Development of *Moringa Oleifera* based Total Mixed Ration for Meat Goat

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THESIS DECLARATION

I hereby declare that the work embodied in this thesis is the result of the original research and has not been submitted for a higher degree to any universities or institutions.

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Date :

I certify that the report of this final year project entitled "Development of Moringa Oleifera based Total Mixed Ration for Meat Goat" by Nur Izzati Binti Shaefe, matric number F15A0154 has been examined and all the correction recommended by examiners have been done for the degree of Bachelor of Applied Science (Animal Husbandry) witth Honours, Faculty of Agro Based Industry, Universiti Malaysia Kelantan.

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ABSTRACT

Adequate nutrition is important for meat type goat to improve growth and health performances. A good quality forage and balance amount of grains are important sources of nutrients, minerals and vitamins. Total mixed ration (TMR) is a feeding method that involves the mixing of all forages, grains, protein feeds, minerals and vitamins. This feeding method is effective, efficient and profitable to increase animal productivity. *Moringa oliefera* (Moringa) is commonly known as 'drumstick tree' with high nutritive values. The current study aims to develop *Moringa oliefera* based TMR (mTMR) for meat goat in order to reduce the cost of the feed and access cost ratio of mTMR. The mTMR was tested in the lab to make sure that the mTMR fulfill the goat requirement. The data was recorded and analysed using IMB SPSS Statistic version 23(2015) software and further analysed using Duncan multiple comparison test if there was any significant value. Crude protein (CP) and metabolisable energy (ME) contents in mTMR were 12.30±0.28% and 10.38±0.06MJ/kgDM while the goat requirements of CP and ME were 13.17% and 10.5MJ/kgDM. There were no significant differences of chemical composition between mTMR and basal diet in local farm. The newly formulated mTMR was beneficial in reducing the feeding cost and it contained sufficient amount of nutrient that are needed by the goat.

Keywords: *Moringa Oleifera*, total mixed ration, meat goat requirement

Pembangunan Jumlah Catuan Campuran Berasaskan *Moringa Oleifera* untuk Kambing Daging

ABSTRAK

Pemakanan yang mencukupi adalah penting untuk kambing jenis daging untuk meningkatkan pertumbuhan dan kesihatan. Makanan yang berkualiti dan jumlah baki bijirin yang baik adalah sumber penting nutrien, mineral dan vitamin. jumlah catuan makanan (TMR) adalah kaedah pemakan yang melibatkan pencampuran semua makanan ternakan, biji-bijian, protein, mineral dan vitamin. Kaedah pemakanan ini berkesan, cekap dan menguntungkan untuk meningkatkan produktiviti haiwan. Moringa oliefera (Moringa) biasanya dikenali sebagai ‘drumstick tree' dengan nilai-nilai pemakanan yang tinggi. Kajian semasa ini bertujuan membangunkan TMR berasaskan Moringa oliefera (mTMR) untuk kambing daging bertujuan untuk mengurangkan kos makanan dan nisbah kos akses mTMR. MTMR telah diuji di makmal untuk memastikan mTMR memenuhi keperluan kambing. Data tersebut direkodkan dan dianalisis dengan menggunakan perisian IMB SPSS Statistic versi 23 (2015) dan selanjutnya dianalisi dengan menggunakan ujian perbandingan berbilang Duncan jika terdapat sebarang nilai penting. Kandungan protein kasar (CP) dan metabolisable (ME) dalam mTMR adalah 12.30 ± 0.28% dan 10.38 ± 0.06MJ / kgDM manakala keperluan kambing CP dan ME adalah 13.17% dan 10.5MJ / kgDM. Tiada perbezaan ketara komposisi kimia antara mTMR dan diet asas di lading tempatan. MTMR yang baru diformulasikan adalah bermanfaat dalam mengurangkan kos makanan dan mengandungi jumlah nutrien yang mencukupi yang diperlukan oleh kambing.

Kata kunci : *Moringa Oleifera*, jumlah catuan makanan, keperluan kambing daging

TABLE OF CONTENTS

LIST OF TABLES

LIST OF ABBREVIATION

BW	Body weight
Ca	Calcium
CP	Crude protein
DM	Dry matter
DMI	Dry matter intake
g	Gram
h	Hour
H_2SO_4	Sulphuric acid
H_3BO_3	Boric acid
HCl	Hydrochloric acid
kg	Kilogram
ME	Metabolise energy
mg	Milligram
MJ	Mega Joule
ml	Mililitres
mm	Millimeter
mTMR	*Moringa Oleifera* based total mixed ration
N	Nitrogen
NaOH	Sodium Hydroxide
P	Phosphorus
p	Alpha
TDN	Total digestible nutrient
TMR	Total mixed ration
VFA	Volatile fatty acid

LIST OF SYMBOLS

%	Percentage
ºC	Degree Celcius
β	Value lies within reference range

LIST OF EQUATIONS

CHAPTER 1

INTRODUCTION

1.1 Research Background

In 2016, the world goat population is 1.01 billion heads. In Asia, there are 55.4% (556 million) heads of goat from the total population. This is followed by Africa and America with 38.7% (387 million) and 3.8% (37 million) respectively. In Europe, goat population reaches about 1 million heads or 1.7% and the other 0.4% were from Oceania with 4 million heads of goat. Besides, in Malaysia, the total goat population is 105 537 heads of goat (FAOSTAT, 2018).

Goats can be classified into three groups which are meat goat, dairy goat and fiber goat (Yangilar, 2013). The example of meat goat type is Boer and Spanish while dairy goat is Saanen and Toggenburg and Cashmere and Angora are in fiber goat type group.

In Malaysia, the growth of meat type goat is lower than other ruminant subsector such as cattle. However, the demand on meat goat is increasing (Kaur, 2010). The most popular meat goat breed in Malaysia is Boer. This breed is preferred due to its excellent genetic characteristics, high growth rate, high resistance to disease, adapt well to multiple rearing system and climate conditions (Desa, 2011).

However, during dry season, the available feeds are very poor in quality. During this period, the protein content in feed is low while fibre content is high, which resulting in low digestibility and low voluntary feed intake by the animals (Tolera et al, 2000)

Hence, adequate nutrition is required to meet the requirement of meat goat. A good quality fodder is required in intensive and semi-intensive systems of goat rearing systems. Legume such as *Moringa oliefera* (Moringa) has a high growth rate which can be produced up to 100 tonnes of dry matter (DM) per hectare. Moringa can be harvested at 45 to 50 days after reaching one meter in height. The protein content of Moringa leaves is about 25%. It was reported that the quality of amino acid composition in Moringa is similar to soybean meal (Makkar, 2012).

1.2 Problem Statement

The main factor that limit ruminant production in Malaysia is nutritional deficiencies which lead to poor feed intake. Besides, the other constraints in improving animal productivity are high cost of commercial diet and low quality forage. Common nutritional problems faced by the farmers are protein, energy and mineral deficiencies. In Malaysia, protein sources are costly. Hence, legume such Moringa is a potential protein source to be fed to the animals.

1.3 Objectives

The general aim of the project is to develop *Moringa Oleifera* based Total Mixed Ration (mTMR) for meat goat requirement.

The specific objectives of the projects are

1) To evaluate the nutritive values of local feedstuffs as well as mTMR

2) To compare the nutritive values of mTMR with basal diet in local farm

3) To formulate the mTMR to meet the requirement for meat goat.

4) To assess the production cost of new mTMR.

1.4 Hypothesis

Practical and cost-effective total mixed ration (TMR) based on local feedstuffs such as Moringa can reduce high feeding cost to meat goat. It is expected that the nutritive value of mTMR is higher as compared to commercial diets.

1.5 Scope of Study

Moringa oleifera based TMR was studied for the meat goat nutrient requirement which was important for body maintenance, growth, reproduction and production. Meat goat also needs sufficient nutrient to produce good meat quality.

