UNIVERSITI
MALAYSIA
KELANTAN

EFFECT OF PELLETING PROCESS ON PROXIMATE ANALYSIS OF TOTAL MIXED RATIONS FOR LACTATING DAIRY GOATS

SITI NURSOLEHAH BINTI ROZAINAL

F18A0226

DR. NOR DINI BINTI RUSLI

BACHELOR OF APPLIED SCIENCE (ANIMAL HUSBANDRY SCIENCE) WITH HONOURS

FACULTY OF AGRO-BASED INDUSTRY
UNIVERSITI MALAYSIA KELANTAN

2022

DECLARATION

I hereby declare that the work embodied in here is the result of my own research except for the excerpt as cited in the references.

……………………….

Student's signature

Student's name : Siti Nursolehah Binti Rozainal

Matric No : F18A0226

Date :

I certify that the report of this final year project title "Effect of Pelleting Process on Proximate Analysis of Total Mixed Rations For Lactating Dairy Goats" by Siti Nursolehah Binti Rozainal, matric number F18A0226 has been examined and all the correction recommended by examiners have been done for the degree of Bachelor of Applied Science (Animal Husbandry Science) with Honours, Faculty of Agro Based Industry, Universiti Malaysia Kelantan.

Verified by:

………………………

Supervisor signature

Supervisor's name : Ts. Dr. Nor Dini Binti Rusli

Stamp :

Date :

ACKNOWLEDGEMENT

I am incredibly grateful to Allah because He ease my Final Year Project (FYP) throughout these 3 months of time. He gave me strength and Riziki to settle my analysis during the peak times, when there were lots of problems happened at the Animal Laboratory. With His permissions, I can finally settle my analysis on time. However, this also would not be possible to achieve if there were no helps from many individuals and organizations. I would like to thank my supervisor, Ts. Dr. Nor Dini Binti Rusli with my deepest and sincere gratitude for her professional guidance and encouragement support. She gave me a great deal of guidance amid the advancing of FYP throughout all the process in this thesis until complete.

I also would like to express my great thankfulness to my friends, Nur Hanis Binti Romli, Khairina Safi Binti Mohd Marzuki, Nur Aqilah Binti Hapiz, and Nur Nazurah Maryam Binti Roslan for helping me from the beginning. To all laboratory assistants in Animal Laboratory and UPKEM, especially En. Suhaimi Bin Omar, I would like to thank all of you for helping me to handle the machine, sharing some knowledge and provide complete equipment to use in the lab. Also, a big thank you to En. Din and En. Bob for helping us to pelletize our pellet at their place.

My gratitude also dedicated to Universiti Malaysia Kelantan Jeli Campus for aiding and guiding in completing the proximate analysis. With this, I managed to run my

FYP systematically. Finally, thank you to my parents for giving me moral, Doas and financial supports to complete this FYP successfully. May Allah bless and shower all of you with Rahmah for helping me throughout this process.

Kesan Proses Pelet ke Atas Analisa Proksimat Jumlah Catuan Ramuan Untuk Kambing Tenusu yang Menyusu

