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JUDUL: COMPARISON OF BIOMASS YIELD, CHEMICAL COMPOSITION AND SILAGE QUALITY AMONG THREE FORAGE SPECIES USING EFFECTIVE MICROORGANISM ACTIVATED SOLUTION

IJAZAH: BACHELOR OF AGRICULTURE SCIENCE WITH HONOURS (LIVESTOCK PRODUCTION)

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COMPARISON OF BIOMASS YIELD, CHEMICAL COMPOSITION AND SILAGE QUALITY AMONG THREE FORAGE SPECIES USING EFFECTIVE MICROORGANISM ACTIVATED SOLUTION

JACOB MATHAN

DISSERTATION SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF BACHELOR OF AGRICULTURE SCIENCE WITH HONOURS

LIVESTOCK PRODUCTION PROGRAMME
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DECLARATION

I hereby declare that this dissertation is based on my original work except for citation and quotation which have been duly acknowledged. I also declare that no part of this dissertation has been previously or concurrently submitted for a degree at this or any other university.

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ABSTRACT

This study was conducted from April 2013 to September 2013 at the School of Sustainable Agriculture (SSA), Universiti Malaysia Sabah. This study was carried out to determine the biomass yield and chemical composition of three forage species. The effect of effective microorganism activated solution (EMAS) towards the quality of the silage produced from the three forages was also assessed in this study. The treatment in this study was three forage species that were Guinea grass, Splendida grass and Signal grass. For silage production there were two treatments which were the control treatment and silage with 0.001% EMAS. Each treatment consisted of three replications. The experimental design used was Completely Randomized Design (CRD) and the data for biomass yield and chemical composition was analysed using one way ANOVA and the data for silage quality was analysed using two way ANOVA both at 0.05% significance level. No significant differences ($p>0.05$) were observed in fresh yield, DM yield, CP yield as well as OM, Ash contents among the three forages. However, the DM content in Splendida grass was significantly higher ($p<0.05$) compared to the other two grasses. The CP and EE content in Signal grass was significantly lower ($p<0.05$) when compared to the other two forages. The CF content in Guinea grass however was significantly higher ($p<0.05$) than the other two grasses. There was a significant difference ($p<0.05$) in the nitrogen free extract content among the three forages with Signal grass containing the highest amount followed by Splendida grass and Guinea grass. In terms of silage quality, there was no significant difference ($p>0.05$) between the two silage treatments. However, there was a significant difference ($p<0.05$) in the silage quality among forage species. In the control treatment, the pH of Guinea grass was significantly higher ($p<0.05$) compared to the other two forages which had no significant difference among each other. In the treatment with 0.001% EMAS, the pH of Signal grass was significantly higher ($p<0.05$) compared to the other two forages which had no significant difference among each other. It was concluded that Guinea grass was better than Splendida grass and Signal grass on the basis of DM yield, CP yield and overall chemical composition. In addition, the usage of effective microorganism activated solution was also not effective in improving the silage quality. Further research is needed however, to investigate the lactic acid content to understand the type of fermentation microorganism which dominated the fermentation, the effect of water soluble carbohydrate content on silage quality and the performance of the animals when fed silage produced from EMAS.

PERBANDINGAN HASIL BIOJISIM, KOMPOSISI KIMIA DAN KUALITI SILAJ TIGA SPESIS FORAJ MENGGUNAKAN 'EFFECTIVE MICROORGANISM ACTIVATED SOLUTION' (EMAS)

