**MACROMINERAL CONTENT IN *Megathysus maximus* HAY AS INFLUENCED BYPOST- HARVEST HANDLING AND STORAGE DURATION**

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**CHAPTER ONE**

**1.0** **INTRODUCTION**

All the plants depends on soils for their supply of mineral nutrients and grazing ruminants animal obtained a majority of their mineral from plant grown on this soils **(**Faria-Mamol*et al.,* 1997**)**. HoweverRruminant animals also rely on pasture plants for their nutrition than any other various feed products (Aderinola *et a*l., 2007).

Therefore, Minerals are importantly required for virtually all vital processes in the hoof animal body. Mineral and trace element are essential for several crucial physiological function in ruminant (Suttle, 2010) A deficiency of each essential macro or micro mineral in animals’ results in abnormalities that can only be corrected by supplementation of the deficient mineral. In addition to requirements for mammalian functions, ruminants fed forages are dependent on an adequate provision of a number of minerals to optimize rumen microbial activity and thus, forage utilization. Adequate mineral nutrition is essential for optimal ruminant performance (Spear, 1996).

The level of mineral component in plants is a function of interactions among a number of factors including soil type, plant species, dry matter yield, grazing management and climate (Khan et al., 2005) .However, The intake of minerals in ruminants reared in grazing systems depends on the composition and the total consumption of forage, the consumption and the minerals content of water, and the composition of the soil (Rodríguez and Banchero, 2007).

Adequate amounts of essential minerals are critical to maximize the productivity and the health of livestock (Wang *et al*., 2016 ). Furthermore, appropriate mineral levels improve the interaction between production and reproduction (Almeida *et al.,* 2007; Griffiths, *et al*., 2006).

Therefore, a suitable quantity and proportion of essential minerals prevents diseases by activating the immune system, improving growth, production, viability, and fertility (Underwood, 1981). However, since all plants depend upon the soil for their supply of mineral nutrient and grazing ruminant animals obtain the majority of their mineral nutrients from plants grown on these soils and Concentrations of mineral elements in forage are dependent on the interaction of a number of factors, including soil, plant species, stage of maturity, yield, pasture management and climate (McDowell *et al.,* 1983). Most naturally occurring mineral deficiencies in herbivores are associated with specific, regions and are directly related to soil characteristics (Underwood, 1981: McDowell *et al*., 1983).

Therefore, expansion of the agricultural frontier with various Agricultural plants and pastures forages in tropical regions of developing countries for food production requires implementing production strategies with an eco-efficient focus to sustainably meet the increasing demand for food (Rao, 2013).

However, Forage based animal production plays an important role in the affordable supply of nutrient rich foods for the humans. Over the past 60 years, animal husbandry has changed substantially due to the concerted efforts in modern technology, animal breeds, management, growth parameters, feed additives and financial incentives (FAO, 2000).

.According to S.I. Ogunlade (2020), forage production is important to the sustainability and profitability of animal production system. In many regions, forage constitutes a significant proportion of animal diets, particularly for ruminant. Forage is crucial source of nutrient required for growth, development and maintenance of body function in animal. Therefore, the conservation and utilization of forages such as *Megathyrsus maximus* as hay are essential for ensuring food security and sustainable animal production systems. Since animal performance is directly related to forage quality and important sources of minerals in the diet of ruminants and in the case of grazing ruminants, they may be the only source of both macro and micro elements available to meet their requirements.

