ASSESSMENT OF PHYSICAL AND CHEMICAL PROPERTIES OF HAY PREPARED FROM DIFFERENT SPECIES OF FODDER

A THESIS

BY

PIYASHA MONDAL

EXAMINATION ROLL NO. MS- 230833

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

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TO MY

GURUMAHARAJ

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ABSTRACT

The current study was conducted to determine physical properties and nutritional quality of hay prepared from soybean, cowpea and grass pea fodders. Cultivation of fodder species and preparation of hay were carried out in the field laboratory of Agrotechnology Discipline, Khulna University. The fodders for making hay were cut in the morning and drying in the sun for 3 to 4 days. Three fodder species viz. soybean, cowpea, and grass pea were selected for hay preparation. Three replicates were maintained for each species. Three samples were collected from each species for evaluation of physical and chemical properties. To determine the physical properties, leafiness, color, maturity at harvest, odor, softness, and purity was 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) and R software in computer. From the study of physical properties of hay, it was found that leafiness, color, maturity at harvest, odor, softness, and purity was acceptable levels for all the samples under study. Chemical analysis showed that the highest dry matter (DM) content (%) was observed in grass pea (90.40 ± 0.48) and the lowest in soybean (89.47 ± 0.45) ($p<0.001$). The crude protein (CP) was found to be highest ($p<0.001$) in grass pea (16.54 ± 0.45) and lowest in cowpea (11.85 ± 0.47). The highest ($p<0.001$) crude fiber (CP) was found in soybean (28.65 ± 0.40) and lowest in grass pea (18.55 ± 0.50). The highest ($p<0.001$) ether extract (EE) was found in soybean (5.98 ± 0.36) and lowest in cowpea (4.18 ± 0.14). The ash contents were ranged from 9.64 ± 0.34 to 17.49± 1.72 being highest cowpea and lowest in soybean hay. The highest ($p<0.001$) nitrogen-free-extract (NFE) was found in grass pea (49.20 ± 0.53) and lowest in soybean (40.68 ± 0.75). The calcium content was found to be highest ($p<0.001$) in cowpea (2.01 ± 0.10) and lowest in grass pea (1.12 ± 0.08). Highest ($p<0.001$) phosphorus content was found in soybean (1.30 ± 0.03) and lowest in cowpea (0.15 ± 0.01). It can be concluded that by making hay using local knowledge and low-cost inputs, forage can be better preserved. Among the hay prepared from the three grass species, grass pea was found to have better nutritional value in terms of DM and CP contents.

Keywords: Forage, hay, livestock, nutritional value, physical properties.

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LIST OF ABBREVIATIONS

ANOVA	:	Analysis of Variance
CP	:	Crude Protein
EE	:	Ether Extract
DM	:	Dry Matter
i.e	:	That is
hrs	:	Hours
MS	:	Master of Science
USA	:	United States of America
%	:	Percent
Sig.	:	Significance
g	:	Gram
et al.	:	Associates
e.g.	:	For examples
NS	:	Non-significant
SE	:	Standard Error
+	:	Plus
<	:	Less than
=	:	Equal
±	:	Plus, minus
×	:	Multiplication
÷	:	Division

CHAPTER I

Introduction

1.1 Background of the study

The abundance of extremely nutritious forage materials available to ruminants during the rainy season results in well-fed and fattened animals. Because of the low-quality feed resources, they typically suffer from severe weight loss and a notable drop in milk production during the dry season (Lamidi and Ologbose, 2014). In the meantime, ruminants that feed during the dry season are using agro-industrial by-products as an alternative feed source (Mamine et al., 2020). Unless they are further treated before being fed to animals, these materials are known to have low digestibility and poor nutritional quality, which will raise the cost of animal production. Ruminant intake of these agro-industrial byproducts is typically insufficient for body weight maintenance because of their rough texture, low nutritional value, and poor digestion (Kaitho, 1997; Sindhu, 2002). Forage conservation is still the greatest way to guarantee year-round production because of the drawbacks of using industrial waste and crop residues as ruminant feed resources during the dry season. It has been suggested that farmers produce hay and silage due to the abundance of high-quality forages available during the rainy season. The idea behind this is that farmers can employ these conservation techniques on their farm as long as they have enough personnel and can obtain forage from any pasture field during the late wet season (Ewetola, 2018).

The adoption of haymaking as the preferred potential solution to alleviate the forage scarcity during the dry season is hampered by the fact that, toward the end of the field-drying period, more energy from solar radiation and convection is required to remove water from the flowering stem tissue than from the leaves and outer layers of the stem, which lose water quickly in the early stages of the process. As drying progresses, this causes the crop to dry more slowly (Wilkinson, 2016). Hay use as dry season feed has thus been severely hampered by the susceptibility of haymaking to nutrient loss as a result of bad weather (Wilkinson, 2016). Similarly, Nascimento et al. (2000) discovered that the quality of the hay decreased when it was left outside, particularly the crude protein, neutral detergent fiber, and acid detergent fiber. Furthermore, spontaneous heating during storage results in further nutritional losses. According to Guerrero (2006), hay loses dry matter (DM) and gains acid detergent fiber (ADF) and neutral detergent fiber (NDF) with longer storage times.

A crucial factor in livestock production is the availability of high-quality feed. Climate, plant type and maturation stage, soil, and the amount of management inputs all have an impact on this (Wallah et al, 2018; Fulgueira et al., 2007). Nigerian smallholder ruminant farmers, specializing in cattle, sheep, and goats, mostly use unimproved natural pastures as their primary source of nutrition, supplemented by crop leftovers left over after harvest (Bamikole et al, 2004). Because of the poor-quality fodder, they are fed, these animals develop slowly, produce little milk, and breed only occasionally. Poor management of natural grassland, indiscriminate grazing, and low soil fertility are all possible causes of pastures' current low production potential (Dev, 2001; Schafer, 2018; Getabalew & Alemneh, 2019). The issue of inadequate nourishment is exacerbated, especially during the dry season when grassland productivity drastically decreases (Oloyo and Ilelaboye, 2002). Concurrently, it has been demonstrated that financial benefits necessitate a sustainable commercial cattle sector for both individuals and the government, resulting in the creation of appropriate pasture (Bamikole et al, 2004). In an intensive livestock production system, forage species are used that have to demonstrate their superiority in terms of things like palatability, chemical composition, availability of nutrients, persistence in the face of defoliation regimes and unfavorable weather, competition, and compatibility with other forages in the pasture ecosystem (Muhammad and Abubakar, 2004; Okwori & Abdulsalam, 2017). A strategic forage management system and conservation techniques that will ensure a regular supply of high-quality forages to the livestock are highly imperative in light of the emerging shift in animal management systems towards confinement due to land pressure and herders' frequent encroachment into cultivated land, which has resulted in ethnic crises (Bamikole et al, 2004). Through appropriate pasture management practices, such as fertilizer application, adoption of adequate defoliation regimes, and control of bushes and weeds, enough herbage could be made accessible throughout the rainy period (Dev, 2001). Consequently, surplus feed resources were saved for the lean or off-season times. Concurrently, it has been demonstrated that financial benefits necessitate a sustainable commercial cattle sector for both individuals and the government, resulting in the creation of appropriate pasture (Bamikole et al, 2004). Nitrogen fertilizer has been used in an effort to improve the preserved fodder's nutritional quality, especially its nitrogen content (Bamikole et al, 2003). Animal manures are an excellent source of nutrients, and studies conducted on-station have shown that they have a positive impact on soil organic matter, soil structure, and biological life especially when applied at high rates (Gabriel, 2010). Both organic and inorganic types of nitrogen and phosphorus can be found in manure, though plants cannot use them completely. As hay produces a higher dry matter intake than silage and is one of the most adaptable stored forages, it may be held for extended periods of time with minimal nutritional losses if shielded from the weather (Wilkinson, 2016).

