely advice in helping me finish the project.

I would also like to express my gratitude to Khulna University's Agrotechnology Discipline for allowing me to study there and participate in this thesis work. I also extend my sincere gratitude to our discipline's head and all of the teachers at Khulna University's Agrotechnology Discipline for their helpful collaboration throughout the research time.

Additionally, I would like to thank Mr. Minhazul Abedin Sun, a Ph.D. fellow, Mr. Protap Mollick, Mr. Shuvonkor, Mr. Ajay and Mr. Rathin, Farm Caretaker and Lab assistant who are all contributed to the success of the research by helping in the farm and at the lab.

I sincerely thank my parents, brother, and friends for their unwavering support, prayers, and sacrifices in helping me finish this thesis in the allotted time.

My opportunity to finish this fascinating thesis project, which broadens my knowledge and experience, was fantastic. Last but not least, I would like to express my gratitude to everyone who made the thesis project possible.

June 2023 Author

ABSTRACT

Livestock production is often limited by the availability of high-quality forage, either through grazing or cultivated fodder. Most fodder and grass are grown seasonally and are particularly scarce during the dry season. Silage making is a good technology for fodder conservation that can ensure green pasture for livestock throughout the year. Hence, a study was carried out to observe the efficiency of small-scale silage production using simple low-cost technology and to ascertain the nutritional value of the silage. Cultivation of fodder species and preparation of silage are carried out in the field laboratory of Agrotechnology Discipline, Khulna University. The fodder for making silage was cut into 2 to 3 cm pieces, packed in plastic bags, carefully sealed and stored in drums with adequate sealing for 45 to 60 days. Three fodder species viz. Oat (*Avena sativa*), maize (*Zea mays*) and jumbo (*Sorghum bicolour Sorghum sudanefe*) were selected for silage preparation. Three replicates were maintained for each species. Prepared silages were opened and samples were collected for evaluation of physical and chemical properties. To determine the physical characteristics, color, aroma, texture and presence/absence of fungi were examined. Chemical analysis was performed in the animal Husbandry Laboratory, Khulna University following the procedure of AOAC (2003). Statistical analysis was performed using the SPSS (version 22) computer program. From the study of physical properties of silage, it was found that color, odor and texture were acceptable in all the samples and no fungus was observed in any of the samples. Chemical analysis showed that the highest dry matter (DM) content (g/100g) was observed in jumbo silage (22.72±0.88) and the lowest in maize silage (13.64±0.69) ($p<0.001$). The highest ($p<0.001$) crude protein (CP) content (g/100g) was observed in jumbo silage (15.49±1.05) and the lowest in maize silage (8.78±1.15). Crude fiber content (g/100g) was found to be highest in oat silage (34.11±1.59) and lowest in maize silage (31.68±1.40). Ether extract content (g/100g) was found to be highest in oat silage (4.60±1.25) followed by jumbo silage (1.99±0.08) and maize silage (1.22±0.41) ($p<0.01$). It can be concluded that by making silage using local knowledge and low-cost inputs, forage can be better preserved. Among the silages prepared from the three forage species, jumbo silage was found to have better nutritional value in terms of DM and CP content.

Keywords: Fodder, livestock, nutritional value, physical properties, silage.

CONTENTS

LIST OF TABLES

LIST OF PHOTOGRAPES

LIST OF ABBREVIATIONS

DM= Dry Matter

CP= Crude Protein

EE = Ether Extract

CF= Crude Fiber.

NFE= Nitrogen Free Extract

Chapter 1

INTRODUCTION

Livestock production is mainly constrained by lack of continuity in the supply of good quality feed, either grazing or conserved forage. Rearing of livestock includes several types of cost but high-cost accounts for feeding of animals. Ration of farm animals consist mainly roughage and concentrate feed. Although concentrate feed is available throughout the year, but high yielding grasses or good quality fodder is available for short period of time. Low-quality feed and seasonality are to blame for the low productivity rate of the global livestock production system. The livestock's inability to produce enough during periods of feed scarcity is an example of issues with the year-round production of animal goods. The high output of livestock depends on the availability of adequate supplies of high-quality feed, particularly in developing nations, the lack of adequate supplies of high-quality forage is a significant barrier to the production of productive livestock. Shortage of ample amount of grass reduce production performance drastically specially during drought period. While grazing is the cheapest animal rearing method. It might not necessarily be the most profitable option. In most areas, seasonal shortages in the amount and quality of grazing feed limit output (Tamang and Gyeltshen, 2015). Low-quality feed and seasonality are to blame for the low productivity rate of the global livestock production system Ensilage offers alternative means of fodder conservation during the rainy season while retaining nutrient quality of the forage (Kallah *et al.*, 1997). Ensiling is the ideal forage conservation method to overcome this problem. In general, silage is characterized as more quality feed than hay because less time is needed to wilt the forage, causing a small reduction in the feed nutritive value (Ramos *et al.*, 2016). That is why farmers are now-a-days very enthusiastic to produce silage feeds for their animal as it has high nutritive value, good taste, flavour and texture. If there is a lot of production in the monsoon, there is an opportunity to preserve the grass by making silage. Storing grass as silage allows high quality feed for feeding during the dry season (Mellish and Karinga, 2005). High-quality feed is not available in the field during winter and high-quality stored supplements are fed at any time of the year to supplement grass to improve milk production or N utilization (Mannetje, 2008). Therefore, silage production is used to compensate for feed shortages. A good alternative that disrupts livestock production. Making silage is a convenient way to preserve forage crops while increasing their palatability and nutritional content.

Silos of all shapes and sizes, including tower, pit, bunker, pile, trench, and plastic bag systems, are really utilized in silage processing (Rafiuddin *et al.*, 2017) The ability to preserve readily available fodder in tiny amounts for a long time is one of the main benefits of silage bags. Using bags for filling, packing, sealing, handling, and dispensing things is highly convenient (Batra *et al.*, 2016; Reiber *et al.*, 2009).