1.6 Significance of Study

An enhancement of nutritive value in daily feed intake of the goat by strategic nutrient intake and feeding management that improve goat performance resulting in better health is needed.

This study was beneficial for small holders in acquiring new knowledge of goat nutrition and feeding management to overcome nutrient deficiencies and imbalances in meat goat performance.

CHAPTER 2

LITERATURE REVIEW

2.1 Meat Goat

Meat goat needs high quality of feed and optimum balance of nutrients to achieve maximum profit potential (Luginbuhl, 2015). Malaysia, Thailand and Indonesia are developing countries that faced barriers to increase the agricultural and ruminant sector. A major restraint towards the development of the ruminant sector were food shortages and inconsistent quality (Khaing, Loh, Ghizan, Halim and Samsudin, 2015). Meat goat production can be profitable by optimizing the use of high quality forage and reduce the use of expensive concentrate (Luginbuhl, 2015)

According to Federal Agricultural Marketing Authority(FAMA), in 2003 Malaysia had imported 10, 707 tonnes of goat meat that worth RM89 million. The imported number of the meat goat increased to 16, 303 tonnes by 2007 valued RM160 million. This number probably will continue to increase as Malaysia’s population and prosperity increased.

Goat is an animal with bad habit in selecting what they eat. This problem is most critical during summer when feed intake drop. So that, the use of nutrient imbalance will affect the growth and health (Su, 2002)

2.2 Nutritional Requirement by Meat Goat

Nutrient efficiency of feed depends on adequate of energy supply which is important in goat productivity. Limitations of energy may result from low quality of the diet. Low energy feed may not achieve the goat nutrient requirement. Age, body size, growth, pregnancy and lactation are effected by the requirement of energy intake. In addition, the environment, hair growth, muscular activity and relationship with other nutrients in the diet also affect the energy requirement. Amount of energy needed may depends on the weather of the region. Energy requirement may increase if the goat is stress (Mira, 2017).

Protein is important for growth and repair of damage body tissue. It is also important for maintaining healthy production (Luginbuhl, 2015). Poor goat performance may cause by lack of protein in feed intake and feed efficiency. Under extreme condition, protein deficiency may cause severe digestive disturbances, nutritional anemia and edema (Sharifi, Bashtani,Ali Naserian and Khorasani, 2013).

Critical nutrient in livestock ration formulation is calcium (Ca). Calcium deficiency in young animal may lead to retarded growth and development. Milk production of he goat may increase if intake of the Ca level high. So that, appropriate calcium level in diet is important in preventing the problem (Sharifi, 2013). Phosphorus(P) important in the formation of bones and teeth (Medline Plus, 2018). Phoshorus is a second most abundant element in animal requirement after Ca. Animal that suffer P deficiency may lower resistance to infection which leads to appetite loss and reduce weight (Inorganic Feed Phosphate, 2018).

Water requirement of goat depends on the amount of water needed for maintenance. Amount of water level in goat body varies with age, fat body amount and environmental temperatures (Giger-Riverdin, Morand-Fehr & Sauvant, 2011). Table 2.1 shows nutritional requirement of maintenance meat goat.

Table 2.1: Nutritional requirement of maintenance meat goat (30-40kg)

Elements	Nutrient requirement, DM basis
DMI (% body weight)	2.8
CP (%)	13-15
TDN (g)	452-560
ME (MJ/kgDM)	10-11
Ca (g)	0.2-0.3
P (g)	0.17

Source: National Research Council (2007)
Notes: DM- Dry matter, DMI- Dry matter intake CP- Crude protein, TDN-Total digestible nutrients, ME-Metabolise energy, Ca-Calcium, P-Phosphorus

2.3 Total Mixed Ration (TMR)

2.3.1 Introduction

Total mixed ration (TMR) is a combination of forages, grains, protein feeds, minerals and vitamins that formulated to form a single mix of feed. Formulated TMR is more effective, efficient and profitable compared to regular concentrate that fed the animal. Urbanisation decreases the allocation of land for fodder cultivation and results in the competition of human food chain. Thus, the price of feed ingredient has gone up (Ramachandra et al 2007; Kishore, Kumar, Rao, 2017). So that TMR helps farmers to cut down the cost of labour thus save time to feed the animal. Besides, it also contributes more in controlling precision feed amount compared to the regular feeding by separating the ingredient. TMR effectively balanced to their nutrient specifications that may boost production (Linn, 2018).

A TMR feeding system can enhance 7% growth of goat meat compare to a computerizes concentrate feeding system (Su, 2002). It is frequently stated that TMR is the best option for landless and small farmers for feeding their animals a balanced diet as it can form a sole feed source for hours. Crop residue feeding value can be increased by incorporating them with the required nutrient into TMR (Kishore, Kumar and Rao, 2017).

2.3.2 Benefit of TMR

Total mixed ration leads to various advantages depending on the formulation made. Total mixed ration helps in improvement of rumen fermentation which rumen process is enhanced, digestibility improved, stabilise the pH and minimised digestive upsets. Besides, TMR helps in increasing dry matter intake in ruminant as their digestive functionality and wellbeing are maintained at high level and continuous feed accessibility (Mavromichalis, 2015).

A TMR gives more precise in formulation and feeding when well managed. At the point when a TMR is mixed properly, the animals cannot considerably consume the forage or concentrate more or less than formulated (Patz Corporation, 2008). Less palatable feeds can be mask off by mixing the feeds together in a TMR (Lammers, Heinrichs & Ishler, 2015).

2.3.3 Preparation of TMR

During TMR preparation, physical properties of the ingredients should be considered as it may affect the size, shape, density, water absorption capacity and adhesiveness. Dry ingredient must be mixed well before adding the moist ingredient as dry ingredients of small particle size will stick high-moisture ingredients such as silage and molasses (Silva-del-Rio, 2012).

Forage quality is the key to success in TMR. The less number of times the forage is exposed to air, it able to keep it fresh (Ontario Goat, 2018). Two information that need to be well calculated in TMR are nutrient requirements as concentrations and their concentrations in feedstuff. For requirement, farmers need to consider the absolute amount and feed intake to determine the required concentration of nutrient in the goat diet (University, 2000).

Preparation of TMR is using crop residues and agriculture waste. The crop residue is made into small pieces before grinding to small particle and mixed well in a mixer to have a uniform blend. In TMR, crop residues and locally by-product can be used and roughage proportion used depends on animal productivity and type of fibre (Kishore, Kumar, and Rao, 2017).

The use of fibrous crop residue in TMR formulation can be the main ingredient and it is beneficial in optimum growth and milk production. Characteristic and level of forage in TMR influenced the volatile fatty acid (VFA) in the rumen and animal performance. Rate and amount of saliva production may increase by increasing the chewing activity that is related to rumen functionality and fermentation activity. Urea can be added in TMR formulation for effective utilisation of agro-industrial by-products (Kishore, Kumar and Rao, 2017).

Goat is the best suited to feed with TMR based on roughage and concentrate with a ratio of 50:50 or 60:40. A TMR feeding system becomes more popular day by day among farmers. It was reported that the net benefit over feed cost of TMR was 24% as compared to conventional system feeding (Kishore, Kumar and Rao,2017)

2.4 *Moringa Oleifera* (Moringa)

2.4.1 Introduction to Moringa

Moringa is originated from Northern India and currently cultivated across Southeast Asia, Africa and South America. It has been reported as a nutritious, therapeutic and prophylactic tree. It has been known widely as it produces high leaf mass high potential in quality forage as animal feed source (Cohen-Zinder et al., 2015). Moringa is a multipurpose tree of economic importance because it has several industries and medical uses (Aregheore, 2002).