1.2 Justification

Historically, grass peas (*Lathyrus sativus* L.) have been grown for human use as food as well as for use as grain and fodder by animals. Yan et al. (2006) stated that the main qualities of this legume grain are its durability, tolerance to drought, and adaptability to a range of soil types, including marginal ones. Furthermore, this species is thought of as a fodder crop because of its high protein content. In fact, in many underdeveloped countries with particularly unfavorable weather, grass peas are a popular crop for subsistence farming because of their economic yield in adverse climatic conditions (Praveen et al., 1994). The utilization of grass pea grain has been hampered by the presence of β-N-OxalylDi Amino Propionic acid (β-ODAP), a water-soluble non-protein amino acid, despite the grain's high protein content. When consumed in large quantities over a prolonged duration, this Anti-Nutritional Factor (ANF) acts as a neurotoxin and weakens the lower limbs. It can cause the disease neurolathyrism in humans and monogastric animals (Hanbury et al, 2000). Consequently, the crop is no longer part of programs aimed at enhancing agriculture. The other ANFs that are most frequently identified in this legume, according to Hanbury et al. (2000), include tannins, lectins, saponins, alkaloids, non-starch polysaccharides, protease and amylase inhibitors, vicine and convicine, and phytate. Environmental conditions and the existence of natural enemies such as insects and pests can both raise plant ANFs (Hanbury et al., 1999). The majority of these substances are broken down in the rumen and do not seriously affect ruminants' nutritional needs. Condensed tannin (CT) can affect the digestibility of proteins and cell walls, though (Scharenberg et al., 2007). According to Poland et al. (2003), the nutritional value of grass pea hay was comparable to that of alfalfa hay. Pregnant sheep fed grass pea hay rather than alfalfa hay showed no adverse consequences. Some Lathyrus species are suitable for multipurpose legume crops in Iran, according to Ahmadi et al. (2012).

1.3 Objectives of the study

1. To determine the physical properties of hays prepared from three species of fodders.

2. To assess the nutritive value of different hays prepared from three species of fodders.

CHAPTER II

Review of Literature

2.1 History of hay in the world

Small- and large-scale animal husbandry success depends on the availability of sufficient supplies of high-quality feed. Particularly legume forage is a more affordable source of protein than the majority of cereals, making it a feed choice that is within budget. Leguminosae with a high protein content and good nutritional value include alfalfa (*Medicago sativa* L.) (Suwignyo et al., 2016). Additionally, alfalfa grows in tropical climates like Indonesia and can provide fruitful seeds (Suwignyo et al., 2017). According to Ehsanpour and Razaviadeh (2005), legume plants such as Medicago sativa have been cultivated for their medicinal benefits, suitable foliage, and animal feed, among other uses. Alfalfa is an inexpensive feed crop with good nutritional and digestible value that is widely used worldwide. Alfalfa has been dubbed the "Queen of Forage Crops" because of these qualities (Small, 2011). Because it contains a wide range of macro- and micronutrients, vitamins, and amino acids, alfalfa offers distinct advantages over other Leguminosae species (Sajimin, 2011). Alfalfa is also very digestible and contains a lot of dry organic matter. Compared to comparable legume plants, alfalfa plants have four times more chlorophyll. Conversely, according to Suwignyo et al. (2014), there are no appreciable differences in the digestibility of alfalfa cultivars when assessed *in vitro*. Alfalfa has the ability to be fed to animals, including non-ruminant ones.

Alfalfa needs to be dried into hay with a moisture level of less than 15% in order to make long-term storage easier. There are two ways to produce hay: naturally and artificially. Aeration or direct sunshine are two ways that natural drying can be achieved. Alfalfa can also be dried artificially with a drying device, like a 55°C oven (Utomo, 2015). The nutritional value, color, absence of mold, and consistency of the plants all contribute to the quality of the hay. Hay quality is additionally evaluated based on its chemical and physical attributes. Alfalfa's chemical and physical makeup might change after it dries. Thus, in order to ensure the production of alfalfa hay feed of the highest caliber, it is imperative to determine how drying methods impact these characteristics (Utomo, 2015).

Egyptian clover (*Trifolium alexandrinum*) is the main forage crop grown in Egypt in the winter (EL-Nahrawy, 2008a and 2008b). Nonetheless, the summer is usually when the feed scarcity peaks. Consequently, the quality of pastures and the availability of feed fluctuate significantly seasonally for ruminants in Egypt. As a result, the quantity and quality of milk and meat produced follow a seasonal rhythm. This problem is mostly the result of uneven forage production and quality measures during the growing season. One tactic that could be used to mitigate this issue in Egypt's summer months is mixed farming of particular summer grass and legume species. As a result, the cattle may have access to additional nutrients for the whole growing season. A crucial part of self-sustaining, low-input agricultural systems that have historically been used in the Mediterranean region is mixture cropping (Adesogan et al., 2002). Its primary goals have been to increase the amount and quality of fodder while making the best use of available resources, including light, space, and nutrients (Ghanbari Bonjar & Lee, 2003; Zhang & Li, 2003; Azraf-ul-Haq et al., 2007; Dahmardeh et al., 2009). Because of their high nutritional value, legumes—especially their protein and the crude fiber found in grasses—are regarded as significant feed crops (Rakeih et al., 2008). But there isn't enough for human consumption or fodder in monocultures of grasses or legumes (Osman & Nersoyan, 1986). Combining grass and legume forages can be a useful strategy to increase the final product's forage quality and nutritional content (Ross et al., 2004; Lithourgidis et al., 2006). Feeding pure fodder, like grasses or legumes, as opposed to their grass-legume blends, reduces the quantity of fodder consumed, according to research by Ansar et al. (2010). According to Holland & Brummer (1999) and Al-Khateeb et al. (2001), the most productive combinations among these forage crops are those that have complementary maturity and harvesting schemes, complement each other in growth distribution and ecological niche, and do not significantly compete with each other for growth and life requirements. Due to its high crude protein content, cowpea (*Vigna unguiculata* L.) is a leguminous fodder crop (Khan et al., 1987). Additionally, it has been shown to be resilient to many biotic stressors, including high temperatures, water stress, and other environmental conditions (Ehlers & Hall, 1997; Dadson et al., 2005), as well as drought (Oduor & Schagerl, 2007). It is consequently anticipated that when cultivated in Egypt in the summer, it will demonstrate enough output and adaptability. Conversely, due to its xerophytic traits, sorghum (Sorghum spp.) is a significant fodder grass with a broad range of ecological adaptation (Ahmad et al., 2007). Pearl millet (*Pennisetum glaucum* L.), another summer forage grass grown in Egypt, is a short-duration, quick-growing crop that is grown for grain and fodder and is notable for its high dry matter production, high tillering potential, and resistance to heat and drought (Ayub et al., 2007). However, because it has a low protein content like other fodder grasses, it cannot support a sustainable dairy production system on its own. Its feed is fed to almost all kinds of cattle and can be utilized as silage or hay. The Relative Feed Value (RFV) and Relative Forage Quality (RFQ) are the two most well-known metrics used to assess the quality of hay. The American Forage and Grassland Council (AFGC) Hay Marketing Task Force created the RFV, a commonly used forage quality index (Rohweder et al., 1978). It turned become a vital instrument for marketing and education about fodder quality. Hay pricing and determining the market value of fodder have long been shown to be highly beneficial to hay growers and animal producers (Moore & Undersander, 2002b). The National Forage Testing Association (NFTA) has reported its value. Based on laboratory data for acid detergent fiber (ADF) and neutral detergent fiber (NDF), respectively, expected values for both Digestible Dry Matter (DDM) and Dry Matter Intake (DMI) are used to compute RFV. While Net Energy (NE) is utilized by contemporary energy systems for TDN can be used to compute any of the NE metrics, including growth, maintenance, and lactation (White et al, 20017). Therefore, if TDN was employed to represent available energy, nutritionists would be more inclined to utilize a measure of fodder quality. Most models would be compatible with a forage quality index that takes into account both DM intake and TDN. Thus, when forage is provided as the only source of energy and protein, relative forage quality (RFQ) was offered as an alternative quality indicator for an evaluation of voluntary intake of available energy. Similar to RFV, TDN (% DM) represents the accessible energy component and DMI (% BW) represents the intake component. The RFQ was updated with new scientific and technological developments, modernizing the RFV system (Moore and Undersander, 2002a and 2002b). The greater fiber digestibility of grass and its effect on energy and intake potential were better reflected by the RFQ index. Instead of focusing on cowpea, Sudan grass, and pearl millet as individual crops, the current study aims to evaluate the potential of forage cowpea-Sudan grass and forage cowpea-pearl millet combinations to increase hay quality over three cuts.