**1.1** **OBJECTIVES**

**1.1.1** **Broad objective**

Macromineral content in *Megathyrsus maximus* hay as influenced bypost-harvest handling and storage duration

**1.1.2 Specific objectives**

**To determine the**

i. Macro mineral content (calcium, phosphorus, potassium and magnesium) of hay produced from *Megathyrsus maximus* as influenced by post-harvest handling (whole, chopped and shredded)

*ii*. Macro mineral content of hay produced from *Megathyrsus maximus* as influenced by storage duration (0, 4 and 8) weeks respectively

**CHAPTER TWO**

**2.0** **LITERATURE REVIEW**

**2.1** **Origin of *Megathysus maximus***

Guinea grass was previously known as *Panicum maximum* Jacq. In 2003, the subgeneric name*, Megathyrsus*, was added to generic rank and it was renamed *Megathyrsus maximus* (Simon and Jacobs, 2003). The grasses of Poaceae are ecologically dominant and are by far the most economically important family in the world (Sánchez-Moreiras *et al*., 2003; Heywood *et al*, 1978; Favaretto *et al*., 2018). The guinea grass is a perennial forage species belonging to this family. The guinea grass forms an agamic complex with *Panicum infestum* and *Panicum trichocladum* (tribe of Paniceae) and belongs to the subfamily Panicoideae of the Poaceae (Savidan and Pernès, 1982). It is native to Africa (tropical origin), but this grass was distributed to almost all tropical countries as a source of animal forage due to its good forage quality, particularly as feed for beef (Aganga and Tshwenyane, 2004). Due to its high forage production, nutritional value and increased adaptability to different ecological regions, guinea grass has been broadly introduced and exploited in most tropical and subtropical zones, such as Brazil, Japan, the USA, and Australia (Savidan and Pernès, 1982; de Sousa *et al*., 2011; Smith, 1979). After its introduction to the subtropical rainfall zones (900 mm) in the last decade, it was cultivated in many subtropical arid and semiarid regions of North Africa and the Mideast*. Megathyrsus maximus* is widespread throughout Southern Nigeria on roadsides, waste places and in the wetter parts of the North (Stanfield, 1970). It is a very variable species in East Africa and numerous natural types exist, some of which have been described as botanical varieties. According to Bogdan (1977), the cultivars that are grown in various countries represent apomictic or vegetative clones with little or no variability within the cultivar. Most of these known cultivars are large- sized forms.

**2.2 Morphology *of Megathyrsus maximus***

Guinea grass is a large tufted, fast-growing perennial grass. It has a broad morphological and agronomic variability, ranging in height from 0.5 to 3.5 m, with stems of 5 mm to 10 mm diameter. There are two main types: a tall/medium tussock type, taller than 1.5 m at flowering, and a short tussock type (Cook *et al*., 2005). The root is a short creeping rhizome; culms are erect, hirsute at the nodes. Leaves are blade-shaped, glabrous to pubescent up to 35 mm broad. Inflorescence is a panicle, 15 to 50 cm long. Spikelets are 3-4 mm green to purple (Ecoport, 2009).The inflorescence is a large multi-branched, open panicle with loose, flexuous branches. The lower branches of the inflorescence are arranged in a whorl. The lower floret is usually male with a well-developed palea (upper bract enclosing flower) (Gibbs Russell *et al* .1991). The fertile (female) upper lemma is pale. Spikelets are green to purple and flowering occurs from November to July

**2.3** **Importance *of Megathyrsus maximus* in Animal production**

Guinea grass is well suited for zero grazing system and can be used for making silage and hay. Guinea grass can be managed as a long-term pasture forages if grazed consistently, but it should not be grazed under 35 cm height, nor under very wet conditions (FAO, 2009). As the grass rest-period affects animal performance, a good rest-period is to wait for regrowth of 2.5 leaves/tiller(Candido *et al.,* 2005). For silage and hay, a good cutting height is 60-90 cm, but for higher yields of acceptable quality it can be cut at up to 1.5 m, as it does not become coarse even if left to grow to that height (Hongthong Phimmasan, 2005). Better quality silage is obtained if Guinea grass is cut during pre-anthesis or anthesis (Sarwatt *et al*., 1989). Ensiled Guinea grass has a good texture and it was possible to mix grass of different ages with no effect on silage quality (Babayemi *et al.,* 2009). Guinea grass yields an average of 30 t DM/ha/year (Cook *et al*., 2005). The yields depend on the cultivar and fertilizer application. For instance, unfertilized Guinea grass yields around 7t DM/ha while N-fertilized pastures can yield up to 42t/ha (Hongthong Phimmasan, 2005). Guinea grass produces around 1.7-3.1 million seeds/kg (Ecoport, 2009).