ABSTRAK

Kajian ini telah dijalankan untuk menentukan hasil biojisim dan kimia komposisi tiga spesies foraj. Kesan EMAS terhadap kualiti silaj yang dihasilkan daripada tiga foraj turut dinilai dalam kajian ini. Rawatan bagi kajian ini adalah tiga spesies foraj iaitu *rumput guinea, rumput splendida* dan *rumput signal.* Untuk pengeluaran silaj terdapat dua rawatan iaitu rawatan kawalan dan rawatan yang terdiri daripada silaj dengan 0.001% EMAS. Setiap rawatan terdiri daripada tiga replikasi dan menggunakan rekabentuk CRD. Data untuk hasil biomas dan komposisi kimia dianalisis menggunakan ujian ANOVA satu hala dan data kualiti silaj dianalisis menggunakan ujian ANOVA dua hala dan kedua-duanya pada aras keertian 0.05%. Tiada perbezaan yang signifikan ($p>0.05$) dalam hasil segar, hasil DM, hasil CP serta kandungan OM dan Ash antara ketiga-tiga foraj. Walau bagaimanapun, kandungan DM di rumput Splendida adalah jauh lebih tinggi ($p<0.05$) berbanding dengan rumput lain. Kandungan CP dan EE di rumput Signal adalah jauh lebih rendah ($p<0.05$) berbanding foraj lain. Kandungan CF di rumput Guinea bagaimanapun adalah lebih tinggi ($p<0.05$) daripada rumput lain. Terdapat perbezaan yang signifikan ($p<0.05$) dalam kandungan ekstrak nitrogen antara ketiga-tiga foraj dengan rumput Signal mengandungi jumlah tertinggi diikuti oleh rumput Splendida dan rumput Guinea. Dari segi kualiti silaj, tiada perbezaan yang signifikan ($p>0.05$) antara kedua-dua rawatan silaj. Walau bagaimanapun, terdapat perbezaan signifikan ($p<0.05$) antara species foraj dari segi pH silaj. Dalam rawatan kawalan, pH rumput Guinea adalah lebih tinggi ($p<0.05$) berbanding dengan dua foraj yang lain yang tidak ada perbezaan yang signifikan. Dalam rawatan dengan 0.001% EMAS pula, pH rumput Signal adalah lebih tinggi ($p<0.05$) berbanding dengan dua foraj yang lain yang tidak ada perbezaan yang signifikan. Kesimpulannya adalah bahawa rumput Guinea adalah lebih baik daripada rumput Splendida dan rumput Signal atas dasar hasil DM, hasil CP dan komposisi kimia secara keseluruhan. Di samping itu, penggunaan EMAS juga tidak berkesan dalam meningkatkan kualiti silaj. Penyelidikan lanjutan diperlukan untuk menyiasat kandungan asid laktik untuk memahami jenis mikroorganisma yang menguasai fermentasi, kualiti tepat silaj dan prestasi haiwan apabila diberi makan silaj dari EMAS.

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LIST OF SYMBOLS, UNITS AND ABBREVIATIONS

%	Percentage
>	More than
<	Less than
ANOVA	Analysis of Variance
CF	Crude Fibre
cm	Centimetre
CP	Crude Protein
CRD	Completely Randomized Design
DM	Dry Matter
e.g.	Example
EE	Ether Extract
EM	Effective Microorganism
EMAS	Effective Microorganism Activated Solution
g	Gram
H_2SO_4	Sulphuric Acid
ha	Hectare
HCl	Hydrochloric Acid
h	Hours
kg	Kilogram
LAB	Lactic Acid Bacteria
m	Metre
M	Molarity
ml	Millilitre
MOP	Muriate of Potash
N	Normality
NaOH	Sodium Hydroxide
NFE	Nitrogen Free Extract
pH	Negative log of hydrogen ion concentration
S1	Silage Treatment 1

S2	Silage Treatment 2
Sdn Bhd	Sendirian Berhad
SPSS	Statistical Package for Social Science
SSA	School of Sustainable Agriculture
t/ha	Tonnes per hectare
t/ha/yr	Tonnes per hectare per year
T1	Treatment 1
T2	Treatment 2
T3	Treatment 3
TSP	Triple Super Phosphate
VFA	Volatile Fatty Acids
WSC	Water Soluble Carbohydrates