Table 2.1 displays the means of the tested parameters as impacted by the three cut backs of alfalfa grass. It is evident that as compared to the advanced cuts, the first cut had a far higher NFE. For the first and third cuts, NFE levels were 148.29 and 132.10 (g /kg–3), respectively. Conversely, when compared to the first and second cuts, the third cut consistently exhibited much greater amounts of DM content and fiber fractions (NDF and ADL). For DM, NDF, and ADL, the differences between the first and third cuts were 3.8, 4.0, and 0.3%, respectively.

One of the main reasons why forage quality declines with maturity and why unfavorable hay-curing conditions result in quality loss is a reduced leaf-to-stem ratio. The initial cut's higher proportion of leaves in the feed compared to subsequent cuttings is often correlated with superior quality in terms of higher levels of NFE and lower amounts of fiber fractions. This is because reproductive growth lowers the ratio of leaves to stems and, consequently, the feed's quality. It is also well-known that leaves are of higher quality than stems. Repetitive cuts typically result in higher fiber fractions for the same reason.

Table 2.1 Means of the tested quality parameters for the three cuts alfalfa hay (Salama & Zeid, 2016)

Cut	**DM g kg^{-1}**	**CP g kg^{-1}**	**NFE g kg^{-1}**	**NDF g kg^{-1}**	**ADF g kg^{-1}**	**ADL g kg^{-1}**	**DDM % DM**	**DMI % BW**	**TDN % DM**	**RFV**	**RFQ**
1	207.13^{c*}	146.02^{a}	148.29^{a}	532.57^{c}	275.69^{c}	32.25^{b}	67.42^{a}	2.34^{a}	64.65^{a}	124.66^{a}	191.40^{a}
2	233.71^{b}	140.88^{a}	141.59^{b}	552.27^{b}	291.45^{b}	33.41^{ab}	66.20^{b}	2.25^{b}	62.83^{b}	117.80^{b}	179.18^{b}
3	244.96^{a}	119.56^{b}	132.10^{c}	572.44^{a}	311.07^{a}	35.08^{a}	64.67^{c}	2.17^{c}	60.68^{c}	111.15^{c}	167.15^{c}

2.2 Physical characteristics of hay

Physical and chemical analysis was used to evaluate the quality of alfalfa (*Medicago sativa* L.) hay (Table 2.2). Physical characteristics such as color, odor, mold presence, and drying time were evaluated. Nutrient content was measured to assess chemical quality (Rusdy, 2017).

Table 2.2 Physical characteristics of alfalfa hay (*Medicago sativa* L.) (Suwignyo et.al., 2020)

Physical characteristic	**Treatment**		
	P_1	**P_2**	**P_3**
Color	Chocolate	Brownish-green	Green
Fungi present	None	None	None
Drying time (days)	17	21	7

The three treatments resulted in varied colored hay, most likely due to temperature differences. P3 remained greener than P1 and P2, and none of the treatments included mold. Oven-drying resulted in higher-quality hay, consistent with recent research (Utomo, 2015) indicating a brilliant green color close to the plant's natural color before drying. According to Utomo (2015), high-quality hay is free of dirt and mold. Weather-related factors influenced the time required to produce hay across treatments. This study backs up Rusdy's (2017) theory regarding the effects of wind speed, groundwater content, sunshine, and relative humidity on how long it takes to digest hay in the field. Hay dried in an oven (P3) at 55°C more quickly than it did in P1 and P2.

2.3 Chemical composition of hay

The nutrient content of raw feed material or feed was then determined using chemical tests to obtain proximate analysis results for the various treatments, namely Nitrogen Free Extracts (NFE; Table 2.3), Dry Matter (DM), Organic Matter (OM), Crude Protein (CP), Crude Fiber (CF), and Ether Extract (EE).

Table 2.3 Chemical composition of hay from three different varieties of alfalfa (Suwignyo et al. 2020)

Chemical Composition (%)	Treatments		
	P_1	P_2	P_3
Dry matter (DM)	21.27±0.65ab	20.93 ± 0.14a	21.70±0.11b
Organic matter (OM)	89.44±1.93ns	90.41±1.74ns	89.86±0.73ns
Ether extract (EE)	2.88±0.40a	5.43±0.52b	6.47±0.52c
Crude fiber (CF)	30.07±2.22b	23.64±3.32a	22.71±2.04a
Crude protein (CP)	18.31±2.54a	22.80±2.26b	6.47±0.52c
Nitrogen-free-extract (NFE)	38.18 ±1.39a	38.53±2.27ab	40.82±2.52b
Total digestible nutrient (TDN)	31.55±6.10a	54.93±10.12b	57.61±6.45b

abc, values with distinct superscripts on the same line differed substantially ($P < 0.05$); non-significant (ns) ($p > 0.05$).

2.4 Soybean hay

Soybean plants can be grazed or harvested from the blossoming stage until they are virtually maturity in order to provide premium hay (Blount et al., 2013). In terms of protein and fiber content, alfalfa hay harvested in the early bloom stage is comparable to soybean feed harvested when the leaves begin to turn yellow but before they fall (Brown & Ryan, 2003). Stalks of forage soybeans are tough and fibrous, thus eating them by themselves may cause digestive issues. Frequent seeding and early harvesting will help ease these concerns. After cutting, the folder must be conditioned (rolled and crushed) to get rid of moisture (Blount et al., 2013). Forage soybeans have the advantage of being picked from full bloom to maturity at any time, making them an excellent choice for hay (Blount et al., 2013; Wright, 2013). The yield of hay at full bloom is around half that of 50–75% ripe seeds. Conversely, soybean hay with an excessive number of beans might cause scouring, decreased appetite, and digestive issues in addition to a diet high in fat (Barnes, 2006).

Table 2.4 Chemical composition of soybean hay (Foster et al., 2009)

Main analysis	**Unit**	**Avg**	**SD**	**Min**	**Max**	**Nb**
Dry matter	% as fed	91.5	5.2	86.2	96.6	3
Crude protein	% DM	15.9	4.1	10.4	22.9	13
Crude fibre	% DM	33.8	5.6	25.7	38.5	4
NDF	% DM	47.0	7.8	38.5	59.0	7
ADF	% DM	34.9	5.6	28.1	42.8	7
Lignin	% DM	7.0	1.7	5.3	9.6	7
Ether extract	% DM	5.4	3.3	2.5	8.9	4
Ash	% DM	7.6	3.3	4.2	12.1	5
Gross energy	MJ/kg DM	19.6				
Minerals	Unit	Avg	SD	Min	Max	Nb
Calcium	g/kg DM	8.6		7.8	9.4	2
Phosphorus	g/kg DM	1.9	0.5	1.6	3.1	8

ADF = acid detergent fiber; NDF = neutral detergent fiber.