ABSTRAK

Prestasi kambing tenusu yang menyusu boleh ditambah baik dengan memberikan mereka jumlah catuan campuran (TMR), kerana ia menyediakan nutrisi yang seimbang untuk memenuhi keperluan tenaga dan protein untuk kecekapan yang optimum. Walau bagaimanapun, penggunaan TMR perlu dipantau setiap hari disebabkan oleh bahan-bahannya mempunyai kelembapan yang tinggi. Untuk mencegah panas dan kerosakan, TMR dijadikan pelet. Proses pelet boleh mempengaruhi kualiti dan nilai suapan. Oleh itu, kajian ini bertujuan untuk menilai kesan daripada process pelet pada analisa proksimat dan komposisi mineral TMR untuk kambing tenusu yang menyusu. TMR ini diformulasi menggunakan ramuan tempatan yang terdiri daripada serbuk isirung kelapa sawit (PKC), penyulingan asid lemak sawit (PFAD), molase, pra-campuran vitamin/mineral, garam, rumput Napier, hampas soya, serbuk kacang soya, dan natrium bikarbonat sebagai ejen pelekat. Dua bentuk TMR yang berbeza disiasat; TMR konvensional dan TMR dipeletkan. Formulasi pelet TMR ini adalah *isocaloric* dan *isonitrogenous*. Analisa proksimat pelet TMR mempunyai nilai keputusan yang berbeza pada sebelum dam selepas proses pelet. Ini adalah kerana TMR itu telah melalui proses pemanasan semasa proses pelet. Terdapat sedikit perubahan dalam kandungan proksimat TMR. Antara campuran dan TMR yang sudah dipeletkan, tiada perbezaan yang ketara ($p>0.05$) dalam protein kasar, kelembapan, abu, bahan kering dan ekstrak Ether, tetapi ada perbezaan ketara ($p<0.05$) dalam serat kasar. Penemuan hasil kajian dapat membantu menambah baik kualiti dan ketahanan pelet TMR untuk disimpan lebih lama dan pada masa sama untuk mengurangkan kos makanan haiwan.

Kata kunci: Menyusu, Kambing susu, Pelet jumlah catuan campuran, TMR pelet.

Effect of Pelleting Process on Proximate Analysis of Total Mixed Rations for Lactating Dairy Goats

ABSTRACT

Lactating dairy goat performance can be improved by feeding a total mixed ration (TMR), as it provides a nutritionally balanced ration to meet the energy and protein needs for optimum efficiency. However, the use of TMR needs to be monitored daily due to high moisture ingredients. In order to prevent the overheated and spoiled condition, TMR was pelletized. Pelleting process may affect TMR quality and feed value. Therefore, this study aims to evaluate the effect of pelleting process on the proximate and mineral compositions of TMR for lactating dairy goats. The TMR was formulated using local ingredients which consists of palm kernel cake (PKC), PFAD, molasses, vitamin/mineral premix, salt, Napier grass, soy hull, soybean meal and sodium bicarbonate as the binding agent. Two different forms of TMR were investigated; conventional TMR and pelleted TMR. The formulated TMR pellet was isocaloric and isonitrogenous. The proximate analysis of TMR pellet has different value results for before and after pelletizing. This is because the TMR was undergo heating process during pelletizing. There were some changes in the proximate of the TMR. Between mixture and pelleted TMR, there is no significant difference ($p>0.05$) in CP, moisture, ash, DM, and EE, but have significant difference ($p<0.05$) in CF. The current finding may help in improving the quality of the pellets on shelf for a longer period and reduces the feed cost.

Keywords: Lactating, Dairy goat, Total Mixed Ration pellet, TMR pellet.

TABLE OF CONTENTS

LIST OF ABBREVIATIONS

TMR	Total mixed ration
CP	Crude protein
CF	Crude fibre
DM	Dry matter
EE	Ether extract
DMI	Dry matter intake
FCR	Feed conversion ratio
ANOVA	Analysis of variance
PKC	Palm kernel cake
PDI	Pellet durability index
MJ	Megajoules
ME	Metabolisable Energy
TDN	Total digestibility nitrogen
DCF	Digestible crude fibre

LIST OF SYMBOLS

g	Gram
mg	Milligram
kg	Kilogram

LIST OF TABLES & FIGURES

CHAPTER 1

INTRODUCTION

1.1.1 BACKGROUND STUDY

Asia has 146 indigenous goat races, accounting for 26% of the world's goat breeds. Meat races account for around 94 percent of these races, which is consistent with the fact that meat is the most important goat product in every country (Devendra, 2007). Only 13 breeds of milking goats exist in Asia, accounting for around 9% of all breeds. These breeds have low to medium milk content. Many of the "improved breeds" were only used in the nations where they originated. There are also 13 milking goats with various milk outputs (meat and milk). Many of these breeds are still figuring out what they can do. Improvements were made in Asia with higher yields due to the presence of only a few indigenous dairy species that produce limited amounts of milk. Alpine, Anglophone, Saanen, Toggenburg, and Boer are among of the languages spoken. These breeds were created on the fly with indigenous races, resulting in a wide range of results and crossbreds. In Malaysia and Trinidad, for example, crossbreeding with the Anglo-Nubian generation has continuously boosted output up to F2-F3.