The feed value of maize silage is always high, it has a lot of energy, it tastes delicious, and it is environmentally friendly (Densley *et al.*, 2011). Maize silage may also efficiently recycle plant nutrients, especially substantial amounts of nitrogen and potassium (Bean, 2012). In recent decades, it has been reported that maize can produce good quality silage which enhance milk production of dairy cattle but all farmers are not cultivating maize. Oats *(Avena sativa)* are an annual crop that are popular in temperate areas (Sterna and Brunava, 2016) and are used for both grain and fodder in many nations (Kim, 2014). Oats can be used as forage, fodder, straw, silage chaff, and human nourishment when they are rolled or crushed into meal or flour (Ahmad *et al.*, 2014). 113 phytochemicals have been found in oats, making them a functional food (Sterna and Brunava, 2016; Raguindin *et al.*, 2020). It includes a variety of phenolics and avenanthramides. Many oat products contain mixed-linkage -glucan, a water-soluble dietary fiber, which is thought to be the primary physiologically active ingredient. Fast-growing, tasty, succulent, and nutrient-rich fodder crops include oats (Irfan *et al.*, 2016).

Sorghum-Sudan hybrids, often known locally as "Jumbo" or "Sudax," resemble Sudan grass but are taller, have longer stems and leaves, and produce higher yields. It is a species that can endure long periods of drought and is adaptive, strong, and very productive. Moreover, it can be grown all year round and stored after harvesting for regrowth. It is delectable and can be fed fresh, as silage, or as grazed on the ground. One of the most significant forages, jumbo grass produces a high herbage production per unit of land.

Research Gap

Little information is available about the efficiency of silage preparation from different fodder species particularly in the coastal area of Bangladesh. The physical and nutritional properties of Oat, Maize and Jumbo are not available.

The findings of proposed research will help know which fodder species is suitable for high quality silage preparation as well as the physical and nutritional quality of silages prepared with different fodder species.

Objectives

i. To determine the physical quality of silages from different fodder species.
ii. To determine the nutritive value of different types of silage.

Chapter 2

LITERATURE REVIEW

2.1. History of silage

Green fodder was kept for animals in some regions of Germany around the beginning of the 19th century using the same method as the sauerkraut-making procedure. French farmer Auguste Goffart of Sologne, close to Orléans, became interested in this. He wrote about his experiences storing green harvests in silos in a book that was published in 1877 (Auguste, 1877). There was a lot of interest in Goffart's experience (Chisholm, 1911). The ensiling of green corn fodder was quickly embraced by farmers in New England due to the favorable dairy farming circumstances in the United States. In 1876, Francis Morris of Maryland prepared the nation's first batch of silage (Crisp, 1908). The technique was first used in the United Kingdom by Thomas Kirby for British dairy herds as a result of the system's successful outcomes in the US (Thomas, 1901). Artturi Ilmari Virtanen, a professor of chemistry at the University of Helsinki, created the contemporary silage, which is acid- and air-preserved. Virtanen received the 1945 Nobel Prize in Chemistry "for his research and discoveries in agricultural and nutrition chemistry, especially for his fodder preservation method," which was essentially the creation of contemporary silage. Early silos were constructed of stone or concrete, either above or below ground (Artturi, 2020). It is now known, however, that air can be effectively excluded in a tightly packed stack, even though in this situation a few inches of the fodder around the walls is typically unusable due to mildew. Wooden cylinders of 35 or 40 feet in depth were typically used to build constructions in the US. (Chisholm, 1911) when agriculture first became mechanized in the late 1800s, stalks had to be manually cut and collected using a knife and a horse-drawn wagon. They were then fed into a stationary machine called a "silo filler" that sliced the stalks and blew them up a constricting tube to the top of a tower silo.

2.2. Silage

Silage is a form of fodder manufactured from green foliage crops that have been acidified to the point of preservation by fermentation. Cattle, sheep, and other ruminants can be fed it (cud-chewing animals). Ensilage, ensiling, or silaging are terms used to describe the fermentation and storing process. Silage is typically produced utilizing the entire green plant from grass crops, such as maize, oats, jumbo or other cereals (not just the grain). Silage must be manufactured from plant material that is an appropriate moisture content: between 50%

and 60%, depending on the method of storage, the level of compression, and the amount of water that will be lost during storage, but not more than 75%. It is not necessary for the weather to be as fair and dry during harvest as it is while harvesting for drying. Crops are shred after harvesting into pieces that are 15 mm (12 in) length. The material is tightly packed and laid out in regular layers on the silo floor. Straw or another dry porous material may be strewn over the surface of the silo or stack before it is filled with material. To prevent overheating in the case of the stack, additional pressure is supplied by weights. In the silo, the pressure of the material, when chaffed, restricts air from all except the top layer (Chisholm ed. 1911).

Silage goes through an anaerobic fermentation process that turns sugars into acids and begins roughly 48 hours after the silo is filled. After two weeks into fermentation, it is essentially finished. The trapped oxygen is used up during the aerobic period that precedes the commencement of anaerobic fermentation. By controlling the chemical reactions that take place in the stack, how tightly the fodder is packed affects the type of silage that is produced. As a result of the limited oxygen supply caused by dense packing, the existing carbohydrates are broken down into acetic, butyric, and lactic acids by the accompanying acid fermentation. This item is referred to as sour silage. (Chisholm, ed. 1911) When the mass is crushed at a temperature of 60–70 °C (140–160 °F), the action stops and sweet silage is produced. If the fodder is unchaffed and loosely packed, or the silo is built gradually, oxidation progresses more quickly and the temperature rises. While making sour silage, up to one-third of the albuminoids may be transformed into amino and ammonium compounds; when making sweet silage, a lesser proportion is changed, but they are less digestible. (Chisholm, ed. 1911) Sour silage has an unpleasant odor when the fermentation process is improperly handled because too much ammonia or butyric acid is produced (the latter is responsible for the smell of rancid butter). In the past, the fermentation process was carried out by local microorganisms; however, in the present, certain bulk silage is injected with particular microbes to expedite fermentation or enhance the resulting silage. The most popular lactic acid bacteria strain found in silage inoculants is Lactobacillus plantarum. Pediococcus species, Enterococcus faecium, and Lactobacillus buchneri are among other bacteria that are utilized.