2. 5 Grass pea hay

The leaf and seeds of grass peas are useful fodder. Fresh, dried, or converted into silage are the three possible uses for them (Yadav et al., 2006; Emile et al., 2008). Particularly important are the straw and chaff from grass pea plants (Yadav et al., 2006). The primary purpose of *Lathyrus sativus* in some nations, like Australia, is the production of fodder.

Table 2.5 Chemical composition of grass pea hay (Poland et al., 2003; Kiraz, 2011)

Main analysis	**Unit**	**Avg**	**SD**	**Min**	**Max**	**Nb**
Dry matter	% as fed	91.4	4.8	87.4	98.3	4
Crude protein	% DM	19.1	2.3	17.5	22.5	4
Crude fibre	% DM	28.5		26.5	30.5	2
NDF	% DM	43.4	4.6	40.0	48.6	3
ADF	% DM	32.7	6.3	25.4	36.4	3
Ether extract	% DM	2.9		2.5	3.3	2
Ash	% DM	9.9	1.5	8.3	11.1	3
Gross energy	MJ/kg DM	18.6				
Minerals	Unit	Avg	SD	Min	Max	Nb
Calcium	g/kg DM	13.3				1
Phosphorus	g/kg DM	2.1				1

Table 2.6 Chemical composition of cowpea hay (Foster et al., 2009; Singh et al., 2010; Ravhuhali et al., 2011)

Main analysis	**Unit**	**Avg**	**SD**	**Min**	**Max**	**Nb**
Dry matter	% as fed	91.2	2.0	86.7	96.2	18
Crude protein	% DM	14.8	3.3	9.9	22.9	20
Crude fibre	% DM	32.6	6.8	21.1	43.3	11
NDF	% DM	49.0	5.3	42.6	59.2	17
ADF	% DM	37.2	5.2	28.6	46.8	17
Lignin	% DM	8.0	1.7	4.1	11.2	16
Ether extract	% DM	1.7	0.5	1.1	2.6	11
Ash	% DM	13.7	2.7	8.9	18.7	19
Gross energy	MJ/kg DM	17.5	0.7	16.9	18.7	5
Minerals	Unit	Avg	SD	Min	Max	Nb
Calcium	g/kg DM	13.1	3.1	7.2	17.0	14
Phosphorus	g/kg DM	3.9	1.6	1.1	5.6	14
Potassium	g/kg DM	33.2	10.0	11.7	45.3	9
Sodium	g/kg DM	2.6		1.2	4.1	2
Magnesium	g/kg DM	6.6	1.6	4.2	9.2	10
Manganese	mg/kg DM	97	27	70	124	3
Zinc	mg/kg DM	56	20	40	79	3
Copper	mg/kg DM	6	1	5	7	3

2.6 Cowpea hay

Cowpea hay is a staple food found in local markets throughout West Africa. Cowpea hay is a dual-purpose legume that can be used as animal feed in smallholder settings. Sudan grass can also be cultivated with cowpea to make hay. Cowpea hay can be on par with alfalfa hay when it is cultivated especially for hay. 3-5 t ha^{-1} is the typical yield of hay. As the crop ages, the quality of the hay decreases (Cook et al., 2005). Cutting should occur when 25% of the pods are colored on cowpea plants cultivated especially for hay (Van Rij, 1999). In Australia, 70–90 days after sowing, during peak flowering, is the best time to harvest a cowpea crop for hay (Cameron, 2003).

The annual herbaceous legume cowpea (*Vigna unguiculata*) is diploid (2n=22) and is grown for its edible seeds and fodder. Cowpeas grown in cultivation have glabrous leaves and tap roots, and they can grow upright, prostrate, or ascending. With up to 1% of spontaneous cross-pollination, this crop is self-pollinating. Climbing types can go to 2 m and 80 cm in height. According to Pottorff et al. (2012), cowpea is a multipurpose grain legume that may be fed to both people and animals. In the semi-arid tropics, which include Asia, Africa, Southern Europe, the Southern United States, Central America, and South America, this legume is vital for sustenance and forage (Singh, 2005; Alemu et al., 2016). This natural legume is primarily produced in temperate regions of the world, including Sub-Saharan Africa (Srivastava et al., 2016). Young leaves, green pods, and green grains are utilized as vegetables, while dry grains are used as animal and human feed (Owade et al., 2020). Cowpea seed is commonly used in "nifro" and "shiro" dishes in Ethiopian cuisine. Weng et al. (2019) report that cowpea grain has an average protein level of 22.8 to 28.9%, which is high. All plant components can be eaten as a wholesome source of protein and minerals, according to research by Islam et al. (2006). For this reason, cowpeas are referred to as the "hungry-season crop," harvested before cereal crops are ready. While dry grains are used as animal and human feed, young leaves, green pods, and green grains are consumed as vegetables (Owade et al., 2020). In Ethiopian cuisine, cowpea seed is frequently used in "nifro" and "shiro" dishes. Cowpea grain has a high average protein content of 22.8 to 28.9%, according to Weng et al. (2019). All plant components can be ingested as a healthy source of minerals and protein, according to research by Islam et al. (2006). That's why cowpeas are called the "hungry-season crop," as they are harvested before grain crops reach maturity. While grains are used for main courses and snacks, immature pods and seeds are prepared similarly to vegetables (Antova et al., 2014).

Cowpea is grown in drier regions of Ethiopia, including the Rift Valley and the highlands in the east and west Hararge zone. In these places, sorghum is often planted beside it. Furthermore, it's grown in the northeastern Amhara region's Shewa Robit, Kobo, North and South Wollo zones, Waghimira, Southern and Eastern Tigray, Ethio-Somali, Afar, Wolayita, and Jinka zones (Kassaye, 2013). In addition to low-rainfall areas of the Southern Nations, Nationalities, and Peoples' Region (SNNPR), such as the Konso, Derashe, Humbo, Hammer Bako, Loka Abaya, Gofa, and Loma woredas, it is grown in the South Omo zone, Tigray, and Gambella (Alemu et al. 2019). Arid areas with intermittent rainfall make for over 70% of Ethiopia's arable land (UNDP, 2014). Kebede and Bekeko (2020) report that the country's cowpea output is limited by a lack of access to current technologies, including improved seed types, disease and pest management strategies, and fertilizers. Ethiopia has significant crop production potential, with around 66.5% of arable land suitable for cowpea production (Simion, 2018). Ethiopia has spent several decades studying ways to increase biomass and cowpea seed yield. Ethiopia has conducted a number of studies on the adaptability, introduction, selection, and gathering of landrace cowpeas. To make major contributions, the Ethiopian Institute of Agricultural Research

(EIAR) works with national and international research institutions. The nation's progress in agriculture during the last fifty years.

CHAPTER III

Materials and Methods

3.1 Site selection

The experiment was conducted at the Field Laboratory of Agrotechnology Discipline, Khulna University, Khulna-9208, Bangladesh.

Figure 3.1. Site of the experiment

3.2 Selection of grass species

Cowpea (*Vigna unguiculata*), soybean (*Glycine max*) and grass pea (*Lathyrus sativus*) forages were used to prepare the hay.

3.3 Design of Experiment

The research was conducted using a completely randomized design (CRD) to ensure unbiasedness and reliability of the results. Three species namely cowpea (*Vigna unguiculata*), soybean (*Glycine max*) and grass pea (*Lathyrus sativus*) forages were used to prepare the hays. Each species represented as a treatment group. No control group was considered as the research focus on comparative analysis among the treatments. Experiment layout is shown in Table 3.1.