The Moringa tree is an outstanding source of nutrition especially in the area where the food source is scarce and seasonally available. The leaves, stem and seed pods of the tree can be used to provide nutritional value of the tree. The dried leaves powder can be stirred in the soup or sauces as a thickening agent or used to brew a healthy drink (The Moringa, 2008).

2.4.2 Nutritional Value of Moringa

Moringa can fed either fresh or dried to animals. It had been categorized in high crude protein content, adequate amino acid profile, high level of vitamins A, B, and C and high moisture content leaves (150-200g/kg DM) (Cohen-Zinder et al., 2015). It was reported that Moringa contains 27.1g, 2.3g, 38.2g and 19.2g of protein, fat, carbohydrates and fibre respectively and also contains 7.5% of moisture per 100 g of leaf powder (Moringa Source, 2018).

Moringa leaves are largerly used as a protein source due to high protein content that is balanced with amino acids. Moringa contain approximately 200g/kg DM of CP compare to *Leucaena Leucocephala* leaves. Moringa was reported has a mode of action that is more nutritional that can increasing the ruminal degradation, digestion, health and animal production performance (Soltan et al., 2017).

Moringa is rich in vitamin A, vitamin C, potassium, calcium, iron and protein. The level of vitamin A in Moringa leaves is four times higher than compared to carrot (Moringa Facts, 2015). The comparison of fresh Moringa leaves with the other common foods is shown in Table 2.2.

Table 2.2 Comparison of fresh Moringa leaves to common foods values per 100 gm edible portion

Nutrient	Moringa leaves	Other foods
Vitamin A	6.8 mg	Carrots : 1.8 mg
Vitamin C	220 mg	Orange : 30 mg
Calcium	440 mg	Cow's milk : 120 mg
Potassium	259 mg	Bananas : 88 mg
Protein	6.7 gm	Cow's milk : 3.2 gm

Source : Gopalan, Rama & Balasubramaniam, 1989, Trees for Life, 2011

2.4.3 Benefit of Feeding Moringa to Goat

Moringa is one of the valuable protein source for ruminant. Based on Gutierrez et al (2012), it mentioned that the protein and organic matter in Moringa are nutrient that are readily digestible in the rumen and/or in the intestine. Moringa leaves contain low amount tannin with no or low of condensed tannins but contain saponins that helps impair palatability (Worku, 2016).

It was reported that Moringa leaves could replace a commercial concentrate (250 g/d) in a diet which was higher in daily gain (21 g/d) compared to other legume tree leaves (Worku, 2016). Moringa may promote rumen microbial protein synthesis due to the substantial contents of readily fermentable nitrogen and energy (Soliva et al., 2005). As Moringa leaves have highly nutritious with excellence palatability, digestibility and balanced chemical composition of protein and minerals, it may classify as most useful trees for feed supplements to animals.

CHAPTER 3

MATERIALS AND METHODS

3.1 Materials

Materials used in this study and experiments were petroleum ether, hydrochloric acid, boric acid, distilled water, fresh Moringa, fresh Napier, commercial goat pellet and coconut meal.

3.2 Equipment

The equipment used in the experiments were measuring tape, weighing balance, aluminum dish, force air oven, Kjedhal digestion machine, grinder, Fiber bag system, FOSS Soxtec 2055 Fat Extraction System, incinerating crucible, furnace, thimbles, siever, test tube, measuring cylinder and beaker. Experiments were conducted at Faculty of Agro Based Industry(FIAT) and Faculty of Veterinary Medicine (FPV) laboratories, Universiti Malaysia Kelantan (UMK).

3.3 Sample Preparation

Forage samples of Moringa and Napier grass were harvested from Yusuf Ecofarm, Tanah Merah, Kelantan. Moringa and Napier grass was harvested at 45-50 days and 3 months of maturity stage respectively. Moringa sample were taken for 5kg while Napier sample were taken for 3kg only. Concentrate sample of commercial goat pellet and coconut meal were bought from the animal feed shop. The commercial goat pellet was bought 5kg while coconut meat waste only bought 2kg. Fresh sample were cut into small pieces and stored in the dry condition to avoid mould growth before drying process.

3.3.1 Drying Samples

Fresh forage and concentrate samples were dried for 24 h at 60^{o}C in an air-circulation oven to obtain air dries samples ready for grinding. The dried sample was weight immediately before put in the dessicator.

3.3.2 Grinding

Feed samples were ground using grinding machine to 1mm particle size and stored in airtight containers away from heat and light.

3.4 Chemical Analysis

3.4.1 Dry Matter (DM)

The empty aluminum dish was weighed and recorded as W1. Approximately 2g of sample are weighed and recorded as W2. The feed is placed in the container and dry in the force air oven for 24 hours at 110^{o}C. The dried sample was weighed and recorded with the container immediately after drying and record as W3. The dry matter was determined using the formula as follow:

$$DM\ (\%) = \frac{W3 - W1}{W2} \times 100 \qquad (3.4a)$$

Where W1-weight of empty dish, W2-weight of sample (g), W3- weight of dried sample (g)

3.4.2 Ash

The empty crucible (W1) and approximately 2 g of sample (W2) were weighed. The samples were incinerated in furnace at ±600˚C for 8 hours and allowed to cool in desiccator to room temperature. The final weight denoted as W3 and ash content of the sample was determined as follow:

$$Ash\ (\%) = \frac{W3 - W1}{W2} \times 100 \quad (3.4b)$$

Where W1- Weight of empty crucible (g), W2- Weight of Sample (g), W3-Weight of crucible and ash (g)

3.4.3 Crude Protein (CP)

Crude protein was measured by calculating the nitrogen levels in food and Kjeldahl method are used. Kjeldahl method were divided into three parts which are (1) Digestion, (2) Distillation and (3) Titration.

3.4.3.1 Digestion

Approximate one gram of the sample were weighed and transferred into each digestion tubes. Each tube was filled with 2 pieces of Kjeltab tablet and 12 mL of concentrated H_2SO_4 solution and then into each tube was put inside the fume chamber and placed inside the digestion rack. The digestion block of Gerhardt Kjeldatherm turned on and heated to reach 400^{o}C for pre-heating before inserting the digestion rack. The fume manifold was attached tightly on the top of the digestion tube before turning the H_2SO_4 aspirator completely to prevent the vaporized H_2SO_4 from escaping. The pre-heated digestion block was reset from 400^{o}C to 250^oC for 30 minutes before reset to 400^oC for another 30 minutes. After the total time 60 minutes of digestion, the digestion rack were removed into theack holder inside the fume chamber and let it to cool.

3.4.3.2 Distillation

The distillation unit were run for 3 times to clean the system. 40% of NaOH was placed in alkali tank of Gerhardt Vapodest distillation unit and the digested samples were diluted with 80mL of distilled water and 50 mL of 45% NaOH. 30mL of receiver solution were added to the receiver flask and the reaction was allowed to settle. 250mL Erlenmeyer titration flask was placed on receiving platform and filled in with 4% boric acid (H_3BO_3) along with indicator and then added into receiver solution tank. The digestion tube containing diluted digest were attached to distillation unit and the sample were distilled for 5 minutes. Steam distillates which are green in colour were collected and receiving flask are removed from the unit for titration process.

3.4.3.3 Titration

The H_3BO_3 receiving solution was titrated with standard 0.1M HCl to each light pink colorization end point. The volume of HCl used for the titration was recorded and CP was determined as follow:

$$N\ (\%) = \frac{[V - V(blank)]\ \times n\ \times 14.007}{W} \quad (3.4c)$$

Where V-Volume of acid neutralized sample (ml), n-Concentration of HCl, W- Weight of sample (mg)

$$CP\ (\%) = N\ (\%) \times 6.2 \quad (3.4d)$$

3.4.4 Crude Fibre (CF)

Crude fibre analysis was done using Fibre bag system. Fibre bags were prepared by drying for 1 hour at 105^{o}C and allowed to cool on desiccator for 30 minutes. The weights were recorded denote as M1. Approximately 1 g of samples are weighed into fibre bags then inserted in glass spacers and denoted as M2. Fibre bags with glass spacers that contained the samples were inserted to carousel. The samples were washed in petroleum ether 40/60 cold to de-fatting the samples and allowed to dry for 2 minutes.