In Northern America, oats are one of the most common cereal forages utilized for silage. Oat fodder is mostly utilized in Europe for silage (Suttie and Reynolds, 2004). Compared to other cereal crops, oats produce more silage or green feed per hectare (Fraser and McCartney, 2004). If timely water is received for germination and growth, oats might be one of the best affordable emergency forages (balage) following a drought (Bagg, 2012). Oat forage suitable for silage can be harvested at the boot, milky dough, or soft dough stages. Oat silage has a low DM, high palatability, high energy, and high protein content when it is cut at the boot stage. Wilting is required during ensiling in order to lower moisture and stop sewage. Oat silage has more DM and a higher calorie value when it is cut at the dough stage, but less protein and palatability (Mickan and Hill, 2006). While choosing a harvesting stage, consider the needs of the animals: boot stage for high nutritive value requirements, such as for breastfeeding dairy cows, and soft dough stage for fodder quantity requirements, such as in late pregnancy (Barnhart, 2011). It is hotly contested and relies on local conditions and requirements whether to cut oats at the milky dough stage or soft dough stage. Water soluble carbohydrates are lower and fermentation is more difficult to start when silage is generated in the dough stage. It is advised to chop oat forage to a length of 10-20 mm since the thickness and hollowness of oat stems prevent the compression necessary for anaerobic conditions (Suttie and Reynolds, 2004). It has been demonstrated that urea, enzymes, and inoculants enhance aerobic stability, pH decline, and lactic acid production in oat silage, which enhances feed intake and milk output (Meeske *et al.*, 2002).

Table 2.3.1. Oat forages nutritional parameters

Main analysis	Unit	Avg.	SD.	Min.	Max.	Nb
Dry matter	% as fed	26.3	6.7	14.1	38.3	43
Crude protein	% DM	10.5	4.1	5.8	26.2	66
Crude fibre	% DM	30.2	3.5	21.5	34.7	37
NDF	% DM	54.2	8.1	34.2	65.6	37
ADF	% DM	31.0	6.3	19.6	39.3	37
Lignin	% DM	4.5	1.1	3.3	6.1	10
Ether extract	% DM	3.4	1.0	2.0	4.7	21
Ash	% DM	10.1	1.8	7.0	14.5	58

Avg. = Average; SD= Standard deviation; Min. = Minimum; Max. = Maximum; Nb= Number of samples; DM= Dry matter.

Arelovich *et al.* (2003); Bargo *et al.* (2001); Demarquilly *et al.* (1970); Dougall (1954); Fulkerson *et al.* (2007); McCartney and Vaage (1994); Wallsten *et al.* (2010).

Table 2.3.2. Oat silage nutritional parameters

Main analysis	Unit	Avg.	S.D.	Min.	Max.	Nb.
Dry matter	% as fed	30.5	4.6	23.7	38.5	27
Crude protein	% DM	9.5	1.6	6.7	12.1	30
Crude fibre	% DM	32.4	2.6	26.5	35.9	17
NDF	% DM	53.4	5.3	44.2	62.2	15
ADF	% DM	35.9	2.8	29.9	39.5	24
Lignin	% DM	4.1	1.2	2.0	6.0	13
Ether extract	% DM	5.8	1.4	3.4	7.6	7
Ash	% DM	9.4	2.2	6.0	14.9	30

Avg. = Average; SD= Standard deviation; Min. = Minimum; Max. = Maximum; Nb= Number of samples; DM= Dry matter.

Abeysekara (2003); Christensen *et al.* (1977); McCartney and Vaage (1994); Wallsten *et al.* (2010); Woodman (1945).

2.4. Maize Fodder

Green fodder from maize (*Zea mays* L.), especially when it includes stalks, leaves, and ears, is a high-energy source for ruminant livestock. In cooler climates, maize fodder is often ensiled, however year-round maize production in the tropics may allow for continual collection of green forage, negating the need for ensiling (Brewbaker, 2003). In times of shortage (dry, hot summers and winters), grazing whole maize plants also supplies green feed to animals (Potter, 2012; Newport, 2006). A good source of fodder for smallholder-owned livestock in difficult environments with limited forage is maize green forage (Methu *et al.*, 2006). In comparison to the majority of other tropical fodder crops, where the DM is frequently less than 40% digestible, maize is a higher calorie feed. Whereas maize feed in the tropics matures within three months, is only collected once, and doesn't require a lot of labor or expensive technology, grass forages in the region must be harvested virtually monthly (Brewbaker, 2003).

The popularity of baby corn as a vegetable is rising all throughout the world. Baby corn is made up of young, immature cobs of maize plants that were picked before pollination and a few days after silk emergence. Baby corn can be grown using the same hybrids as regular maize crops or using specially adapted hybrids that are smaller and produce multiple stalks. Baby corn is a commercial crop that matures quickly and only needs 55–60 days between planting and harvest. The crop remnants, which include stalks, leaves, husks, and silk, provide very good quality fresh feed that cattle find appetizing because it is picked at an early stage of growth. It can be grown year-round in tropical regions. 2013 saw an output of more than 276 000 t of baby corn in Thailand. It can be expected that the remaining 85% of the production, which only makes up 15% of the edible baby corn cob, might produce more than 1 million t of fodder (green matter). You can feed baby corn forage either fresh or ensiled. Central America is the original home of the maize plant, which later expanded to the Caribbean, Southern, and Northern America. Now, 58°N in Canada and Russia and 40°S in Chile and Argentina, and from sea level to an altitude of 3800 m in the Andean mountains, are the ranges where it grows, thanks to genetic selection and hybridization (Ecoport, 2010). In the 18th and 19th centuries, maize was a useful backyard plant in Europe. In France, maize was widely planted to supply "fourragettes," or green forage, beyond the region where grain could be grown (South Brittany, former Maine, Paris Basin, Lorraine). In the late summer and early fall, when other grasses were in short supply, it was employed in animal diets. Up until the 1970s, when new pioneer hybrids began to be produced, this forage method was in use. Average daytime temperatures of 18 to 21 °C, yearly precipitation of at least 750 mm, and rich, deep soils are all ideal for development. However, maize can survive a wide range of soil types, pH values between 4.3 and 8.7, and annual rainfall amounts between 230- and 4100-mm. Plants are killed by frost. At flowering, drought is harmful because it interferes with pollination and reduces yields. Flooding is not something maize can handle.