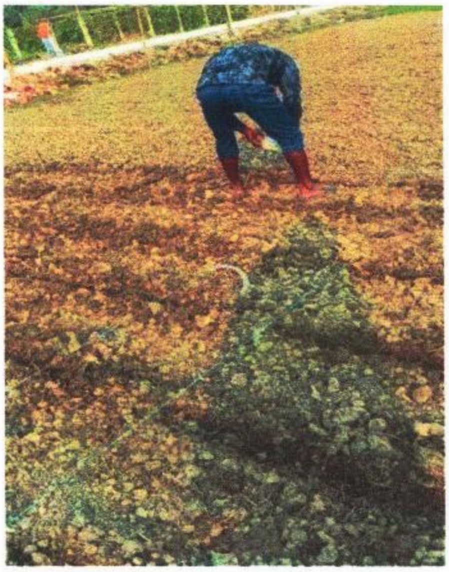
Table 3.1 Layout of the experiment

Species	Replications		
	R_1	R_2	R_3
S_1	$S_1 R_1$	$S_1 R_2$	$S_1 R_3$
S_2	$S_2 R_1$	$S_2 R_2$	$S_2 R_3$
S_3	$S_3 R_1$	$S_3 R_2$	$S_3 R_3$
S_1	$S_1 R_1$	$S_1 R_2$	$S_1 R_3$
S_2	$S_2 R_1$	$S_2 R_2$	$S_2 R_3$
S_3	$S_3 R_1$	$S_3 R_2$	$S_3 R_3$
S_1	$S_1 R_1$	$S_1 R_2$	$S_1 R_3$
S_2	$S_2 R_1$	$S_2 R_2$	$S_2 R_3$
S_3	$S_3 R_1$	$S_3 R_2$	$S_3 R_3$

Here, (S_1 = Cow pea fodder, S_2 = Soybean fodder, S_3 = Grass pea fodder)

3.4 Cultivation of fodders

Cowpea, Soybean and grass pea forages were cultivated at the field laboratory of Agrotechnology Discipline, Khulna University, Khulna. The grass seed were collected from local market of Daulatpur Bazar, Khulna. At first the seeds were being soaked in water for one night. Weeding was done properly in each plot before sowing. The seeds were being sowed at 29 December, 2023. Irrigation was done in each plot when necessary.

Photograph 3.1 Land preparation and sowing for fodder production

3.5 Preparation of hay

After 90 days of sowing forages was harvested at the early flowering stage to make hay. The grass was cut from 8:00 am to 9:00 am to dry the dew. After harvesting, the grasses were spread on the ground for sun dry. The sun dry continued to maintain a dry matter (DM) content of 85 to 90%. The drying process was taken between 3 to 4 days. After drying, the prepared hay was kept under the shed for further analysis.

Photographs 3.2 Preparation of hay

3.6 Sample collection and processing

After the completion of sundry, the representative samples were collected from each replication. The samples were kept in zipper bag for further analysis. The samples were finely grounded using an electric grinder before subjected to the chemical analysis.

3.7 Assessment of physical properties

To assess the physical properties, the samples were subjected to observe by visual inspection in its leafiness, color, maturity at harvest, odor, softness, and purity.

3.8 Assessment of chemical properties

To determine the chemical properties, the samples were subjected to the proximate analysis. Proximate analysis of hay samples was done according to AOAC (1990).



Photographs 3.3 Hay samples for processing

3.9 Proximate analysis of hay sample

3.9.1 Crude Protein Analysis

Test procedures

Digestion

Digestion was completed by using DK 8 Heating Digester VELP CIENTIFICA. One gram (1 g) of sample was weighted with an accuracy of ±0.1 mg. For each sample, 2 catalyst and 12 ml H_2SO_4 (98%) were added and then placed into digestion block. The temperature of the digestion block was maintained at 420°C and sample was heated for 60 minutes until the fumes stopped. Then the sample was taken to cool at 50-60°C.

phosphoric acid (Primary orthophosphate) (secondary orthophosphate) (Phosphate)

pH=0↔ ⟷ pH=14

Phosphorus in aqueous solution can be determined by either yellow colour or blue colour method. Total P of soil is determined by yellow colour method and available P in soil is determined by blue color method. Both the methods are described below.

3.10 Data analysis

On a computer, data were entered and examined using the R and SPSS programs. Analysis of variance will be performed to examine the effects of different fodder species on the chemical properties of silages. The treatment means were compared using DMRT, with a significance level of $p<0.05$.

3.9.2 Crude fibre analysis

Test Procedures

Crude fiber analysis was conducted by using VELP SCIENTIFICA FIWE Raw Fiber Extractor. One gram (1 g) sample was taken in crucibles were fixed with the channels. 150 ml 1.25% H_2SO_4 was taken in the flask of the analyzer adding 3-5 drops n-octanol as anti-foam agent. The fiber analyzer's switch was switched on. Boil for precisely thirty minutes. The residual agent was filtered thirty minutes later. The crucible was washed three times, adding 30 ml of hot deionized water to the top each time, and using compressed air to mix the contents of the crucible. The last wash was drained, and 150 ml of 1.25% KOH and three to five drops of an anti-foam agent were added. Once more, after 30 minutes of boiling and three washings, the crucible was cooled with a final washing in cold deionized water. The crucible was then cleaned three times with 25 milliliters of acetone while being stirred with compressed air. Using 25 ml of acetone, the contents of the crucible were cleaned. Following that, the crucibles were dried in an oven at 105^0 C for an hour, and they were chilled in a desiccator to determine their dry weight (F1). After cooling in a desiccator (F2), the crucibles were put into a muffle and heated to 550° C for three hours to reweighted.

Calculation:

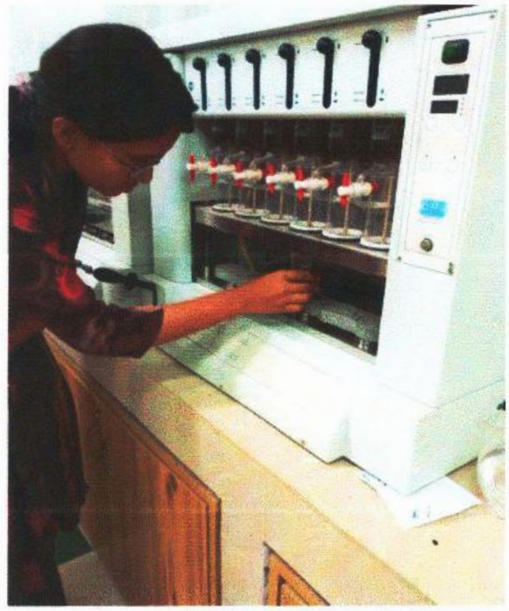
$$\text{Crude Fibre (\%)} = \frac{F1-F2}{F0} \times 100$$

Where,

F_0 = Weight of sample in gram

F_1= Weight of oven dried sample in gram

F_2= Weight of ash containing crucible in gram

Photograph 3.4 Determination of ether extract

Calculation:

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

Where,

W_1 = Weight of sample in gram

W_2 = Weight of empty vessel in gram

W_3 = Weight of vessel and ether extract in gram

3.9.4 Dry matter determination

Test procedure

At first envelopes were weighted (W_1). After harvesting, fresh shoot weight (W_2) of forage was taken and the envelope was filled with sample and dried in oven for 24 hours at 105°C. Thereafter the dried sample containing envelope (W_3) is weighted.

Calculation:

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

Where,

W_1 = Weight of envelope in gram W_2 = Weight of fresh sample in gram

W_3 = Weight of envelope and dried sample in gram

3.9.5 Ash analysis

Test procedure

Crucibles were placed in muffle furnace, allowing 30 minutes to reach 600°C. Weight of crucible was recorded (W_1). About 3 g sample was weighted into a crucible which had been tarred. Weight of sample was recorded (W_2). Crucibles were placed into muffle furnace at 600°C for 6 hours. Crucibles were allowed to cool in furnace to less than 20°C and crucibles were placed in desiccator with a vented top. Crucibles were cooled in desiccator to room temperature and were weighed immediately and the weight was recorded (W_3). Ash% was calculated and reported to one decimal place.