**2.4 Importance of *Megathyrsus maximus* in crop production**

Guinea grass is a fast growing, bulky grass that helps prevention soil erosion since it provides rapid ground cover (Roose, 1994). While it spreads slowly when it is well managed, Guinea grass can spread very fast and become a weed in ungrazed areas where soil disturbance has occurred. It is a major weed in sugarcane fields since it grows well in shaded conditions (Ecoport, 2009).

**2.5** **Importance and production of Hay for livestock production**

Forages conservation is important to feed livestock during periods of shortage, caused by limited forage growth or inadequate pasture conditions, Conserved forages can take the form of hay, haylage or baleage, and silage. The aim in forage conservation is focus on minimizing losses, which start immediately after harvesting.

The process of selecting a conservation method should take into account the suitability of the forage for a given technique, storage capability, weather conditions, and the intended use of the conserved forage. The selected conservation technique should maximize nutrient conservation efficiency and minimize cost of production. According to (Collins and Coblentz, 2013), Hay is defined as forage conserved under aerobic dry or reduced moisture conditions. Fresh forage typically has between about 75% and 85% moisture concentration. Thus, the goal in hay production is to remove moisture as quickly as possible to achieve a target moisture concentration equal to or less than 20% (or a target dry matter concentration greater than 80%). The process of reducing moisture is called curing and is normally accomplished with energy provided by the sun (field curing) or by artificial barn drying using heated or unheated air. Moisture concentration less than 20% prevents plant respiration and allows for an almost complete conservation of plant nutrients for extended periods (years). Factors that affect the process of moisture loss for hay production can be categorised into three types: (1) forage-related, (2) weather-related, and (3) management (Rotz, 1995; Collins and Owens, 2003):

**2.6** **Effect of Post-harvest handling method of forage grasses**

**Shredding**

Shredding is a type of processing that mechanically treats forage in order to separate plant tissues apart and rupture the plant cell. Shredding, a type of processing (Koegel et al., 1988), where the particles of grass-clover are crushed and broken between two or more rollers rotating with different speed, has been investigated earlier with respect to effects on forage quality (Koegel *et al.,* 1992; Descoteaux and Savoie, 2002). Compared to the traditional precision chopping, shredding attempts to disrupt the forage particles by separating rigid plant tissues apart and by rupturing a larger proportion of the plant cell walls, in order to increase the surface area for microbial adhesion and thereby increase rate of digestion (Lehmann *et al*., 2017).

**Chopping**

This is a general method for forage food into bite-sized pieces (about 1/4-inch in size, or the thickness of a pencil). A large-bladed chef's knife is helpful for chopping, dicing, and mincing Cutting is a size reduction process which can be done by pushing or forcing a thin sharp knife through the material to be chopped. When forage crops are used as feeds for animals, size of the fodder (forage) must be reduced as much as possible to aid proper feeding and palatability.

Adgidzi (2007) reported that, the average chopping rate for the dry materials was 24kg/h and the average chopping rate for the wet materials was 15.6kg/h. These values indicate that the machine performed better with dry materials than the wet materials Therefore, the output capacity, chopping efficiency and length of cut of a forage chopper may be affected by the mechanical properties, physical properties of the material, and the cutting knife parameters (Adgidzi, 2007).