Whole ensiled maize plants are used to make maize silage. Anywhere maize can grow, from temperate to tropical areas, it is one of the most excellent forages for ruminant animals. There are various reasons why maize silage is so popular. It is a reliable source of tasty and high-energy forage for all kinds of ruminants, including dairy cattle, beef cattle, sheep, and goats (Roth and Heinrichs, 2001). It is one of the highest producing fodder crops, requiring less labor (because it is harvested in a single operation), and is generally less expensive to produce (per t DM) than other forage crops (NASS, 2015; Arvalis, 2011; Roth and Heinrichs, 2001). Because it is feasible to turn a maize grain crop that has been harmed by frost, rain, or drought into maize silage, maize silage is also a useful approach to secure the crops (Arvalis, 2011; Roth and Heinrichs, 2001).

Since the early 19th century, Germany, Scandinavia, and the French Alps have used a technique that involves preserving green crops in silos in a manner akin to making sauerkraut. The method was popularized in 1877 by the French agriculturist Auguste Goffart in a book (Goffart, 1883), which was later translated into English (Goffart and Brown, 1880). Ensiling green maize was later introduced to the USA shortly after this. However, in Northern Europe, the technique did not really take off until the 1970s and 1980s when early maize hybrids were created, allowing maize to be grown in milder climates. Today, maize silage has essentially replaced green maize forage as the primary source of maize fodder for animals. For instance, 20% of the diets of both dairy and beef cattle in France in 2015 consisted of maize silage. 16.8 million ha are used for maize forage globally (AGPM, 2015). With 6.1 million hectares of maize fodder, including 1.2 million ha devoted to biogas generation, the EU-28 was the largest producer in 2015. Since 2000, the amount of maize fodder produced in Europe has grown gradually, from 4 million ha to 6 million ha in 2015. According to NASS (2016), there were 2.51 million acres of maize silage in the USA in 2015.

Forage made of maize should be gathered at 30 to 35% DM. Yield, nutritional value, and silage quality are trade-offs when deciding when to harvest (Arvalis, 2011). The best time to harvest a plant is when it has attained physiological maturity and is fully developed. This typically happens 50 to 55 days after the cob silks are formed and corresponds to a DM of 32 to 38% for the entire plant. This is related to the milk line, which marks the transition from the grain's dent to liquid portion, and the black layer, which appears at the base of the kernel after the kernel has reached full maturity. The milk line of the grain should be located between 1/3 and 2/3 of the grain from the top at the ideal moment (Ashley, 2001). The grain should be ground to prevent loss of digestibility once the black coating forms, which indicates that the DM concentration is greater than 37% (Ashley, 2001) Poor silage quality may be caused by DM concentration that is too low or too high. Early harvesting causes low DM concentration in silage, which can be bulky and lower feed intake and animal performance. According to a low DM concentration causes nutritional losses (DM, water soluble carbs, and protein) during ensiling. Due to poor starch and fiber digestibility, silage harvested too late can have low nutritional value. Intake of DM may be decreased by the reduced palatability of such silage. Inadequate packing conditions from a late harvest may cause heating issues. To get around this, finely chopped late-harvested maize silage should be used.

Table 2.4.1. Maize forage nutritional parameters

Main analysis	Unit	Avg.	S.D.	Min.	Max.	Nb.
Dry matter	% as fed	23.3	6.4	12.6	47.6	51
Crude protein	% DM	7.9	2.1	3.0	12.8	98
Crude fibre	% DM	28.7	3.9	19.1	36.6	82
NDF	% DM	63.2	7.1	54.7	81.5	32
ADF	% DM	31.3	5.5	23.3	45.7	32
Lignin	% DM	4.3	0.8	2.9	6.0	23
Ether extract	% DM	1.9	0.6	0.7	3.1	55
Ash	% DM	7.0	2.1	2.5	11.8	97

Avg. = Average; SD= Standard deviation; Min. = Minimum; Max. = Maximum; Nb= Number of samples; DM= Dry matter.

Axtmayer *et al.* (1938).

Table 2.4.2. Maize silage nutritional parameters (Dry matter <25%)

Main analysis	Unit	Avg.	S.D.	Min.	Max.	Nb.
Dry matter	% as fed	23.5	1.1	20.2	24.9	187
Crude protein	% DM	8.0	1.3	5.1	11.7	180
Crude fiber	% DM	23.6	2.2	18.3	29.6	174
NDF	% DM	49.3	5.1	47.7	65.0	11
ADF	% DM	27.0	4.7	26.4	43.0	10
Lignin	% DM	3.2	1.4	3.0	7.5	10
Ether extract	% DM	2.6	1.3	1.2	6.6	17
Ash	% DM	4.8	1.0	2.3	7.7	177

Avg. = Average; SD= Standard deviation; Min. = Minimum; Max. = Maximum; Nb= Number of samples; DM= Dry matter.

Andrieu (1976); Valentin *et al.* (1999).

2.5. Jumbo Grass

A promising grass because to its quick growth and great output is jumbo grass (Sorghum bicolor Sorghum sudanefe) (Stuart, 1990). It is well-known for its great productivity and extremely late flowering period, which is brought on by brief day lengths. Because of its accessibility during times of summertime fodder shortage, it is also significant. There is, however, a paucity of knowledge about the nutritive value of Jambo grass and its silage in various environments.

Table 2.5.1. Chemical composition of Jumbo Grass and Jumbo Grass Silage

Component	Jumbo grass	Jumbo grass silage
Dry matter	44.3	42.1
Crude protein	12.7	12.7
Neutral detergent fiber	62.8	58.8
Acid detergent fiber	32.4	34.0
Ash	8.88	9.50

Chapter 3

MATERIALS AND METHODS

3.1. Experimental site: Cultivation of fodder and production of silage is carried out in the Field Laboratory of Agricultural Technology Discipline of Khulna University. The proximate composition of the silage samples was determined at Animal Husbandry Laboratory of Agricultural Technology Discipline, Khulna University, Khulna.