Photographs 3.5 Determination of ash

Calculation

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

Where,

W_1 = Weight of crucible in gram W_2 = Weight of sample in gram

W_3 = Weight of crucible and ash in gram

3.9.6. Calcium determination

NaOH (10%): Dissolve 10g NaOH into 100ml solution with dw. This solution raises the pH of the medium.

2. **Murexide indicator** (solid): Thoroughly mix 0.1g murexide with 20g of powered K_2SO_4 (base).
3. Standard Ca solution (1000 ml 0.01N Ca solution): Take 0.5004 reagent grade $CaCO_3$ into a 1000 ml volumetric flask, add 100ml dw and then slowly add 100 ml dw and then slowly add 5 ml 6N HCl with shaking and make the volume with dw.

Standard EDTA solution (500ml 0.01N): Dissolve 0.9307g disodium EDTA (mw=327.254, ew=327.254 ÷2 =163.627) into 500 ml solution with dw.

5. Ammonium acetate (1000ml 1N): Dilute 57ml glacial acetic acid upto 500ml, add 69ml concentrated NH_4OH. Adjust the pH at 7 and finally volume 1000ml with dw. This was used to extract available Ca^{2+} and Mg^{2+} from soil.[Or,dissolve 77g NH_4OAc crystals(mw=77)

77g NH_4OAc crystals (mw=77) into approximately 900 ml dw. Adjust the pH 7 and make final volume 1000 ml with dw.]

Procedure:

1. Take 4g air dried soil into a 250 ml conical flask and 40 ml 1N NH_4OAc(pH-7)
2. Shake the mixture thoroughly for half an hour and filter the soil with WN-1 filter paper.
3. Take 2 to 5 ml aliquot in porcelain cup.
4. Add 5 to 10 ml NaOH (10%) depending upon the initial pH of the sample.
5. Add 0.02 to 0.05g murexide indicator. The mixture appears pink in presence of Ca.
6. Titrate against 0.01N ETDA solution. At end point, the color appears purple.
7. Run a blank titration.

Calculation:

1000 ml 1N EDTA=20g Ca.

Therefore, Ca (%) = [20×(T-B) ×S ×f v× 100] ÷ (1000×E×W)

Where, T=Amount of EDTA required in sample titration. B=Amount of EDTA solution.

S=Strength of EDTA solution. fv=Final volume of the extract.

E=Volume of extract taken for titration. W=Weight of the soil.

3.9.7. Phosphorus determination

In soil, phosphorus is not as common as nitrogen and potassium. The range of total concentrations found in surface soil is from 0.02 to 10%. Regretfully, interactions between the different forms of P in soils and the many elements that affect P availability are crucial to affecting P management. The amount of total P in soil has little to no association with these interactions.

The amount of P in soil is almost equally supplied by organic and inorganic sources. In most soils, organic matter makes up between 15 and 80% of the total P content, or roughly 50% of the total P content. Similar to soil organic matter, the distribution of soil organic P differs among soils and likewise diminishes with depth. Soil organic matter has a P concentration ranging from approximately 1 to 3%. Esters of H2PO4 make up the majority of organic P compounds, which are mostly known as:

1. Inositol phosphates: Microbial activity and the breakdown of plant residues provide the majority of inositol phosphates in soils (10 to 50% of total organic P).
2. Phospholipids, which make up 1 to 5% of all organic P.
3. Other substances and nucleic acids (0.2–2.5 percent of total organic P).

When organic P is converted to inorganic P or fertilizer P is added to soil, the inorganic P in solution that is not absorbed by plant roots or immobilized by microbes may be absorbed to mineral surfaces (labile P) or precipitated as secondary P compounds. P fixation (or pretense) is a term that is often used to characterize surface absorption and precipitation reactions taken together. The most important factor for P fixation is soil pH. Phosphorus fixation is observed minimum and hence, their availability to plants. Water soluble forms of P are pH dependent as shown below.

$$H_3PO_4 \leftrightarrow H_2PO_4^{-} \leftrightarrow HPO_4^{2-} \leftrightarrow PO_4^{3-}$$

Distillation

Distillation process was conducted by using UDK 129 Distillation Unit VELP SCIENTIFICA. After cooling the sample, it was mixed with 50 ml distilled water. Fifty milliliter (50 ml) NaOH was added with the solution. The digestion flask was then given into the distillation chamber. Thirty milliliter (30 ml) Boric acid solution was taken in a conical flask and 3 drops of indicator were added into it. The water flow was previously adjusted. The distillation process was done until the color of indicator mixture solution did not turn into green color.

Titration

The sample of the flask was then taken for titration. Then 0.1% H_2SO_4 was taken in burette pipe and added drop wise. The procedure was continued until the color of the solution of the conical flask turn from green to blue. When the solution color had changed the titration procedure ended. The strength of titrate was then recorded.

Calculation

Wt. of the sample (W) = 1g

Hcl required in titration = A

(Assume, A=24ml)

Normality of HCL (N) = 0.1 N

Milliequivalent wt. of HC = 0.014

%N = (N×A×0.014)/W

=0.1×24×0.014)/1×100

=3.36

%CP=%N×6.25=21.0

CHAPTER IV

Results and Discussion

4.1 Appraisal of hay's physical properties

The parameters for physical properties of hays observed by visual inspection (color, odor, juiciness, and tenderness) have been shown in Table 4.1.

Table 4.1 Physical properties of hays from three different fodder species

Properties	Conditions	Soybean	Cowpea	Grass pea
Leafiness	Very leafy	16.7	16.7	25.0
	Leafy	58.3	50.0	41.7
	Slightly steamy	25.0	25.0	33.3
	Steamy	00	8.3	00
Maturity at harvest	Harvest before bloom	16.7	25.0	33.3
	Early bloom stage	41.7	41.7	25.0
	Late bloom stage	25.0	16.7	25.0
	Matured stage	16.7	16.7	16.7
Odor	Fresh	50.0	33.3	41.7
	Dusty	25.0	33.3	33.3
	Moldy	16.7	16.7	25.0
	Burnt	8.3	16.7	00
Color	Natural green color	50.0	58.3	58.3
	Light green color	50.0	25.0	16.7
	Yellow to brownish	00	16.7	25.0
Softness	Very soft	25.0	25.0	25.0
	Soft	50.0	50.0	58.3
	Slightly harsh	25.0	25.0	16.7
Purity	Other forage <5.0%	58.3	58.3	41.7
	Other forage 5 to 20%	25.0	25.0	33.3
	Other forage >20%	16.7	16.7	25.0

There were three samples of hay in different conditions observed for the determination of physical properties of hay. Leafiness, color, maturity at harvest, odor, softness, and purity of hays prepared from three forage species were determined.

4.1.1 Leafiness

The judging score of hay leafiness in different conditions (very leafy, leafy, slightly steamy and steamy) among soybean, grass pea and cow pea fodders are presented in table 4.1. Leafy condition was appeared highest for all kinds of hays (soybean, cowpea and grass pea) whereas, steamy condition was seen lowest. Among the three species, soybean showed the best result as 58.3% leafy as compared to cowpea (50.0%) and grass pea (41.7%). According to some writers, alfalfa hay with a high leaf content may contain 65–70% leaves, while alfalfa hay with a low leaf content may only have 10–15% leaves (Duane, 1997). For legume hay, a high leaf-to-stem ratio is more important than for grass hay because, as plants develop, legume leaves retain their quality in relation to stems, but the quality of grasses' leaves and stems declines simultaneously (Duane, 1997).