**2.7** **Effect of Minerals Composition in Pasture and Livestock Production**

Minerals are inorganic substances, present in all body tissues and fluids and their presence is necessary for the Maintenance of certain physicochemical processes which are essential to life. Minerals are chemical constituents used by the body in many ways. Although they yield no energy, they have important roles to play in many activities in the body (Malhotra, 1998; Eruvbetine, 2003).Every form of living matter requires these inorganic elements or minerals for their normal life processes (Hays and Swenson, 1985; Ozcan, 2003). Minerals may be broadly classified as macro (major) or micro (trace) elements. The third category is the ultra-trace elements. The macro-minerals include calcium, phosphorus, sodium and chloride, while the micro-elements include iron, copper, cobalt, potassium, magnesium, iodine, zinc, manganese, molybdenum, fluoride, chromium, selenium and sulfur (Eruvbetine, 2003). The macro-minerals are required in amounts greater than 100 mg/dl and the micro-minerals are required in amounts less than 100 mg/dl (Murray *et al*., 2000). The ultra-trace elements include boron, silicon, arsenic and nickel which have been found in animals and are believed to be essential for these animals. Evidence for requirements and essentialness of others like cadmium, lead, tin, lithium and vanadium is weak (Albion Research Notes, 1996).The mineral elements are separate entities from the other essential nutrients like proteins, fats, carbohydrates, and vitamins. Animal husbandry had demonstrated the need for minerals in the diet (Hegsted *et al*.,1976).

**2.8 Macro Minerals, their Sources, functions and Associated \problems for pasture and Animals**

Forages are the major sources of minerals in the diets of ruminants in the tropics. The natural pasture is considered the major source of forages which is given little or no management input, thereby supplying insufficient amount of nutrient and biomass (Mohammed-Saleem, 1994). Sown pasture, which is a purposely managed pasture with better nutrient and carrying capacity is been considered the way to go (Onifade *et al*., 2005; Dele, 2008).

All plants require 17 elements to complete their life cycle, and an additional four elements have been discovered to be essential for some plants (Havlin *et al*. 2005). With the exception of C, H, and O, which plants obtain from air and water, plants derive the remaining 14 elements from the soil or through fertilizers, manures, and amendments (Parikh and James, 2012). Most naturally occurring mineral deficiencies in herbivores are associated with specific regions and are directly related to soil characteristics (Underwood, 1981; McDowell *et al.,* 1983). When mineral nutrients in herbage are deficient in respect of animal requirements, changes in concentrations brought about by climatic, managerial or, seasonal influences as well as plant maturity can be significant factors in incidence or severity of deficiency states by livestock wholly or largely dependent on these plants (Underwood, 1981).Plants consume primary macronutrients in large quantities, while their intake of secondary macronutrients is lower. Each of these nutrients has a crucial function, necessary for nourishing the plant. A shortage in any of them leads to deficiencies with different adverse effects on the plant’s general state, depending upon which nutrient is missing and to what degree. The potential of forages produced to meet the mineral needs of livestock in the available form of the minerals, is of utmost importance, as minerals could be regarded as salt of life. Life itself in animals is dependent on mineral elements as the beating of heart is brought about by balance between some minerals in the fluid bathing the heart muscle (McDowell, 1992).

Soluble mineral may interact with microbial cells, other minerals or other forage components to form insoluble compounds (Spears, 1994). A complete study of mineral utilization in tropical forages is therefore very essential, biological availability of macro-minerals in Guinea grass like the primary macronutrients are Nitrogen (N), Phosphorus (P), and Potassium (K).Plant species with higher P and K in their leaves are more productive and beneficial for livestock, because both of these elements are very important for livestock (Ashraf *et al.,* 1992; Irigoyen *et al*., 1992). Ca and Mg are also useful for livestock because of their essence for normal growth of livestock (Walker, 1980; Underwood, 1981; Khan *et al*., 2004).

**2.9** **Biochemical functions of mineral elements in Animals**

Minerals are important to the health and well-being of ruminant animals in the tropics as their deficiency as well as abundance could amount to low productivity. Minerals are required by both plants and animals in critical and balance amount, the excess and deficiency both reduces the efficiency of vegetation and dependent livestock production (Dele, 2012).