3.2. Selection of fodder species: Oat, Maize and Jumbo fodders were used to prepare the silages.

3.3. Land preparation and fodder cultivation: 3 experimental plots (three plots for oat, maize and jumbo) with each of 12 m^2 were prepared by properly weed slashing, ploughing, laddering and manuring. Sheep manure, urea, triple super phosphate (TSP) and muriate of potash (MP) were utilized prior to plow. After land preparation, oat, maize and jumbo seeds were sowed. In oat's, maize's and jumbo's plots line to line distance was 25 cm,40 cm, 30 cm respectively and seed to seed distance was 10cm,25cm,10cm respectively.

Photograph 1. Fodder cultivation

3.4. Harvesting of fodder:

Fodder species	Sowing date	Harvesting date	Total days
Oat	03.12.2022	09.03.2023	96
Maize	03.12.2022	09.03.2023	96
Jumbo	03.01.2023	06.04.2023	93



Photograph 2. Fodder harvesting.

3.5. Silage preparation: Nine plastic bags were used to prepare the silages. Oats and Maize fodder were harvested 96 days, jumbo fodders were harvested 93 days after sowing. The fodders were chopped at 2 to 3 cm and filled the plastic bags and compact it as much as possible to make it anaerobic condition. The filled bags were sealed properly and kept in drum with proper sealing.



Photograph 3. Silage preparation.

3.6. Layout of Experiment:

Treatment	Replication		
	R_1	R_2	R_3
T_1	T_1R_1	T_1R_2	T_1R_3
T_2	T_2R_1	T_2R_2	T_2R_3
T_3	T_3R_1	T_3R_2	T_3R_3

Here, Treatments were fodder species.

T_1= Maize fodder.

T_2= Oat fodder.

T_3= Jumbo fodder.

3.7. Opening of silage and sample collection: Oat and Maize fodder were kept 60 days and Jumbo fodder was kept 45 days for ensiling process.

Photograph 4. Maize silage, Oat silage and Jumbo silage.

3.8. Assessment of physical properties: To assess the physical properties, the samples were subjected to observe it's color, odor and texture.

3.9. Assessment of chemical properties: To determine the chemical properties, the samples were subjected to the proximate analysis. Proximate analysis of silage samples will be done according to AOAC (1990).

3.9.1. Determination of dry matter

Test Procedures

At first, the crucible was weighed (W1). Then Approximately 2 g dried and ground sample was taken to each crucible. The weight of the sample and crucible (W2) was recorded. Samples were placed in preheated oven at 104+ 1°C and dried for 24 hours and after 24 hours dried samples were removed from the oven. After oven-dry crucible containing the dried sample was weighed (W3).

Photograph 5. Determination of dry matter.

Calculation

$$\% \text{ DM} = \frac{(W3 - W1)}{(W2 - W1)} \times 100$$

Where,

W1 = weight of crucible in grams

W2 = initial weight of sample and crucible in grams

W3 = dry weight of sample and crucible in grams

3.9.2. Determination Crude Protein (CP)

Test Procedures

Crude protein was determined followed by the Kjeldahl method. The power of the KDN Kjeldahl block digester was turned on and digestion tubes were checked and replaced those that were cracked or chipped. 0.2-0.6 g (usually ~0.3 g) samples were weighted out and taken. The protein analysis was done by following three different steps which are discussed below:

Digestion

For concentrate samples,

1g of sample was taken into the test tube. For each sample 2 catalyst tablets VCM, 2 antifoam tablets VS and 20 ml concentrated sulfuric acid (96-98%) were added into the test tube and the test tube was shaken gently. The sample with the H_2SO_4 mixture was given in the digestion block. The exhaust fan near the digestion block was turned on. The sample was heated 2 times in the digestion block. Firstly, 40 min at 300°C and then 90 min at 420°C. Then the test tube was kept into the digestion block for 15 minutes for cooling.

For the forage sample,

1g of grounded sample was taken into the test tube. For each sample, 2 catalyst tablets VCM, 2 antifoam tablets VS and 12 ml concentrated sulfuric acid (96-98%) were added into the test tube and the test tube was shaken gently. The sample with the H_2SO_4 mixture was given in the digestion block. The exhaust fan near the digestion block was turned on. The sample was heated for 60 min at 420°C in the digestion block. Then the test tube was kept into the digestion block for 15 minutes for cooling.

Distillation

After cooling the sample, it was mixed with 50 ml distilled water. Then the test tube with the sample was then put into the distillation cycle. 30ml 2% Boric acid solution was taken in a conical flask and 3 drops of methyl blue were added to it. The conical flasks were then placed near the distillation tube. The water flow and the flow of 50 ml 40% NaOH were previously adjusted. After that, the button was pressed to begin the distillation process. The distillation process was done for 5 min until the color of the indicator mixture solution did not turn into bottle green color.

Titration

The sample of the conical flask was then taken for titration. For concentrates, 0.1N HCl was taken into the burette pipe for titration and added dropwise and on the other hand, for grasses, 0.2 N HCl was taken. The procedure was continued until the color of the solution of the conical flask turns blue from bottle green. When the solution color had changed, the titration procedure was ended. The strength of the titrate was then recorded.

Photograph 6. Determination of crude protein.

Calculation

Nitrogen (%) $= \frac{(ml\ sample - ml\ blank) \times 0.1 \times 14.01 \times 100}{1000 \times sample\ weight(g)}$

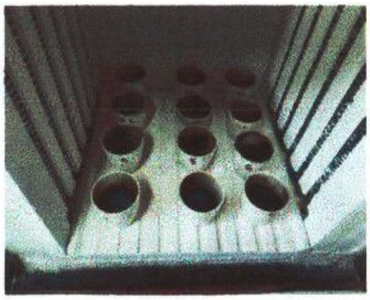
Crude protein (%) = Nitrogen (%) × Conversion factor *

*= Conversion factors for animal and plant origins ingredients are 6.25.