In second step, washing procedure that consist of two phases were involved. In both phases, the samples were boiled for 30 minutes after start of boiling with 0.13 mole H_2SO_4 and 0.313 mole NaOH in phase 1 and 2 respectively. Phase 1 is to remove the acid while phase 2 aims at removing alkali. The samples were washed with hot water for three times after boiling in both phrase.

The fibre bags were removed from carousel and dried at 105°C for 4 hours and then placed in desiccator for 20 minutes to cool after the washing procedure. The fibre bags were weighed with incinerating crucible and the weight were denoted as m3. The empty incinerating crucible and incinerating crucible with empty fibre bags as blank were weighted and the weights are denoted as M6 and M5 respectively. The fibre bags were heated at 600°C for 4 hours in the furnace followed by cooling in the desiccator for 30 minutes. The crucible containing ash was weighted and the weight was denoted as M4. The CF (%) was determined based on the following formula:

$$CF\ (\%) = \frac{(m3 - m1 - m4 - m5) - Blank\ Value\ \times 100}{m2} \qquad (3.4e)$$

Where m1- Fibre bag (g), m2-Initial sample weight (g), m3- Incinerating crucible and dried fibre bag after digestion (g), m4- Incinerating crucible and ash, m5- Blank value of the empty fibre bag (g)

$$Blank\ value = (m7 - m6) \qquad (3.4f)$$

Where m6- Incinerating crucible (g), m7- Incinerating crucible and ash of the empty fibre bag (g)

3.4.4 Ether Extract (EE)

The equipment used for this method was FOSS Soxtec 2055 Fat Extraction System. The aluminium cups were heated at $103^{o}C$ for 30 minutes and allowed to cool in desiccator for 20 minutes. The initial weight of cups were recorded and denoted as W1. Approximately 1g of samples were weighed into the thimbles and the weight was denoted as W2. A layer of de-fatted cotton was placed on top of each sample. The thimbles were then inserted to the extraction unknit by attaching them to the magnets. The aluminium cups were filled with 80mL petroleum ether and placed in extraction unit. The samples undergo the immersion, rinsing and recovery during the extraction process. After the completion of the extraction process the cup was heated in oven at $103^{o}C$ for 30 minutes and cold in desiccator for 20 minutes. The final weight was recorded as W3. Ether extract was determined as follow:

$$EE\ (\%) = \frac{W3 - W1}{W2} \times 100 \qquad (3.4g)$$

Where W1- Weight of empty aluminium cup(g), W2- Weight of sample (g), W3- Weight of residue after extraction(g)

3.5 Calculation of NFE, TDN and ME

Value of NFE was calculated using equation 3.5a

$$NFE = 100\% - CP\% - CF\% - EE\% - ash\% \quad 3.5a$$

The TDN and ME value has been calculated using equation 3.5b and 3.5c respectively.

$$TDN = 5.31 + 0.412\ CP + 0.249\ CF + 1.444\ EE + 0.937\ NFE \quad 3.5b$$

$$ME = 0.185\ TDN - 1.89 \quad 3.5c$$

3.6 Formulation of mTMR

The mTMR was formulated based on goat body weight requirement. The system used in formulating this mTMR was Feed Formulation Software Dssmardi (MARDI, Malaysia). The mTMR followed the goat requirement as stated in Table 3.1

Table 3.1: Goat nutrient requirement

Category	Body Weight	Production System	Total ME (MJ/day)	Total TDN (g/day)	Total CP (g/day)	Total Ca (g/day)	Total P (g/day)	DMI (kg)	DMI (% BW)
Meat Goat	30.00	Intensive	8.16	540.25	101.12	3.31	2.39	0.83	2.77

Source: National Research Council ,2007

Notes: ME- Metabolise Energy, TDN-Total Digestible Nutrient, CP-Crude Protein, Ca-Calcium, P-Phosphorus, DMI-Dry Matter Intake, BW-Body Weight

3.7 Cost Ratio

Cost ratio was calculated based on the following formula

$$\text{Cost/kg of mTMR} = \frac{Total\ cost\ feedstuff\ of\ mTMR\ (RM)}{Total\ weight\ of\ ingredients\ used\ (kg)} \qquad (3.7)$$

3.8 Statistical Analysis

All data generated were analysed using IBM SPSS version 23 (2015). If there were significant differences between treatments ($p<0.05$), the data were compared using Duncan Multiple Range Test (DMRT).

CHAPTER 4

RESULT AND DISCUSSION

4.1 Chemical Composition of Feedstuffs

There were variations of nutritional content in feedstuffs. The chemical composition of feedstuff used for the preparation of mTMR is given in Table 4.1. There are three replication of each feedstuff used in this project. The result shows that the DM(%) of commercial goat pellet (91.07±0.49) was significantly higher ($p<0.05$) than coconut meat waste (10.90±0.52), Moringa (24.60±0.14) and Napier (18.80±1.40). Ash content(%) in Moringa (10.67±0.030) and commercial goat pellet (10.60±0.74) were significantly higher ($p<0.05$) than Napier (5.60±0.15) and coconut meat waste (1.17±0.03).

The ash value of the Moringa in this study was higher than the values reported by Ogbe and John (2012) and Sodamade, Bolaji and Adeboye (2013). They reported that ash values of 7.93% and 6.00%, respectively. The value obtained in this study was slightly higher (10.67%). Higher CP content (%) was recorded in Moringa (20.30±0.42) compared to Napier grass (13.33±1.56), commercial goat pellet (10.23±2.04) and coconut meat waste (5.17±1.82). Crude fibre content (%) in coconut meat waste (51.47±3.75) was significantly higher ($p<0.05$) than Napier (33.33±1.56). Same to EE content (%) in coconut meat waste (26.97±0.39) was significantly higher than commercial goat pellet (6.60±0.04).

The CP value reported by Sodamade, Bolaji and Adeboye (2013) was higher (39.13%) than the value obtained in this study (20.30%). However, Ogbe and John (2012) reported lower value (17.01%). Moringa leaves are usually considered as source of protein. However, the protein content range from 15% to more than 30% DM as it depends on the stage of maturity and on the fodder's respective proportions of leaflets, petioles and stems, the latter being much poorer in protein (Ogbe and John, 2012). Likewise, the fibre content of moringa leaves reported in the literature is extremely variable, with an ADF content ranging from 8% to more than 30% DM.

The respective value for TDN in commercial goat pellet (74.91±0.98) and coconut meat waste (73.56±0.49) were higher than in Napier (65.10±0.47) and Moringa (65.02±2.23). The ME content (MJ/kgDM) in commercial goat pellet (11.97±0.04) and coconut meat waste (11.72±0.22) were also higher than Napier (10.15±0.13) and Moringa (10.14±0.28).

Amount of Ca content (%) in Moringa (1.91±0.02) was significantly higher($p<0.05$) than commercial goat pellet (0.80±0.02), Napier (0.49±0.02) and coconut meat waste (0.80±0.02). Phosphorus content (%) in Moringa (0.97±0.04) was significantly higher ($p<0.05$) than coconut meat waste (0.65±0.03), commercial goat pellet (0.40±0.07) and Napier (0.17±0.01).

Moringa leaves contain high levels minerals (about 10% DM), particularly Ca and Fe. Moringa leaves contain high amounts of a wide range of vitamins (ß-caroten, ascorbic acid, vitamin B1, B6 and niacin (Yang et al., 2006).