4.1.2 Maturity at harvest

The result of maturity at harvest judging score of soybean, cowpea and grass pea hays are presented in Table.4.1. Harvesting before bloom, early bloom stage, late bloom stage, and maturity stage were the four criteria used for grading. Of all the hays made from the three fodder species, early bloom stage had the best appearance. Stage of maturity is the most significant element influencing hay quality within each forage species and the one where the biggest changes can be achieved (Gary, 2011).

4.1.3 Odor

The result of odor judging score of three species of hay for four conditions (fresh, dusty, mold and burnt) are presented in table.4.1. Here the score indicates that soybean hay was fresher than cowpea and grass pea. Some authors reported that High quality hay generally has a sweet, fresh odor and musty odors denote low quality. (Putnam and Orloff, 2003).

4.1.4 Color

The result of color judging score of three species of hay are presented in Table 4.1. In different species color score of hay were higher in natural green color than the other conditions and cow pea and grass pea showed the best results than soybean. High quality hay generally has a bright green color (Putnam and Orloff, 2003).

4.1.5 Softness

The result of softness judging score of three species of hay are presented in table 4.1. Softness of different kinds of hays were judged based on three conditions such as very soft, soft and slightly harsh. Soft condition was appeared to be highest score for all hays under study being highest in grass pea (58.3%). According to some writers, hay's softness (or texture) matters because people will consume more of it than brittle hay.

4.1.6 Purity

The result of purity judging score of three species of hay for different conditions are shown in Table 4.1. Four conditions were used to assess the purity of hays such as presence of other forage <5.0%, presence of other forage <5.0 to 20.0% and presence of other forage >20.0%. The results revealed that presence of other forage less than 5% appeared to be highest for all kinds of hay being highest in soybean & cowpea (58.3%) and lowest in grass pea (41.7%). According to other writers (Rocateli & Zhang, 2017), purity and hay's nutritional content might or might not be related. Additionally, they mentioned that occasionally, certain impurities—like young legumes in old grass hay—might be more beneficial to animals than the primary hay. However, the highest-priced hay is typically pure (Rocateli & Zhang, 2017).

4.2 Chemical analysis

To ascertain the proximate composition of hay, three types of samples were created, each with three replications. Dry matter (DM), crude protein (CP), crude fiber (CF), ether extract (EE), ash, and nitrogen-free extract (NFE) were measured in proximate analysis at Khulna University's Animal Husbandry Laboratory of the Agrotechnology Discipline. Table 4.2 displays the proximal component values that were determined.

4.2.1 Dry matter (DM)

The DM content of different kinds of hay are shown in Table 4.2. The average DM contents (%) of three hays were 89.47 ± 0.45, 89.89 ± 0.23 and 89.89 ± 0.23 for soybean, cowpea and grass pea, respectively. Mean differences for dry matter contents was not significant ($p>0.05$).

The three pure forage grass stands (BSG, WSG, and PM) exhibited the lowest significant values among the three hay quality indices, according to Salama & Zeid (2016), who also noted the same tendency.

Table 4.2 Proximate composition (%) of hays from three different fodder species

Species	Dry matter (%)	Crude protein (%)	Crude fiber (%)	Ether extract (%)	Ash (%)	Nitrogen- free-extract (%)
Soybean	89.47 ± 0.45	15.06^{b} ±0.11	28.65^{a} ±0.40	5.98^{a} ±0.36	9.64^{b} ±0.34	40.68^{b} ±0.75
Cowpea	89.89 ± 0.23	11.85^{c} ± 0.47	23.58^{b} ±0.57	4.18^{b} ±0.14	17.49^{a} ±1.72	42.90^{b} ±1.61
Grass pea	89.89 ± 0.23	16.54^{a} ±0,.45	18.55^{c} ±0.50	4.25^{b} ±0.17	11.46^{b} ±0.14	49.20^{a} ±0.53
Total	89.92 ± 0.24	14.48 ± 0.62	23.59 ± 1.27	4.80 ± 0.28	12.86 ±1.14	44.26 ± 1.22
F-Value	1.344	39.389	104.872	17.555	16.414	17.088
Level of significance	NS	***	***	***	***	***

NS = Not significant; *** = $p<0.001$; Means with uncommon superscripts in a row differ significantly ($p<0.05$).

Table 4.3 Calcium and phosphorus contents of hays from three different fodder species.

Species	Ca (%)	P (%)
Soybean	1.51^{b} ± 0.08	1.30^{a} ± 0.03
Cowpea	2.01^{a} ± 0.10	0.15^{b} ± 0.01
Grass pea	1.12^{c} ± 0.08	0.19^{b} ± 0.01
Total	1.54 ± 0.12	0.54 ± 0.16
F-Value	28.056	1059.801
Level of significance	***	***

*** = $p<0.001$; Means with uncommon superscripts in a row differ significantly ($p<0.05$).

4.2.2 Crude Protein (CP)

The CP content of different kinds of hay are shown in table 4.2. The highest CP content was observed in grass pea ($16.54^a \pm 0.45$) followed by soybean ($15.06^b \pm 0.11$) and cowpea ($11.85^c \pm 0.47$). Means from three kinds of hay were differed significantly ($p<0.001$). The highest CP content of grass pea indicates this hay is good quality and most acceptable than other two types of hay. The results of this study were not as high as those of Utomo (2015), who discovered that hay prepared from alfalfa collected before blooming had a crude protein concentration of 21.10%. The various forage species utilized to prepare the hay are the cause of this difference. Sajimin (2011) reported that crude protein ranges were found in alfalfa. The crude protein content of alfalfa from Indonesia's Ciawi area is 24.6% (Sajimin, 2011).

4.2.3 Crude fiber CF)

The CF content of different kinds of hay are shown in Table 4.2. The CF contents were $28.65^a \pm 0.40$, $23.58^b \pm 0.57$ and $18.55^c \pm 0.50$ for soybean, cowpea and grass pea, respectively where the mean differences were highly significant ($p<0.001$). Others also reported the variation of CF content among hays prepared from different fodder species (Ravhuhali et al., 2011; Singh et al., 2010).

4.2.4 Ether Extract (EE)

The EE content of different kinds of hay are shown in Table 4.2. The highest EE contents was observed in soybean ($5.98^a \pm 0.36$) followed by cowpea ($4.18^b \pm 0.14$) and grass pea ($4.25^b \pm 0.17$). EE contents were significantly ($p<0.001$) varied among the means. Others also reported the variation of EE content among hays prepared from different fodder species (Olanite et al., 2014).

4.2.5 Ash

The ash content of different species of hay are shown in Table 4.2. Ash contents of different kinds of hays ranged from 11.46±0.14 to $17.49^a \pm 1.72$ being highest in cowpea and lowest in grass pea. The mean differences were highly significant ($p<0.001$).

4.2.6 Nitrogen-Free-Extract (NFE)

The nitrogen-free-extract (NFE) contents of different species of hay are shown in Table 4.2. The average nitrogen-free-extract (%) of different species of hays were calculated as $40.68^b \pm 0.75$ for soybean, $42.90^b \pm 1.61$ cowpea and $49.20^a \pm 0.53$ grass pea. Among these three species of hay the nitrogen free extract contents were significantly varied. Variations in NFE contents (%) of different hay were also reported by other authors (Suwignyo et al., 2020).