3.9.3. Determination of Total Ash (TA)

Procedures

At first, the crucible was weighed (W1). About 2 g sample was weighed (W2) into a crucible that had been tarred. Crucibles were placed in a muffle furnace at 600°C for 4 hours. After 4 hours, crucibles were allowed to cool in a furnace and after that, the crucibles were placed in the desiccator. Crucibles were cooled in desiccators to room temperature and were weighed immediately (W3).



Photograph 7. Determination of ash.

Calculation

Ash (%) $= \frac{(W3 - W1)}{W2} \times 100$

Where,

W1 = weight of crucible in grams

W2 = weight of sample in grams

W3 = weight of crucible and ash in grams

3.9.4. Determination of Ether Extract (EE)

Procedures

At first, the sample was weighed (W1), from 3 to 10 g. The samples were then introduced directly inside the cellulose thimble. Then the sample containing thimble was introduced into the extraction set. Extract collecting vessel was weighed (W2) and 70ml acetone was added into the vessel. Then the extraction vessel with solvent was introduced in the extraction equipment. The extraction unit was closed and the unit was turned on by a general switch located on the control panel. For acetone, the temperature was fixed at 110°C. The cooling water flow and heating were started. When the solvent was started boiling, the thimble was immersed by placing the slider into an "immersion" position. After 60 minutes, the thimble was extracted from solvent placing the slider into the "washing" position. After 60 minutes of reflux washing, the slider was placed into the "recovery" position. After 30 minutes of recovery, the stopcock located under the water-cooled condenser was closed and the solvent was completely evaporated from the extraction vessel. Then the extract collecting vessel with boiling stones was dried in an oven for 30 minutes at a temperature high enough to evaporate completely solvent residues. Then the extract collecting vessel was cooled and weight (W3) was taken.

Photograph 8. Determination of ether extract.

Calculation

Ether Extract (%) $= \frac{(W3 - W2)}{W1} \times 100$

Where,

W1 = initial weight of sample in grams

W2 = initial weight of vessel in grams

W3 = weight of vessel and Lipid residue in grams

3.9.5. Determination Crude Fiber (CF)

Procedures

The crude fiber was determined by following the method of AOAC (1990). At first, the sample moisture was determined separately by heating in an oven at 105°C to constant weight and was cooled in a desiccator. 1 g sample was weighed accurately (W). The switch of the fiber analyzer was turned on. 1.25% sulfuric acid was added to the 150ml notch, after preheating by the hot plate in order to reduce the time required for boiling. Then 3-5 drops of n-octanol as an antifoam agent was added. 30 minutes was boiled exactly from the onset of boiling. Then for draining sulfuric acid, it was connected to the vacuum. 30 ml of hot deionized water was added and washed three times, connecting each time to compressed air for stirring the content of the crucible. After draining the last wash, 150ml of preheated 1.25% potassium hydroxide (KOH) and 3-5 drops of antifoam were added and was boiled for 30 minutes. Then again 30 ml of hot deionized water was added and washed three times, connecting each time to compressed air for stirring the content of the crucible. Then in order to cool the crucibles, the last washing was performed with cold deionized water and then the crucible content was washed three times with 25 ml of acetone, stirring each time by compressed air. The crucible was removed and the dry weight was determined after drying in an oven at105°C for an hour and then was cooled in a desiccator. The weight represents the crude fiber plus ash content (W1). The crucible was then placed in a muffle furnace and heated up to 550°C for three hours and reweighted after cooling in a desiccator (W2).

Photograph 9. Determination of crude fiber.

Calculation:

Crude fiber (%) $= \frac{(W1 - W2)}{W} \times 100$

Where,

W = initial weight of sample in grams

W1 = weight of crude fiber plus ash content in grams

W2 = weight of ash in grams

3.9.6. Determination of Nitrogen Free Extract (NFE)

The calculation for nitrogen free extract is:

% NFE = 100 % – (% EE + % CP + % Ash + % CF).

As nitrogen-free extract is calculated by difference, all the errors associated with proximate analysis are additive in the estimate of nitrogen-free extract.

3.10. Statistical analysis: Data were recorded and analyzed using SPSS program in computer.

Chapter 4

RESULTS AND DISCUSSION

4.1. Physical Characteristics of silages

Physical properties of silage samples are presented in Table 4.1.1. A dark green color was observed for maize silage while both oat and jumbo silages showed yellowish green color. Non-acid aroma was observed in maize silage but no acid aroma in oat and jumbo silage. Dense/solid texture was present in oat and jumbo silages but the maize silage showed a slightly soft texture. No fungus was appeared for any type of silage under study. Podkowka and Podkowka (2011) claim that color and scent can be utilized to identify well-fermented silage. Poorly fermented silage will be olive, blue-green, or dark brown in color (Podkowka and Podkowka, 2011), whereas well-fermented silage should be pale green or dull yellow in color. All of the silages prepared in this experiment had pleasing physical characteristics, including a brownish-green color and a delicious aroma. Jumbo was the only silage harvested at 45 days that had a moist texture despite the fact that all other silage had a hard and soft texture. There were no molds in the silages made from all cutting frequencies, but only the top layer of the silage made from maize, which was harvested at 90 days, contained very negligeable amount of mold. According to Gordon *et al.* (1963), mold infections can be noticed when the forage is very damp.