Table 4.1: Chemical composition ±SE of ingredients of mTMR

Variables	**Ingredients**			
	Moringa	**Napier**	**Commercial goat pellet**	**Coconut Meat Waste**
DM (%)	24.60±0.14[b]	18.80±1.40[a]	91.07±0.49[d]	70.90±0.52[c]
Ash(%)	10.67±0.03[c]	5.60±0.15[b]	10.60±0.74[c]	1.17±0.03[a]
CP(%)	20.30±0.42[c]	13.33±0.09[b]	10.23±2.04[a,b]	5.17±1.82[a]
CF(%)	22.40±5.19[a,b]	33.33±1.56[b]	17.63±0.31[a]	51.47±3.75[c]
EE(%)	4.10±0.75 [b,c]	2.50±0.51[a]	6.60±0.04[a,b]	26.97±0.39[c]
TDN (g)	65.02±2.23[a]	65.10±0.47[a]	74.91±0.98[b]	73.56±0.49[b]
ME (MJ/kgDM)	10.14±0.28[a]	10.15±0.13[a]	11.97±0.04[b]	11.72±0.22[b]
Ca (g)	1.91±0.02[d]	0.49±0.02[b]	0.80±0.02[c]	0.17±0.01[a]
P(g)	0.97±0.04[d]	0.17±0.01[a]	0.40±0.07[b]	0.65±0.03[c]

Note: SE-Standard Error, mTMR- Moringa based total mixed ration, DM- Dry matter, CP-Crude protein, CF-Crude Fibre, EE- Ether Extract, TDN-Total digestible nutrients, ME-Metabolise energy, Ca-Calcium, P-Phosphorus

4.2 Formulation of mTMR

Table 4.2 shows the amount of feedstuff that are needed in mTMR formulation based on requirement of 30kg of maintenance goat weight using Feed Formulation Software Dssmardi (MARDI, Malaysia).

Table 4.2: Amount nutrient formulated in mTMR based on goat requirement

Elements	Goat Requirement	Formulated
TDN (g/d)	540.25	570.46
ME (MJ/d)	8.16	8.99
CP(g/d)	101.12	109.30
Ca (g/d)	3.31	7.59
P(g/d)	2.39	4.58
DMI (kg/d)	0.83	0.83
Ca/P	1.38	1.66

Notes: mTMR- Moringa based total mixed ration, DMI- Dry Matter Intake, CP- Crude protein, TDN-Total digestible nutrients, ME-Metabolise energy, Ca-Calcium, P-Phosphorus

Table 4.3 shows the amount of nutrient in feedstuff in formulation of mTMR to the percentage of diet ratio.

Table 4.3: Amount of nutrient in formulation mTMR

	Mixing (% in feed)	Diet(%)	ME (MJ)	TDN (g)	CP(g)	Ca(g)	P(g)	DMI (kg)
Moringa	36.77	30	2.53	161.90	50.55	4.76	2.42	0.25
Napier	48.11	30	2.53	162.10	33.19	1.22	0.42	0.25
Commercial goat pellet	6.62	20	1.99	124.35	16.98	1.33	0.66	0.17
Coconut meat waste	8.50	20	1.95	122.11	8.58	0.28	1.08	0.17
TOTAL	**100.00**	**100**	**8.99**	**570.46**	**109.30**	**7.59**	**4.58**	**0.83**

Notes: mTMR- Moringa based total mixed ration, DMI- Dry Matter Intake, CP- Crude protein, TDN-Total digestible nutrients, ME-Metabolise energy, Ca-Calcium, P-Phosphorus

4.3 Chemical Composition of mTMR

Chemical composition of mTMR shown in Table 4.4. The respective values for mTMR were 56.65±0.24% DM, 15.97±0.14% ash, 12.30±0.28% CP, 23.92±0.49% CF and 8.42±0.17% EE. Amount of TDN (g) and ME (MJ/kgDM) in mTMR was 66.33±0.34 and 10.38±0.06 respectively. The mTMR contained 0.94±0.03% Ca and 0.55±0.01% P.

The mTMR was examined to identify the difference between formulated mTMR and the actual amount of element in mTMR. The amount of CP in mTMR was lower than calculated. Experimental result shows that amount of CP in mTMR was 12.30% while the calculated amount of CP in formulated mTMR was 13.17%.

Amount of DM was formulated based on body weight. According to the nutritional requirement for 30kg maintenance goat by NRC, they need 2.8% of DM from their body weight. So that, the DM in mTMR was only 0.84kg.

Amount of TDN in formulated mTMR was 68.93% higher than actual amount which is 66.33%. Metabolisable energy in actual was slightly difference compared to formulated mTMR. In actual, the amount of ME in mTMR was 10.38 MJ/kgDM while formulated was 10.83 MJ/kgDM.

Table 4.4: Replication of chemical composition ±SE of mTMR

Variables	mTMR			
	Replication 1	**Replication 2**	**Replication 3**	**Average**
DM(%)	56.0673	57.0087	56.8746	56.65±0.24
Ash(%)	16.1656	15.6272	16.1125	15.97±0.14
CP(%)	12.5843	12.6875	11.625	12.30±0.28
CF(%)	24.87	22.82	24.07	23.92±0.49
EE(%)	8.01	8.59	8.65	8.42±0.17
TDN(g)	65.58	66.38	67.03	66.33±0.34
ME(MJ/kgDM)	10.24	10.39	10.51	10.38±0.06
Ca (g)	0.95	0.89	0.98	0.94±003
P (g)	0.57	0.52	0.55	0.55±0.01

Notes: SE-Standard Error, mTMR- Moringa based total mixed ration, DM- Dry matter, CP- Crude protein, CF-Crude Fibre, EE- Ether Extract, TDN-Total digestible nutrients, ME-Metabolise energy, Ca-Calcium, P-Phosphorus

Table 4.5 shows the comparison of chemical composition between mTMR and basal diet of local farm from Yusuf EcoFarm, Kemahang, Tanah Merah, Kelantan.

Table 4.5: The comparison of chemical composition ±SE between mTMR and basal diet of local farm.

Variables	mTMR	Basal Diet (Mira,2017)	
		Napier Grass	Commercial Goat Pellet
DM(%)	56.65±0.24	16.09±0.01	91.19±0.08
Ash (%)	15.97±0.14	5.33±0.01	7.19±0.05
CP (%)	12.30±0.28	15.54±0.05	17.13±0.74
CF (%)	23.92±0.49	33.26±0.09	20.07±0.33
EE (%)	8.42±0.17	2.44±0.08	3.33±0.10
Ca (g)	0.94±003	0.40±0.002	3.86±0.006

Notes: SE-Standard Error, mTMR- Moringa based total mixed ration, DM- Dry matter, CP- Crude protein, CF-Crude Fibre, EE- Ether Extract, Ca-Calcium

4.4 Production Cost

Table 4.6 shows the cost of ingredients used in mTMR formulation and their cost per production for 30kg goat. In this study, higher feed cost was recorded in mTMR formulation compare to commercial feed. This was due to the unpopular use of Moringa as feedstuff in Malaysia, so that the price of Moringa is higher among other feedstuff. However, the Moringa cost can be reduced if the farmers plant the Moringa tree at farm area. Moringa tree takes 8 months of period to be matures before can be harvested for the first time. After that, it can be harvested for every 40 to 50 days (Makkar, 2012).