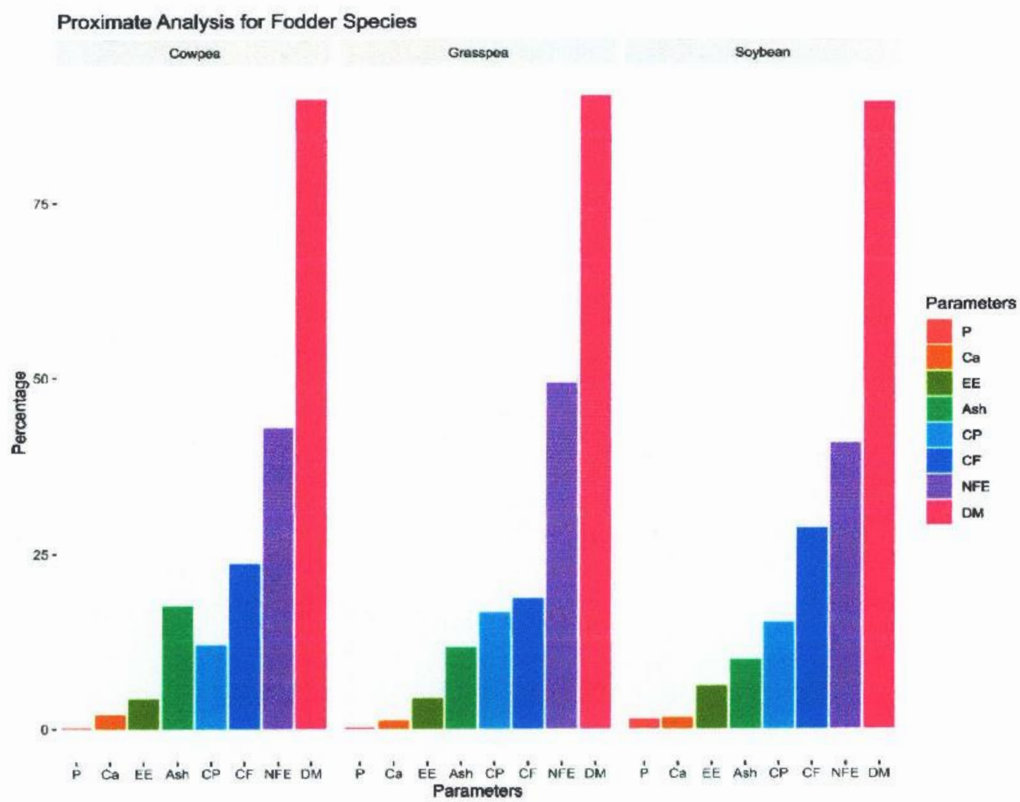


Figure 4.1 Proximate analysis for fodder species

4.2.7 Calcium

The calcium content of different kinds of hay are shown in Table 4.3. The calcium contents of different species in the form of hay were $1.51^b \pm 0.08$ for soybean, $2.01^a \pm 0.10$ for cowpea and $1.12^c \pm 0.08$ for grass pea. Among these three species most important mineral (Ca) was found sufficient. The mean difference for calcium content was found highly significant ($p<0.001$). Study of Ravhuhali et al. (2011) also stated the variations in calcium content among the hays prepared from different species of forage.

4.2.8 Phosphorus

The phosphorus content of different kinds of hays are shown in Table 4.3. The average phosphorus content was ranged from $0.15^b \pm 0.01$ in cowpea to $1.30^a \pm 0.03$ in soybean. The mean differences among three species were found significant ($p<0.001$). As the phosphorus content increase in hay that also increase the good quality hay. Other researchers (Singh et al., 2010) also reported the variations in phosphorus contents of hays from different species of fodders.

4.3 Correlation matrix

Table 4.4 presents correlations among various nutritional parameters related to determine different chemical components of soybean, cowpea and grass pea hay. Table 4.4. contains a Pearson correlation coefficient, indicating the nutritional quality of the hay and the relationships among the nutritional parameters. The correlation matrix revealed that positive and significant correlations were observed between ether extract (EE) & crude fiber (0.752**), ether extract & phosphorus (0.893**) and calcium and ash content (0.66*) which indicate that as crude fiber content of hays increased the ether extract contents also increased. Correlation matrix also suggest that phosphorus content increased with the increasing of ether extract. Negative significant correlations were exist between crude protein & ash content (-0.773**), ether extract and ash content (-0.598*), crude fiber and nitrogen-free-extract (NFE) content (-0.887**), calcium & NFE content (-0.609*) and phosphorus & NFE content (-0.610*).

Table 4.4 Correlation coefficient among different chemical components of hay

Chemical components	Dry matter (%)	Crude protein (%)	Crude fiber (%)	Ether extract (%)	Ash (%)	NFE (%)	Ca (%)	P (%)
Dry matter (%)	1							
Crude protein (%)	0.310	1						
Crude fiber (%)	-0.488	-.275	1					
Ether extract (%)	-0.212	.190	0.752**	1				
Ash (%)	-0.078	-0.773**	-0.196	-0.598*	1			
NFE (%)	0.469	0.453	-0.887**	-0.548	-0.199	1		
Ca (%)	-0.092	-0.842**	0.416	-0.046	.660*	-0.609*	1	
P (%)	-0.407	0.229	0.833**	0.893**	-0.617*	-0.610*	-0.091	1

**. Correlation is significant at the 0.01 level; *. Correlation is significant at the 0.05 level;

NFE= Nitrogen-free-extract, P = phosphorus, Ca = calcium.

CHAPTER V

Summary and Conclusion

5.1 Summary

Livestock production is often limited by the availability of high-quality forage, either through grazing and cultivated fodder. Most fodder and grass are grown seasonally and are particularly scarce during the dry season. Hay making is a good technology for fodder conservation that can ensure green pasture for livestock throughout the year. The Khulna University Agrotechnology Department field laboratory was used to cultivate fodder species and prepare hay. Three fodder species viz. soybean, cowpea, and grass pea were selected for hay preparation. Three replicates were maintained for each species. After completing sundry, the samples were dried in oven dry. After oven dry grinding the samples properly. Then samples were collected for evaluation of physical and chemical properties. For assessment of the physical properties of hay, leafiness, color, maturity at harvest, odor, softness, and purity 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 hay, it was found that leafiness, color, maturity at harvest, odor, softness, and purity was acceptable for all the samples. Chemical analysis showed that the highest dry matter (DM) content (%) was observed in grass pea (90.40 ± 0.48) and the lowest in soybean (89.47 ± 0.45) ($p<0.001$). The highest ($p<0.001$) crude protein (CP) was found in grass pea ($16.54^{a} \pm 0.45$) and lowest in cowpea ($11.85^{b} \pm 0.47$). The crude fiber (CF) was found to be highest ($p<0.001$) in soybean ($28.65^{a} \pm 0.40$) and lowest in grass pea ($18.55^{c} \pm 0.50$). The highest ($p<0.001$) ether extract (EE) was found in soybean ($5.98^{a} \pm 0.36$) and lowest in cowpea ($4.18^{b} \pm 0.14$). The highest ($p<0.001$) ash was observed in cowpea ($17.49^{a} \pm 1.72$)

and lowest in soybean ($9.64^{b} \pm 0.34$). The highest ($p<0.001$) nitrogen free extract (NFE) was found in grass pea ($49.20^{a} \pm 0.53$) and lowest in soybean ($40.68^{b} \pm 0.75$). The calcium contents of hays were ranged from $1.12^{c} \pm 0.08$ to $2.01^{a} \pm 0.10$ being highest in cowpea and lowest in grass pea where the mean differences were significant ($p<0.001$). The phosphorus content was found to be highest ($p<0.001$) in soybean ($1.30^{a} \pm 0.03$) and lowest in cowpea ($0.15^{b} \pm 0.01$).

5.2 Conclusion

The results of the study revealed that the hays that were tested had good potential for its good physical and chemical properties as animal feed. Among hays, made from three different species of forage, grass pea had the highest crude protein content. It can be concluded that hay made from locally available fodders can replace expensive feed as it is nutritious enough and can be used to meet feed shortages in livestock business. Lack of animal protein can thus be overcome by employing hay, 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-government 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 hays made from other fodders 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 VI

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