Table 4.1.1. Physical properties of silage samples

Properties	Maize silage	Oat silage	Jumbo silage
Color	Dark green	Yellowish green	Yellowish green
Aroma	Not acid or not rotten	Acid (keep fresh)	Acid (keep fresh)
Texture	Slightly soft	Dense/solid	Dense/solid
Fungus	None	None	None

4.2. Chemical composition of silages and fodder

Chemical analyses of all samples were based on dry matter (DM), with the exception of the dry matter of fresh grasses and silages. According to data of the Table 4.2.1, Jumbo silage had the greatest average DM content (g/100g), and maize silage had the lowest (13.64). Among fresh grasses, Jumbo had the greatest average DM content (30.33%) and oat had the lowest (13.67%). The DM content in maize fodder was 14.80%. The highest crude protein (CP) value (g/100g) of the silage samples was found in Jumbo (15.49), followed by oat (9.86) and maize (8.78) (Table 4.2.2). For fodder, Jumbo had the greatest CP (13.27%), followed by oat (11.77%) and maize (6.77%). The highest crude fiber (CF) content (g/100g) was found in oat silage (34.11) and lowest in maize silage (31.68) (Table 4.2.3). Crude fiber content of Jumbo silage was 32.84%. In case of fodder, the highest CF content was found in oat fodder (30.12%) followed by maize fodder (28.19%) and Jumbo fodder (24.48%), respectively. Oat silage had the highest ether extract (EE) concentration (g/100g), and maize silage had the lowest (1.22) (Table 4.2.4). The Jumbo silage had EE content of 1.99%. Oat fodder had EE content of 3.28%, where maize fodder had 2.55%, and Jumbo fodder had 1.48%. The NFE concentration (g/100g) of the silage samples shown in Table 4.2.5 ranged from 33.59 to 43.39, being lowest in oat and highest in maize silage. The NFE contents of fresh fodders were ranged from 55.89% and 38.76%, with jumbo fodder had the highest percentage and oat fodder had the lowest. Ash contents of silages and fresh fodders samples are shown in Table 4.2.6. Among silage samples, ash contents (g/100g) was highest in oat silage (17.84) and lowest in oat silage (6.58). Among fresh fodders samples, ash contents (g/100g) was highest in oat fodder (16.07) and lowest in jumbo (4.88).

Table 4.2.1. Dry matter (DM) contents (%) fresh fodders and silages

Fodder/Silage	Number	Mean ± SE	Minimum	Maximum
Maize silage	3	13.64±0.69	12.34	14.69
Maize fodder	3	14.80±0.46	14.00	15.60
Oat silage	3	16.00±0.56	15.02	16.97
Oat fodder	3	13.67±0.55	12.70	14.60
Jambo silage	3	22.72±0.88	21.08	24.07
Jambo fodder	3	30.33±0.55	29.60	31.40
Overall	18	18.52±1.50	12.34	31.40
F-value		113.67		
p-value		0.000***		

Table 4.2.2. Crude protein (CP) contents (%) fresh fodders and silages

Fodder/Silage	Number	Mean ± SE	Minimum	Maximum
Maize silage	3	8.78±1.15	7.05	10.96
Maize fodder	3	6.77±0.74	5.48	8.04
Oat silage	3	9.86±0.99	8.36	11.73
Oat fodder	3	11.77±0.81	10.80	13.38
Jambo silage	3	15.49±1.05	13.88	17.46
Jambo fodder	3	13.27±0.77	11.73	14.08
Overall	18	10.99±0.77	5.48	17.46
F-value		11.53		
p-value		0.000***		

Table 4.2.3. Crude fiber (CF) contents (%) fresh fodders and silages

Fodder/Silage	Number	Mean ± SE	Minimum	Maximum
Maize silage	3	31.68±1.40	29.40	34.22
Maize fodder	3	28.19±1.03	26.43	29.99
Oat silage	3	34.11±1.59	31.01	36.26
Oat fodder	3	30.12±1.09	28.23	32.01
Jambo silage	3	32.84±1.75	29.43	35.21
Jambo fodder	3	24.48±1.83	21.23	27.55
Overall	18	30.24±0.93	21.23	36.26
F-value		5.60		
p-value		0.007**		

Table 4.2.4. Ether extract (EE) contents (%) fresh fodders and silages

Fodder/Silage	Number	Mean ± SE	Minimum	Maximum
Maize silage	3	1.22±0.41	0.43	1.79
Maize fodder	3	2.55±0.07	2.48	2.70
Oat silage	3	4.60±1.25	3.04	7.08
Oat fodder	3	3.28±0.08	3.15	3.43
Jambo silage	3	1.99±0.08	1.83	2.11
Jambo fodder	3	1.48±0.09	1.29	1.60
Overall	18	2.52±0.34	0.43	7.08
F-value		5.41		
p-value		0.008**		

Table 4.2.5. Nitrogen free (NFE) extract contents (%) fresh fodders and silages

Fodder/Silage	Number	Mean ± SE	Minimum	Maximum
Maize silage	3	43.39±2.59	38.22	46.29
Maize fodder	3	50.81±0.57	49.66	51.43
Oat silage	3	33.59±2.23	29.44	37.06
Oat fodder	3	38.76±0.31	38.23	39.30
Jambo silage	3	43.10±2.87	38.06	47.98
Jambo fodder	3	55.89±2.38	52.46	60.47
Overall	18	44.26±1.92	29.44	60.47
F-value		14.98		
p-value		0.000***		

Table 4.2.6. Total ash contents (%) fresh fodders and silages

Fodder/Silage	Number	Mean ± SE	Minimum	Maximum
Maize silage	3	14.93±0.26	14.55	15.43
Maize fodder	3	11.67±0.49	10.84	12.55
Oat silage	3	17.84±0.52	17.18	18.86
Oat fodder	3	16.07±0.54	15.21	17.07
Jambo silage	3	6.58±0.39	5.89	7.25
Jambo fodder	3	4.88±0.09	4.70	4.98
Overall	18	12.00±1.18	4.70	18.86
F-value		161.25		
p-value		0.000***		

Maize silage has a 34% DM content, according to Pilipavicius *et al.* (2003), which was higher than present study. According to Abeysekara, (2003), oat silage had an average DM content of 30.5%, which was greater than in the current study. More DM was observed in jumbo silage by Touqir *et al.* (2007) (27.5%) than in the current study. Heuze *et al.* (2017) observed DM content of 23.3% in maize fodder, which was generally higher than the current study. Arelovich *et al.* (2003) found DM in oat fodder to be 26.3% which was higher than that of the current study. Jumbo fodder had a DM content of 22.1%, according to Bandara *et al.* (2016), which was lower than in the current study.