Table 4.6 Production cost (RM) of mTMR

Feedstuffs	Cost (RM/kg)	Weight of ingredient used/ 30kg of goat weight(g)	Cost (RM/30kg goat weight)
Moringa	6.00	1012.20	6.07
Napier	0.50	1324.47	0.66
Commercial goat pellet	0.97	182.28	0.18
Coconut meat waste	0.20	234.13	0.05
TOTAL		**2753.08**	**6.96**

Notes: mTMR- Moringa based total mixed ration

$$\text{Cost/kg of mTMR} = \frac{Total\ cost\ feedstuff\ of\ mTMR\ (RM)}{Total\ weight\ of\ ingredients\ used\ (kg)}$$

$$= \frac{6.96}{2.753}$$

= RM 2.53

CHAPTER 5

CONCLUSION AND RECOMMENDATION

In conclusion, the formulation of mTMR are enriched with nutrient that are required by the goat. The formulation follows the basic requirement of forage to concentrate ratio (60:40). Most of the mTMR ingredients in this study were easy to find and fulfill the goat nutritional requirement. Feeds would be more efficient if we mix together than separately because goats are choosy. Hence, TMR is more appropriate as a feed formulation for goats.

In future, the formulation of mTMR will be variously formulate based on requirement for different production stage like pre-weaning, late gestation and lactating. The feeding trials experiment must be done to know the effectiveness and cost benefit ratio of mTMR to the goat.

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APPENDIX A

Figure A1: Ingredients for mTMR

(A)

(B)

(C)

(D)

Notes: (A) Chopped Napier (B) Fresh Moringa (C) Dried coconut meal waste (D) Commercial goat pellet

Figure A2: Sample Preparation

(A)

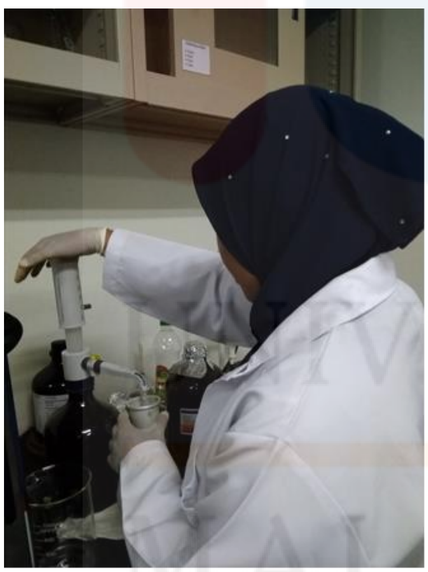
Notes: (A) Grinded Samples in air tight container

APPENDIX B

Figure B1: Chemical Analysis (Ash and EE)

(A)

(B)



(C)

(D)

Notes: (A) Weighted Sample For Ash Analysis (B) Sample in The Furnace for Ash Burning (C) Measuring The Petroleum Ether into Aluminium Cup for EE Analysis (D) FOSS Soxtec 2055 Fat Extraction System Machine

Figure B2 : Chemical Analysis (Crude Protein)

(A)

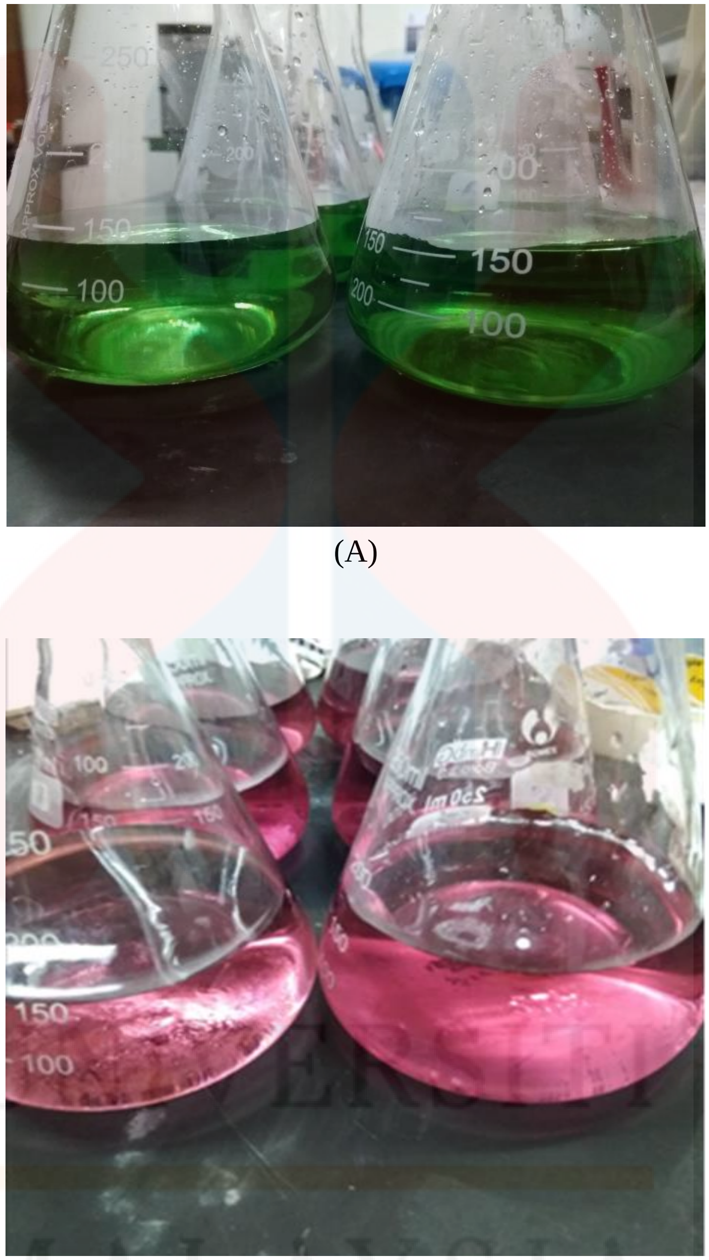
(B)

(C)

(D)

Notes: (A) Kjedhal Tablet (B) Titration of Crude Protein (C) Digestion of sample (D) Distillation of the sample

Figure B3 : Chemical Analysis (Titration of Crude Protein)



(A)

(B)

Notes: (A) The H_3BO_3 Receiving solution (B) Pink Colorization End Point

Figure B4: Chemical Analysis (Crude Fibre)

(A)

(B)

Notes: (A) Defatting Sample with Petroleum Ether (B) Step of Boiling Process using Acid and Alkali

APPENDIX C

Figure C1: The mTMR

(A)

Notes: (A) A formulated mTMR

APPENDIX D

Figure D1: SPSS Data Analysis of mTMR ingredients (General Linear Model)

Between-Subjects Factors

		Value Label	N
SAMPLE	1.00	NAPIER	3
	2.00	MORINGA	3
	3.00	PELLET	3
	4.00	COCONUT	3

Descriptive Statistics

	SAMPLE	Mean	Std. Deviation	N
DM	NAPIER	18.8000	2.42487	3
	MORINGA	24.6000	.30000	3
	PELLET	91.0667	1.04083	3
	COCONUT	70.9000	1.11355	3
	Total	51.3417	31.93833	12
CP	NAPIER	13.3333	.15275	3
	MORINGA	20.3000	.88882	3
	PELLET	10.2333	4.33859	3
	COCONUT	5.1667	3.85270	3
	Total	12.2583	6.24943	12
EE	NAPIER	2.5000	.88882	3
	MORINGA	4.1000	1.58745	3
	PELLET	6.6000	.10000	3
	COCONUT	26.9667	.83865	3
	Total	10.0417	10.35501	12
CF	NAPIER	33.3000	2.69629	3
	MORINGA	22.4000	10.99955	3
	PELLET	17.6333	.66583	3
	COCONUT	51.4667	7.96074	3
	Total	31.2000	14.81424	12
ASH	NAPIER	5.6000	.26458	3
	MORINGA	10.6667	.05774	3
	PELLET	10.6000	1.56205	3