Nutrition has long been recognized as important for maintaining health. Dietary energy, protein, mineral, and vitamin concentrations have profound effects on immune function (Beisel, 1996; Calder, 2013). In Ruminant nutrition, macro minerals are those required at > 0.1% of the diet, and include Ca, Cl, P, K, Na, Mg, and S. Whereas a clinical deficiency or excess of any of these would cause negative health consequences, the following focuses on the most common concerns.

**2.10**  **Biochemical functions of mineral elements in animals**

**Calcium (Ca)**

Calcium functions as a constituent of bones and teeth, regulation of nerve and muscle function. In blood coagulation, calcium activates the conversion of prothrombin to thrombin and also takes part in milk clotting. It plays a vital role in enzyme activation. Calcium activates large number of enzymes such as adenosine triphosphatase (ATPase), succinic dehydrogenase, lipase etc. It is also required for membrane permeability, involved in muscle contraction, normal transmission of nerve impulses and in neuromuscular excitability. Reduced extracellular blood calcium increases the irritability of nerve tissue, and very low levels may cause spontaneous discharges of nerve impulses leading to tetany and convulsions (Hays and Swenson, 1985; Malhotra, 1998; Murray *et al*., 2000). Calcium absorption requires calcium-binding proteins and is regulated by vitamin D, sunlight, parathyroid hormone and thyrocalcitonin. Thyrocalcitonin decreases plasma calcium and phosphate levels whereas parathyroid hormone increases them.

**Phosphorus**

Phosphorus: P is primarily taken up by plants in the form of phosphate ions (HPO42- and HPO4-) from the soil solution. The concentration of P in soil water is generally very low (< 0.01% of the total soil P), with the bulk of the soil P existing as organic P, insoluble compounds of P with Al, Fe, and Ca, and phosphate adsorbed to Fe and Al oxides and phyllosilicates (Stevenson & Cole 1999; Brady & Weil 2008). Phosphate ions from dissolved chemical fertilizers react rapidly in most soils, resulting in P fixation in the soil. These soil reactions involve both adsorption and precipitation processes.

Phosphorus is located in every cell of the body and is vitally concerned with many metabolic processes, including those involving the buffers in body fluids (Hays and Swenson, 1985). It functions as a constituent of bones, teeth, adenosine triphosphate (ATP), phosphorylated metabolic intermediates and nucleic acids. It serves buffering action that is phosphate buffers, functions in the formation of high energy compounds, that is, adenosine triphosphate (ATP) and is involved in the synthesis of phospholipids and phosphoproteins. Practically, every form of energy exchange inside living cells involve the forming or breaking of high-energy bonds that link oxides of phosphorus to carbon or to carbon-nitrogen com-pounds (Hays and Swenson, 1985; Malhotra, 1998; Murray *et al*., 2000). Phosphorus is also needed for soil fertility. In plants, as grasses mature, phosphorus is transferred to the grain. Also, the phosphorus content of the plant is influenced markedly by the availability of phosphorus in the soil. As a result of this, low-quality pastures devoid of legumes and range plants tend to be naturally low in phosphorus, as the forage matures and the seeds fall; characteristically, the range soil is also deficient in phosphorus (Merck, 1986).

**Pottasium**

Potassium is the principal cation in intracellular fluid and functions in acid-base balance, regulation of osmotic pressure, conduction of nerve impulse, muscle contraction particularly the cardiac muscle, cell membrane function and Na+/K+-ATPase. Potassium is also required during glycogenesis. It also helps in the transfer of phosphate from ATP to pyruvic acid and probably has a role in many other basic cellular enzymatic reactions. Its metabolism is regulated by aldosterone. Hyperkalaemia is increased level in serum potassium and this occurs in Addison’s disease, advanced chronic renal failure, shock and dehydration. Toxicity disease or symptoms include dilatation of the heart, cardiac arrest, small bowel ulcers. Hypokalaemia is low level of serum potassium and this occurs in diarrhoea, metabolic alkalosis and familial periodic paralysis. When lactating dairy cows have hypokalaemia, the milk production is markedly lowered. Deficiency disease or symptoms occurs secondary to illness, functional and structural abnormalities including impaired neuromuscular functions of skeletal, smooth, and cardiac muscle, muscular weakness, paralysis, mental confusion (Hays and Swenson, 1985; Malhotra, 1998; Murray *et al*., 2000).