LIST OF FORMULAE

CHAPTER 1

INTRODUCTION

1.1 Introduction

Livestock production is a vital part of agriculture. Livestock are animals that render economic returns to the farmer and are mainly used for various reasons such as for the production of meat, milk, fibres and as a source of energy. In addition, livestock rely on low quality feed grains and roughages that are not used as food for humans as a source of nutrition and convert these products into high quality food for human consumption. The demand for livestock products are expected to rise due to the increasing global population and the increasing demand for food. Thus, there is a need to increase the production of livestock and to ensure that livestock production is efficient and effective. Currently, livestock production is one of the fastest growing agricultural subsectors in developing countries. This growth is driven by the rapidly increasing demand for livestock products, increasing of population growth, urbanization and increasing incomes in developing countries (Delgado 2005). Therefore, effective feeding and management systems are needed to ensure that the productivity of farm animals is increased. Research also needs to be carried out to study new methods of increasing productivity of livestock production. There is a need to increase productivity by making the most efficient use of the production inputs while reducing its impact on the environmental and world's natural resources. The constraints faced by small to medium scale farmers are lack of skills, knowledge and appropriate technologies thus making it difficult to increase productivity. Therefore, the result is that both production and productivity remain below the actual potential and yet losses and wastage in production can be high. Thus, there is a need for more research to identify new methods of husbandry and management that are able to increase the efficiency and productivity of livestock farming.

Nutrition is one of the most important aspects of livestock production. Good nutrition often leads to high productivity in animals. It is a rule of thumb where animals that are cared for and are on a good plane of nutrition are usually animals that are highly productive. Generally, one of the factors that bring about low productivity in farm animals is the lack of focus in proper nutrition which leads to malnutrition and low productivity in animals. A review of available literature indicates that there is insufficient production of forage due to the lack of knowledge on the importance of nutritional values of forages in developing balanced feeding systems for the livestock farmers (Eng, 2004). Najib (2001) reported that farmers mainly depend on available fresh and dried forage to feed their ruminant animals and also produce and conserve forages for periods where there is inconsistent supply of feed. In addition most good quality fodder seeds are not available and there is not enough suitable land in Malaysia for pasture cultivation (Jelan, 2010) due to the widespread cultivation of oil palm.

The cost of feeding animals in developing countries accounts for about 60-70% of total production costs of livestock farming (Madubuike 1993). This shows that more focus should be placed on producing pasture that is of good quality, quantity and low cost in order to increase the profits of farmers and increase the productivity of farms. Understanding that there is a present trend of rising feed stuff prices and global inflation, livestock production is increasingly constrained by feed scarcity and the high cost of feeds (Ayantunde *et al.*, 2005).

Apart from the problem of quantity of forage produced that is insufficient to meet the animal requirements, another problem faced by livestock producers is that the quality and nutritive values of these fodders are not sufficient to meet the nutritional requirements of the animals. Eng (2004) reported that much of the natural forages available consist of mainly weeds such as *Imperata cylindrica* and other low yielding native species like *Axonopus compressus* and *Ottochloa nodosa*. Therefore there is a need to identify which species of fodder is best adapted to both the local climatic and environmental conditions. This will help farmers to choose the best fodder to cultivate thus increasing their productivity.

Forage conservation is also essential to ensure that there is a consistent supply of forages for animal consumption and so that the extra forages will not be wasted. The time in which a grass is harvested affects the nutritive value of the grass. Grasses harvested earlier are usually more nutritive. Thus with the ability to conserve forages effectively, livestock producers can easily harvest all their fodders at the optimal growth stage and conserve them to be given to the animals during times of insufficient feed without affecting the nutritive value of the forage. Different types of grasses have different amount of water soluble carbohydrates which is primarily converted to lactic acid. The quality of silage is determined by its lactic acid content. Therefore, a fodder with higher water soluble carbohydrate content has a better chance of making good quality silage. In addition to that, Woolford and Sawczyc (1984) speculated that low water-soluble carbohydrates crops would benefit more from inoculation, whereas Seale *et al.* (1986) reported that additional water soluble carbohydrates can improve an inoculant's performance. Thus there is a gap in knowledge as to whether or not the usage of effective microorganisms is able to improve the quality of silages. There is also a need to identify which fodder species will make the best silage due to the varying amount of water soluble carbohydrates in the different fodder species.