	COCONUT	1.1667	.05774	3
	Total	7.0083	4.18014	12
CARBOHYDRATE	NAPIER	45.2667	3.44867	3
	MORINGA	42.5333	12.19030	3
	PELLET	54.9333	2.87460	3
	COCONUT	15.2333	3.95517	3
	Total	39.4917	16.45199	12
TDN	NAPIER	65.1000	.81627	3
	MORINGA	65.0200	4.74446	3
	PELLET	74.9100	2.07082	3
	COCONUT	73.8733	1.01204	3
	Total	69.7258	5.39224	12
ME	NAPIER	10.1500	.22338	3
	MORINGA	10.1400	.58592	3
	PELLET	11.9667	.08386	3
	COCONUT	11.7200	.46605	3
	Total	10.9942	.95247	12
CA	NAPIER	.4900	.02646	3
	MORINGA	1.9100	.04583	3
	PELLET	.8000	.05000	3
	COCONUT	.1700	.01732	3
	Total	.8425	.68522	12
P	NAPIER	.1700	.01732	3
	MORINGA	.9700	.08888	3
	PELLET	.4000	.14731	3
	COCONUT	.6500	.07211	3
	Total	.5475	.32051	12

Multivariate Tests[a]

Effect		Value	F	Hypothesis df	Error df	Sig.
Intercept	Pillai's Trace	1.000	1589.055[b]	8.000	1.000	.019
	Wilks' Lambda	.000	1589.055[b]	8.000	1.000	.019
	Hotelling's Trace	12712.443	1589.055[b]	8.000	1.000	.019
	Roy's Largest Root	12712.443	1589.055[b]	8.000	1.000	.019
SAMPLE	Pillai's Trace	2.997	405.801	24.000	9.000	.000
	Wilks' Lambda	.000	246.994	24.000	3.502	.000
	Hotelling's Trace	.	.	24.000	.	.
	Roy's Largest Root	3546.640	1329.990[c]	8.000	3.000	.000

a. Design: Intercept + SAMPLE

b. Exact statistic

c. The statistic is an upper bound on F that yields a lower bound on the significance level.

Tests of Between-Subjects Effects

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	DM	11204.043[a]	3	3734.681	1801.293	.000
	CP	360.649[b]	3	120.216	13.946	.002
	EE	1171.442[c]	3	390.481	388.216	.000
	CF	2029.927[d]	3	676.642	14.091	.001
	ASH	187.176[e]	3	62.392	99.166	.000
	CARBOHYDRATE	2608.543[f]	3	869.514	18.861	.001
	TDN	262.862[g]	3	87.621	12.302	.002
	ME	8.744[h]	3	2.915	18.883	.001
	CA	5.154[i]	3	1.718	1227.054	.000
	P	1.060[j]	3	.353	40.259	.000
Intercept	DM	31631.601	1	31631.601	15256.399	.000
	CP	1803.201	1	1803.201	209.188	.000
	EE	1210.021	1	1210.021	1203.003	.000
	CF	11681.280	1	11681.280	243.263	.000
	ASH	589.401	1	589.401	936.796	.000
	CARBOHYDRATE	18715.101	1	18715.101	405.960	.000
	TDN	58340.302	1	58340.302	8191.351	.000

	ME	1450.460	1	1450.460	9396.709	.000
	CA	8.518	1	8.518	6084.054	.000
	P	3.597	1	3.597	409.923	.000
SAMPLE	DM	11204.042	3	3734.681	1801.293	.000
	CP	360.649	3	120.216	13.946	.002
	EE	1171.442	3	390.481	388.216	.000
	CF	2029.927	3	676.642	14.091	.001
	ASH	187.176	3	62.392	99.166	.000
	CARBOHYDRATE	2608.543	3	869.514	18.861	.001
	TDN	262.862	3	87.621	12.302	.002
	ME	8.744	3	2.915	18.883	.001
	CA	5.154	3	1.718	1227.054	.000
	P	1.060	3	.353	40.259	.000
Error	DM	16.587	8	2.073		
	CP	68.960	8	8.620		
	EE	8.047	8	1.006		
	CF	384.153	8	48.019		
	ASH	5.033	8	.629		
	CARBOHYDRATE	368.807	8	46.101		
	TDN	56.977	8	7.122		
	ME	1.235	8	.154		
	CA	.011	8	.001		
	P	.070	8	.009		
Total	DM	42852.230	12			
	CP	2232.810	12			
	EE	2389.510	12			
	CF	14095.360	12			
	ASH	781.610	12			
	CARBOHYDRATE	21692.450	12			
	TDN	58660.141	12			
	ME	1460.440	12			
	CA	13.683	12			
	P	4.727	12			
Corrected Total	DM	11220.629	11			
	CP	429.609	11			
	EE	1179.489	11			
	CF	2414.080	11			
	ASH	192.209	11			
	CARBOHYDRATE	2977.349	11			

	TDN	319.839	11			
	ME	9.979	11			
	CA	5.165	11			
	P	1.130	11			

a. R Squared = .999 (Adjusted R Squared = .998)

b. R Squared = .839 (Adjusted R Squared = .779)

c. R Squared = .993 (Adjusted R Squared = .991)

d. R Squared = .841 (Adjusted R Squared = .781)

e. R Squared = .974 (Adjusted R Squared = .964)

f. R Squared = .876 (Adjusted R Squared = .830)

g. R Squared = .822 (Adjusted R Squared = .755)

h. R Squared = .876 (Adjusted R Squared = .830)

i. R Squared = .998 (Adjusted R Squared = .997)

j. R Squared = .938 (Adjusted R Squared = .915)

Grand Mean

Dependent Variable	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
DM	51.342	.416	50.383	52.300
CP	12.258	.848	10.304	14.213
EE	10.042	.290	9.374	10.709
CF	31.200	2.000	26.587	35.813
ASH	7.008	.229	6.480	7.536
CARBOHYDRATE	39.492	1.960	34.972	44.012
TDN	69.726	.770	67.949	71.502
ME	10.994	.113	10.733	11.256
CA	.843	.011	.818	.867
P	.548	.027	.485	.610

Figure D2: SPSS Data Analysis of mTMR ingredients (Post Hoc Test)

DM

Duncan

SAMPLE	N	Subset			
		1	2	3	4
NAPIER	3	18.8000			
MORINGA	3		24.6000		
COCONUT	3			70.9000	
PELLET	3				91.0667
Sig.		1.000	1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed.

Based on observed means.

The error term is Mean Square(Error) = 2.073.

a. Uses Harmonic Mean Sample Size = 3.000.

b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

c. Alpha = .05.

ASH

Duncan

SAMPLE	N	Subset		
		1	2	3
COCONUT	3	1.1667		
NAPIER	3		5.6000	
PELLET	3			10.6000
MORINGA	3			10.6667
Sig.		1.000	1.000	.921

Means for groups in homogeneous subsets are displayed.

Based on observed means.

The error term is Mean Square(Error) = .629.

a. Uses Harmonic Mean Sample Size = 3.000.

b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

c. Alpha = .05.

CP

Duncan

SAMPLE	N	Subset		
		1	2	3
COCONUT	3	5.1667		
PELLET	3	10.2333	10.2333	
NAPIER	3		13.3333	
MORINGA	3			20.3000
Sig.		.067	.232	1.000

Means for groups in homogeneous subsets are displayed.

Based on observed means.

The error term is Mean Square(Error) = 8.620.

a. Uses Harmonic Mean Sample Size = 3.000.

b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

c. Alpha = .05.

CF

Duncan

SAMPLE	N	Subset		
		1	2	3
PELLET	3	17.6333		
MORINGA	3	22.4000	22.4000	
NAPIER	3		33.3000	
COCONUT	3			51.4667
Sig.		.424	.090	1.000

Means for groups in homogeneous subsets are displayed.

Based on observed means.

The error term is Mean Square(Error) = 48.019.

a. Uses Harmonic Mean Sample Size = 3.000.

b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

c. Alpha = .05.