**Magnesium**

Acute Mg deficiency in cool season annual forages is a practical problem (i.e., grass tetany) in beef cows and rarely in stocker cattle (wheat pasture poisoning (Horn *et al*., 2005). If demand for Mg exceeds dietary supply, there is no mechanism for the animal to rapidly mobilize Mg from bone, so acute Mg deficiency leads to a tetany condition. Hypomagnesemia is exacerbated by high levels of K in feeds, such as lush forages, because K negatively affects Mg absorption (Fontenot *et al*., 1989; Martin-Tereso and Martens, 2014).

Magnesium is an active component of several enzyme systems in which thymine pyrophosphate is a cofactor. Oxidative phosphorylation is greatly reduced in the absence of magnesium. Mg is also an essential activator for the phosphate-transferring enzymes myokinase, diphophopyridinenucleotide kinase, and creatine kinase. It also activates pyruvic acid carboxylase, pyruvic acid oxidase, and the condensing enzyme for the reactions in the citric acid cycle. It is also a constituent of bones, teeth, enzyme cofactor, (kinases, etc) (Murray *et al*., (2000). The health status of the digestive system and the kidneys significantly influence magnesium status. Magnesium is absorbed in the intestines and then transported through the blood to cells and tissues. Approximately one-third to one-half of dietary magnesium is absorbed into the body. Gastrointestinal disorders that impair absorption such as Crohn's disease can limit the body's ability to absorb magnesium. These disorders can deplete the body's stores of magnesium and in extreme cases may result in magnesium deficiency. When a magnesium-deficient diet is fed to young chicks, it leads to poor growth and feathering, decreased muscle tone, ataxia, progressive incoordination and convulsions followed by death (Merck, 1986). . A common form of magenesium-deficiency tetany in ruminants is called grass tetany or wheat wheat-pasture poisoning. This condition occurs in ruminants grazing on rapidly growing young grasses or cereal crops and develops very quickly. The physiological deficiency of magnesium can be prevented by magnesium supplementation of a salt or grain mixture and adequate consumption is also very important (Hays and Swenson, 1985).

**CHAPTER THREE**

**3.0 MATERIALS AND METHODS**

**3.1 Experimental site**

The field work will be carried out at pasture and range Management Processing Unit located at Directorate of University Farms (DUFARMS), while the chemical analysis will be carried out at the Department of Pasture and Range Management laboratory both at Federal University of Agriculture, Abeokuta (FUNAAB), Ogun State Nigeria**.**

**3.2 Sourcing of Forage Materials**

*Megathyrsus maximus* will be sourced from the pasture and range management farm of the Federal University of Agriculture (FUNAAB)

**3.3 Harvesting of forage Material**

*Megathyrsus maximus* will be harvested at the vegetative stage in an already established pasture from the Directorate of University Farms (DUFARMS) within the University.

**3.4** **Chemical Analysis**

The chemical analysis for the experiment will be carried out at the laboratory of the Department Pasture and range management, (COLANIM) of the Federal University of Agriculture, Abeokuta (FUNAAB)

**3.5 Experimental design**

The experiment will be laid out as a 3x3 factorial experiment in a split plot design with three replicate. Post-harvest handling (whole, chopped, and shredded) and Storage duration (0, 4 and 8) weeks having a total of 27 treatment combinations.90kg of  ***Megathysus maximus*** will be harvested and subdivided into 30kg of whole, chopped and shredded where the 30kg will be replicated into 10kg each, and will be oven dried and stored at 0,4 and 8 weeks respectively

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