Pilipavicius *et al.* (2003) found 9.16% CP concentration in maize silage, which was generally consistent with the current investigation. Abeysekara (2003) noted 9.5% CP, which was primarily in line with the current study in oat silage. In jumbo silage, Touqir *et al.* (2007) found 9.55% CP, which was less than in the current study. Heuze *et al.* (2017) observed CP contents of 7.8% in.maize fodder, which was greater than the current study. In oat fodder, Arelovich *et al.* (2003), observed 10.5% CP, which was less than in the current study. Jumbo fodder had 11.63% CP, according to Bandara *et al.* (2016), which was a little less than in the current study.

In contrast to the current investigation, Pilipavicius *et al.* (2003) identified CF in Maize silage at a rate of 20.2%. Compared to the current investigation in oat silage, Abeysekara's (2003) observation of 32.4% CF was slightly higher. In comparison to this study, Touqir *et al.* (2007) discovered 42.0% CF in jumbo silage. Heuze *et al.* (2017) detected a slightly lower CF of 25.6% in maize fodder than the current study. Average 30.2% CF was found in oat fodder by Arelovich *et al.* (2003) was nearly identical to the results of the current investigation. Jumbo fodder had a CF content of 36.8%, according to Bandara *et al.* (2016), which was greater than the results of the current study.

Pilipavicius *et al.* (2003) observed EE in maize silage at a level of 2.2%, which was somewhat higher than in the current study. Abeysekara (2003) found 5.8% EE, which is greater than the findings of the current study in oat silage. The 1.2% ash observed by Touqir *et al.* (2007) in jumbo silage was largely identical to the results of the current investigation. Heuze *et al.* (2017) observed EE 2.9% in maize fodder, which was largely consistent with the current findings. The 3.4% EE observed in oat fodder by Arelovich *et al.*, 2003, was almost identical to the results of the current investigation. Jumbo fodder had 1.76% EE, according to Bandara *et al.* (2016), which was nearly identical to the findings of the current investigation.

In comparison to this study, Pilipavicius *et al.* (2003) finding of 3.7% ash in maize silage was significantly lower. Average 9.4% ash was reported by Abeysekara in 2003, which is less than in the current investigation. Average 9.50% ash was reported in jumbo silage by Touqir *et al.* (2007), which was more than in the current study. Heuze *et al.* (2017) found ash in maize fodder to be 8.7%, which was generally lower than the current study. According to Arelovich *et al.* (2003), oat fodder had 10.1% ash, which was less than in the current study. Jumbo fodder had an ash level of 8.59%, according to Bandara *et al.* (2016), which was less than in the current study.

Chapter 5

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Summary

The economy and availability of food are primarily reliant on animals like cattle, sheep, and goats in Bangladesh, an agrarian country. Raising livestock is done to advance socioeconomic development. People can get income from growing cattle because it is readily available for purchase. As a result, it aids in lowering poverty.

Approximately 90% of the population lived under the poverty line. They are therefore malnourished because they cannot afford to buy animal protein. Consequently, a variety of resources are needed to boost the supply of animal source protein. The most crucial factor in the longevity and profitability of livestock is animal feed. Animal feed in Bangladesh is often made from fodder, crop remnants, and cereal byproducts. In Bangladesh, there are several fodder and concentrate sources, but their potential hasn't been fully realized due to a lack of knowledge about their nutritional worth. In order to lower the cost of feeding cattle, it is necessary to identify the locally accessible feedstuffs with the highest nutritional value. This must be considered, and it is crucial to comprehend the chemical composition of different feeds in Bangladesh's south-west coastal districts.

Cultivation of fodder species and preparation of silage are carried out in the field laboratory of Agrotechnology Discipline, Khulna University. The fodder for making silage was cut into 2 to 3 cm pieces, packed in plastic bags, carefully sealed and stored in drums with adequate sealing for 45 to 60 days. Three fodder species viz. Oat (*Avena sativa*), maize (*Zea mays*) and jumbo (*Sorghum bicolour Sorghum sudanefe*) were selected for silage preparation. Three replicates were maintained for each species. Prepared silages were opened and samples were collected for evaluation of physical and chemical properties. To determine the physical characteristics, color, aroma, texture and presence/absence of fungi were examined. Chemical analysis was performed in the animal Husbandry Laboratory, Khulna University following the procedure of AOAC (1990). Statistical analysis was performed using the SPSS (version 22) computer program. From the study of physical properties of silage, it was found that color, odor and texture were acceptable in all the samples and no fungus was observed in any of the samples. Chemical analysis showed that the highest dry matter (DM) content (g/100g) was observed in jumbo silage (22.72±0.88) and the lowest in maize silage (13.64±0.69) ($p<0.001$). The highest ($p<0.001$) crude protein (CP) content (g/100g) was observed in jumbo silage (15.49±1.05) and the lowest in maize silage (8.78±1.15). Crude fiber content (g/100g) was found to be highest in oat silage (34.11±1.59) and lowest in maize silage (31.68±1.40). Ether extract content (g/100g) was found to be highest in oat silage (4.60±1.25) followed by jumbo silage (1.99±0.08) and maize silage (1.22±0.41) ($p<0.01$).

5.2 Conclusion

The study's findings revealed that the grass species and silage that were tested have good potential as animal feed. Among these silage and fodder Jumbo had great value for feed intake of livestock animal. One can draw the conclusion that locally available feed can take the place of expensive feed since it is sufficiently nutrient-dense and can be used to address the feed shortage in the livestock business. The lack of animal protein can thus be eliminated by employing silage, which will also improve livestock productivity.

5.3 Recommendations

5.3.1 General recommendations

1. To ascertain the nutritional benefit of fodder conservation, research should be a priority for both the government and non-governmental organizations (NGOs).
2. The government ought to encourage farmers to use locally obtainable conserved forage.

5.3.2 Recommendation for further studies

1. Additional investigation should be done to examine the additional fodder that are locally accessible.

2. Bangladesh's southwest coastal region served as the site of the current study. Additional study can be done in areas with access to several types of fodder in addition to these.

CHAPTER 6

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APPENDICES

Appendix-1: Photographic Presentation of the Study