Thus the purpose of this study is to identify the best forage among *Panicum maximum, Brachiaria decumbens* and *Setaria sphacelata var. splendida* to be used for cultivation by farmers to feed their animals in terms of quantity and quality based on the local soil and climatic conditions. Apart from that, this study is also carried out to identify the effects of using effective microorganism activated solutions in producing silage.

1.2 Justification

There is a need for more studies to be conducted to evaluate the best fodder species that can be planted by livestock producers in Sandakan, Sabah based on the local climate and soil conditions. There is also a need to identify the performance of these grasses in local climatic and soil conditions by identifying the biomass yield and chemical composition for quality and quantity assessment. In addition to that, there is also a need to compare the different methods on ensiling to identify whether the conventional method of silage production or the new method of using effective microorganism is more effective and feasible. There are no researches that study the specific effect of effective microorganisms on the silage production of *Panicum maximum, Brachiaria decumbens* and *Setaria sphacelata var. splendida* specifically and a comparison of all three forages silage quality as most research is done on other grasses. Therefore, there is a need to study the effect of effective microorganisms on the silage quality of *Panicum maximum, Brachiaria decumbens* and *Setaria sphacelata var. splendida* grass silage.

Thus through this research, farmers are able to assess the effectiveness of using effective microorganisms in producing silage to feed their animals in periods of insufficient feed as well as the best species of grass from among the three to be cultivated to produce silage. This study also compared the three forage species stated and identified the best species among the three in terms of biomass yield and chemical composition in order to make it easy for farmers in Sandakan, Sabah, Malaysia to select the best forage to cultivate under local soil and climatic conditions.

1.3 Objective

The objectives of this study are:-

1. To determine the biomass yield of *Panicum maximum, Brachiaria decumbens* and *Setaria sphacelata var. splendida*.
2. To evaluate the chemical composition of *Panicum maximum, Brachiaria decumbens* and *Setaria sphacelata var. splendida*.
3. To study the effect of effective microorganisms (EMAS, Recaventure Sdn Bhd) on the quality of silage made from *Panicum maximum, Brachiaria decumbens* and *Setaria sphacelata var. splendida* grass.

1.4 Hypothesis

a) Comparison of different forage species performance.

H_o: There are no significant differences among forage species on biomass yield and chemical composition

H_a : There are significant differences among forage species on biomass yield and chemical composition

b) Study of the effect of effective microorganisms on the silage quality of three different fodder species as well as the interaction between usage of effective microorganism and forage species on the quality of silage.

H_o : Forage species does not affect the silage quality.

H_a : Forage species affects the silage quality.

H_o : Usage of effective microorganism does not affect the silage quality.

H_a : Usage of effective microorganism affects the silage quality.

H_o : Forage species type and usage of effective microorganism do not interact in their effect on silage quality

H_a : Forage species type and usage of effective microorganism interact in their effect on silage quality