EE

Duncan

SAMPLE	N	Subset		
		1	2	3
NAPIER	3	2.5000		
MORINGA	3	4.1000		
PELLET	3		6.6000	
COCONUT	3			26.9667
Sig.		.086	1.000	1.000

Means for groups in homogeneous subsets are displayed.

Based on observed means.

The error term is Mean Square(Error) = 1.006.

a. Uses Harmonic Mean Sample Size = 3.000.

b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

c. Alpha = .05.

CARBOHYDRATE

Duncan

SAMPLE	N	Subset	
		1	2
COCONUT	3	15.2333	
MORINGA	3		42.5333
NAPIER	3		45.2667
PELLET	3		54.9333
Sig.		1.000	.064

Means for groups in homogeneous subsets are displayed.

Based on observed means.

The error term is Mean Square(Error) = 46.101.

a. Uses Harmonic Mean Sample Size = 3.000.

b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

c. Alpha = .05.

TDN

Duncan

SAMPLE	N	Subset	
		1	2
MORINGA	3	65.0200	
NAPIER	3	65.1000	
COCONUT	3		73.8733
PELLET	3		74.9100
Sig.		.972	.647

Means for groups in homogeneous subsets are displayed.

Based on observed means.

The error term is Mean Square(Error) = 7.122.

a. Uses Harmonic Mean Sample Size = 3.000.

b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

c. Alpha = .05.

ME

Duncan

SAMPLE	N	Subset	
		1	2
MORINGA	3	10.1400	
NAPIER	3	10.1500	
COCONUT	3		11.7200
PELLET	3		11.9667
Sig.		.976	.464

Means for groups in homogeneous subsets are displayed.

Based on observed means.

The error term is Mean Square(Error) = .154.

a. Uses Harmonic Mean Sample Size = 3.000.

b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

c. Alpha = .05.

CA

Duncan

SAMPLE	N	Subset			
		1	2	3	4
COCONUT	3	.1700			
NAPIER	3		.4900		
PELLET	3			.8000	
MORINGA	3				1.9100
Sig.		1.000	1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed.

Based on observed means.

The error term is Mean Square(Error) = .001.

a. Uses Harmonic Mean Sample Size = 3.000.

b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

c. Alpha = .05.

P

Duncan

SAMPLE	N	Subset			
		1	2	3	4
NAPIER	3	.1700			
PELLET	3		.4000		
COCONUT	3			.6500	
MORINGA	3				.9700
Sig.		1.000	1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed.

Based on observed means.

The error term is Mean Square(Error) = .009.

a. Uses Harmonic Mean Sample Size = 3.000.

b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

c. Alpha = .05.

APPENDIX E

Figure E1: SPSS Data Analysis of mTMR (General Linear Model)

Warnings

Post hoc tests are not performed for Sample because there are fewer than three groups.

Descriptive Statistics

	Sample	Mean	Std. Deviation	N
DM	1.00	56.6502	.50924	3
	Total	56.6502	.50924	3
CP	1.00	12.2989	.58592	3
	Total	12.2989	.58592	3
EE	1.00	8.4167	.35346	3
	Total	8.4167	.35346	3
CF	1.00	23.9200	1.03320	3
	Total	23.9200	1.03320	3
Ash	1.00	15.9684	.29671	3
	Total	15.9684	.29671	3
Carbohydrate	1.00	39.3933	.95845	3
	Total	39.3933	.95845	3
TDN	1.00	66.3303	.72677	3
	Total	66.3303	.72677	3
Ca	1.00	.9400	.04583	3
	Total	.9400	.04583	3
ME	1.00	10.3811	.13444	3
	Total	10.3811	.13444	3
P	1.00	.5467	.02517	3
	Total	.5467	.02517	3

Multivariate Tests[a]

Effect		Value	F	Hypothesis df	Error df	Sig.
Intercept	Pillai's Trace	1.000	11702.757[b]	2.000	1.000	.007
	Wilks' Lambda	.000	11702.757[b]	2.000	1.000	.007

	Hotelling's Trace	23405.515	11702.757[b]	2.000	1.000	.007
	Roy's Largest Root	23405.515	11702.757[b]	2.000	1.000	.007
Sample	Pillai's Trace	.000	.[b]	.000	.000	.
	Wilks' Lambda	1.000	.[b]	.000	1.500	.
	Hotelling's Trace	.000	.[b]	.000	2.000	.
	Roy's Largest Root	.000	.000[b]	2.000	.000	.

a. Design: Intercept + Sample

b. Exact statistic

Tests of Between-Subjects Effects

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	DM	.000[a]	0	.	.	.
	CP	.000[b]	0	.	.	.
	EE	.000[b]	0	.	.	.
	CF	.000[c]	0	.	.	.
	Ash	.000[d]	0	.	.	.
	Carbohydrate	.000[b]	0	.	.	.
	TDN	.000[e]	0	.	.	.
	Ca	.000[f]	0	.	.	.
	ME	.000[b]	0	.	.	.
	P	.000[g]	0	.	.	.
Intercept	DM	9627.735	1	9627.735	37126.136	.000
	CP	453.791	1	453.791	1321.842	.001
	EE	212.521	1	212.521	1701.074	.001
	CF	1716.499	1	1716.499	1607.962	.001
	Ash	764.973	1	764.973	8689.410	.000
	Carbohydrate	4655.504	1	4655.504	5067.859	.000
	TDN	13199.139	1	13199.139	24988.889	.000
	Ca	2.651	1	2.651	1262.286	.001
	ME	323.302	1	323.302	17888.539	.000
	P	.897	1	.897	1415.579	.001
Sample	DM	.000	0	.	.	.
	CP	.000	0	.	.	.
	EE	.000	0	.	.	.
	CF	.000	0	.	.	.
	Ash	.000	0	.	.	.

	Carbohydrate	.000	0	.	.	.
	TDN	.000	0	.	.	.
	Ca	.000	0	.	.	.
	ME	.000	0	.	.	.
	P	.000	0	.	.	.
Error	DM	.519	2	.259		
	CP	.687	2	.343		
	EE	.250	2	.125		
	CF	2.135	2	1.068		
	Ash	.176	2	.088		
	Carbohydrate	1.837	2	.919		
	TDN	1.056	2	.528		
	Ca	.004	2	.002		
	ME	.036	2	.018		
	P	.001	2	.001		
Total	DM	9628.254	3			
	CP	454.478	3			
	EE	212.771	3			
	CF	1718.634	3			
	Ash	765.149	3			
	Carbohydrate	4657.341	3			
	TDN	13200.196	3			
	Ca	2.655	3			
	ME	323.338	3			
	P	.898	3			
Corrected Total	DM	.519	2			
	CP	.687	2			
	EE	.250	2			
	CF	2.135	2			
	Ash	.176	2			
	Carbohydrate	1.837	2			
	TDN	1.056	2			
	Ca	.004	2			
	ME	.036	2			
	P	.001	2			

a. R Squared = .000 (Adjusted R Squared = .000)

b. R Squared = .000 (Adjusted R Squared = .000)

c. R Squared = .000 (Adjusted R Squared = .000)

d. R Squared = .000 (Adjusted R Squared = .000)

e. R Squared = .000 (Adjusted R Squared = .000)

f. R Squared = .000 (Adjusted R Squared = .000)

g. R Squared = .000 (Adjusted R Squared = .000)

Grand Mean

Dependent Variable	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
DM	56.650	.294	55.385	57.915
CP	12.299	.338	10.843	13.754
EE	8.417	.204	7.539	9.295
CF	23.920	.597	21.353	26.487
Ash	15.968	.171	15.231	16.705
Carbohydrate	39.393	.553	37.012	41.774
TDN	66.330	.420	64.525	68.136
Ca	.940	.026	.826	1.054
ME	10.381	.078	10.047	10.715
P	.547	.015	.484	.609