CHAPTER 2

LITERATURE REVIEW

2.1 Availability of Livestock Feed in Malaysia

Nutrition is one of the most important aspects of livestock farming. The livestock industry in Malaysia is heavily dependent on imported feed ingredients especially in the non-ruminant sector. Alimon (2010) stated that more than 2 billion tonnes of compounded feed was produced in Malaysia for the local poultry and swine industry and a small proportion for the ruminant and aquaculture sector. However, even though feed is produced in Malaysia, most of the feed ingredients are imported from other nations. Loh (2002) stated that the major problem in Malaysia is its heavy dependence on imported feedstuffs which account for 30 per cent of the total food bill and amounts to RM10 billion a year. Anon (2002) also claimed that locally available raw materials make up about 30% of the total feed ingredients in Malaysia and the use of locally available feed ingredients depends on supply, cost and quality where most of the time the production of these locally available feed ingredients such as fish meal and tapioca is not sufficient to meet the requirements of the local feed industry. Most compounded feeds for the poultry and swine industry were formulated mainly with corn as the energy component and soybeans as the protein components in addition to small quantities of other materials that include fish meal, cottonseed meal, rice bran, wheat milling by-products, tapioca chips and most importantly palm kernel cake (Alimon, 2010). Loh (2002) however, found that in Malaysia, the ruminant industry depends mainly on locally available feedstuffs with only some supplementation provided by imported ingredients. The major local materials used are crop residues and other agro-industrial by products such as rice bran, copra cake, palm kernel cake, oil palm frond, sago, tapioca and broken rice. Alimon (2010) also stated that pellet production for the ruminant subsector mainly utilized by-products such as distillers dried grain, rice bran, corn gluten meal and palm kernel cake as feed ingredients.

The ruminant industry in Malaysia is not well developed and is mainly operated by smallholder farmers with extensive to semi-intensive production systems that depend on native pastures that are often supplemented with locally available feedstuff such as palm kernel cake, palm oil sludge, oil palm frond and soy waste. The problem with this is that in Malaysia the wild grasses, pastures and oil palm fronds which are abundant and palatable are of low protein content and nutritive quality (Jelan, 2010). Therefore, there is a need to identify and compare various improved pasture species and pasture management methods to be introduced to the local smallholder farmers to improve the nutrition of ruminants and hence improve productivity.

2.2 Forage production in Malaysia

Even though Malaysia has an equatorial climate with adequate rainfall and sunshine all year round, there is a lack of high quality natural pastures typified by those found in some of the temperate countries like New Zealand (Eng, 2004). The pasture research team at the Malaysian Agriculture Research and Development Institute (MARDI) over the past 20 years had introduced several hundreds of improved tropical pasture ascensions and also had identified various promising species and genera (Wong *et al.*, 1982; Wong and Najib, 1988). Much of the natural forages available consist of mainly weeds (*Imperata cylindrica*) and other low yielding native species like *Axonopus compressus* and *Ottochloa nodosa* (Eng, 2004). The pasture team at MARDI found that the Digitaria genus, *Brachiaria humidicola* and *Brachiaria dictyoneura* were adapted to bris soils; *Brachiaria humidicola* and *Tripsacum andersonii* (Guatemala grass) were important on acid sulphate soils and in areas with a higher water table; while on peat soils, *Pennisetum purpureum* (Napier Grass) was outstanding. Wong *et al.* (1982), also reported that other promising grasses including *Panicum maximum* (Guinea grass) and *Brachiaria decumbens* (Signal grass) were able to perform in any of the sedentary and alluvial soils in all agroclimatic zones. In the highlands, Wong *et al.* (1982) reported that Napier, Guinea, Signal, Guatemala and Kikuyu grass (*Pennisetum clandestinum*) as well as Nanti Setaria (*Setaria sphacelata cv Nandi*) had good production records as they had shown vigorous growth and seed setting. One of the factors that hinder the development of promising species of tropical pastures for seed production and seed setting in Malaysia is the unfavourable climate (Wong and Chen, 1998).

Wong and Chen (1998) reported that improved pastures were established in Malaysia as part of the establishment of eight commercial ranch operations with six farms in Peninsular Malaysia, and one each in Sabah and Sarawak which was developed by the National Livestock Authority (Majuternak) with the aim of increasing commercial livestock production in the mid 1970s.Current total areas of ranch pastures were approximately 25 00 ha in Peninsular Malaysia, 5 000 ha in Sabah and 20 000 ha in Sarawak (Wong and Chen 1998). One of the problems these pastures faced is that of persistence (Chen, 1985) which were mainly due to the poor tropical soils which had high saturation of aluminium that is approximately 60 to 80 per cent and low soil pH of about 4.0 to 5.5 (Wong and Chen, 1998). This is one of the drawbacks in the establishment of ranch pastures in Malaysia. Hence, the best forage species that is able to perform well and adapt to the local climate must be identified and cultivated on poor tropical soils in Malaysia for better forage growth.

Eng (2004) reported that most farmers in Malaysia do not grow improved forages as many of the farmers in Malaysia consist of smallholders who do not depend on livestock rearing as a major source of income. Therefore these farmers usually feed their animals with natural forages that are found growing on the road side or bunds in paddy fields or they may allow their animals to graze on native grasses and shrubs either on idle agricultural land or under permanent tree crops owned by them or in the plantations where they work. However this extensive and low input production system, because of the inherent low quality and quantity of feed available, inevitably leads to low animal productivity (Eng, 2004). Clayton (1983) reported that the high cost of pasture establishment from rain forests, coupled with the low productivity of the cattle on the farm and the low ex-farm prices offered for the beef produced in Malaysia, has resulted in commercial ranches taking 10 - 12 years to break even on the total expenditure incurred. Hence, there is a need to identify potential improved grasses that can be planted by smallholder farmers and used to feed their animals without incurring high costs. Review of literature also reported that there were few grasses that had been identified for small scale production of seed for local needs in Malaysia and such species were the Ruzi grass (Brachiaria ruziziensis) and Guinea grass (Wong and Chen, 1998).

Chen (1985) identified various problems of forage development in Malaysia one being the limited choice of suitable pasture grass and legume species for specific usage in the open ranch, in small holdings and in plantations. This is because not all improved pasture species can adapt to the local climate in Malaysia (Eng, 2004). Hence it is essential to identify which grass has best adapted to the local climate and is the most productive in various types of soil.

There is also insufficient information on the optimum usage of fertiliser for plant growth and animal production in relation to various soil types in Malaysia (Chen, 1985). The identification of soil properties and the correction of soil nutritional deficiencies are essential in the establishment of pastures. Kerridge and Tham (1974) have clearly established the need for soluble phosphorus in order to successfully establish pasture grasses and legumes in most Malaysian soils. Apart from phosphorus, Tham and Kerridge (1982) also reported deficiencies in potassium, molybdenum, copper and calcium in both pot and field trials done with a number of Malaysian soils. Tham (1980) also found that apart from nitrogen, there is also a need to ensure adequate Phosphorus and Potassium fertilisers to maintain high fodder yields. Review of past literature also showed that for signal grass there is a need to fertilise up to 300 kg N/ha/year in order to sustain a live weight gain of 900 kg/ha/yr when grazed by Kedah- Kelantan cattle at a stocking rate of 8 head/ha. However, when the Nitrogen rate was decreased to 150 kg N/ ha/year, the live weight gain obtained was reduced to 750 kg/ha/year at the same stocking rate. In both cases, phosphorus and potassium fertilisers were applied as standard (Chen *et al.*, 1981).

2.3 *Panicum maximum*

Guinea grass has often been regarded as one of the best tropical grasses. Batistoti *et al.* (2012) stated that the major grasses used as forage for cattle in tropical areas belong to the genus "Brachiaria" or "Panicum" which are able to adapt well and are widely distributed in most tropical areas. Guinea grass (*Panicum maximum* Jacq.) is a warm-season perennial bunchgrass and is widely recognized as one of the best forage crops for tropical and warm-temperate regions of both hemispheres due to its good yield potential and high quality forage when properly managed (Usberti and Subodh, 1978). Quantitative variation in guinea grass introductions from all over the world (Warmke, 1954; Burton *et al.*, 1973; Edye and Miles, 1976; Usberti and Subodh, 1978) showed a wide range of phenotypes for several characters (Usberti and Subodh, 1978). Thus it can be concluded that there is a variation in the performance of guinea

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