This has resulted in an increase in goat farms to meet demand for goat goods such as meat and milk (Derks, 2013). In the last two decades, commercial milk farms have been established in various southeastern Asian nations in response to rising market demand for goat milk (Liang, 2014). Small-scale dairy goat farms in Malaysia help the local market develop dairy production. Import goat feed from another nation, such as Vietnam, to Malaysia. Feed pellets cannot be stored for extended periods of time without spoiling. Because Malaysia is a humid country, pellets can quickly degrade. The moisture concentration of most pellet ingredients is high, causing the pellet to spoil quickly. Although the overheating procedure can assist in reducing pellet moisture content, it also causes poor nutrient content and lowers pellet quality. Pellets of inferior quality will degrade the performance of lactating goats or cause health issues.

Minerals are typically made up of salt, calcium, phosphorus, and trace minerals. Sodium bicarbonate aids in the increase of milk yield and fat content, as well as the reduction of acidosis. Natural sodium bicarbonate is created as they chew natural feed. The sodium cation ($Na+$) and the bicarbonate anion make up sodium bicarbonate (HCO_3-). It is a crystalline white solid that often appears as a fine powder. It has a slightly salty, alkaline flavour. The addition of sodium bicarbonate to the entire mixed ration pellet will aid breastfeeding goat performance while also serving as a low-cost pellet binder. Producers can save money on binding agents, while consumers can benefit from sodium bicarbonate's health benefits. This research done was to evaluate the effect of pelleting process on proximate composition of TMR for lactating dairy goats and also to determine the mineral compositions of TMR pellet with addition of binding agent, which is sodium bicarbonate.

1.2 PROBLEM STATEMENTS

Total mixed ration (TMR) feeding has many advantages over traditional feeding in terms of dry matter consumption, milk yield, and milk composition. However, TMR needs to be monitored daily as it may contain high moisture ingredients. Thus, the feed may get spoiled, and because of the fact, the feed cannot be stored for a longer period of time. The high moisture content of TMR encourages mould and yeast development in the presence of nutrients. As a result of microbial fermentation, the ration can become overheated, and if the process is prolonged for an extended period of time, the ration may spoil. Many nutrients are broken down into undesirable products during the overheating phase. If eaten, overheated feeds can develop an unpleasant taste and flavour that is unsuitable for ruminants, resulting in poor nutrient availability. With the abovementioned problems, a suitable method and strategy for feed processing must be used.

Pelleting is one of the techniques that involve extrusion and compaction processes. Binder has become one of the important parameters in the pelleting technique. The binder should be used in the pelleting to reduce the release of fines during the pelleting process and to improve the strength and shelf-life of pellets. However, the binder would costly and no specific guideline on the use of binder for pelleting process. Since TMR has not yet been pelletized in Malaysia's market before, the optimum techniques in processing the pellets need to be identified. There was limited information on the comparison between extrusion and compaction techniques in making TMR pellets from the local feedstuff. Thus, the current study aims to investigate the use of sodium bicarbonate as a binder in pelleting the TMR. Sodium bicarbonate is widely used as a binder in animal pellet, but not yet being established in the TMR pellet. Poor quality of the pellets will decrease the lactating goat performance.

1.3 OBJECTIVES

1. To formulate and convert the conventional TMR into TMR pellet.
2. To evaluate the effect of pelleting process on proximate composition of TMR for lactating dairy goats.

1.4 HYPOTHESIS

H_o: There is no effect of pelleting process on proximate of TMR for lactating dairy goats.

H_1: There is a significant effect of pelleting process on proximate of TMR for lactating dairy goats.

CHAPTER 2

LITERATURE REVIEW

2.1 LACTATION

Lactation refers to when animals, including humans, produce milk. Goats typically have a 284-day lactation period. Peak production normally happens four to six weeks after the calf is born. To keep their milk production and health, lactating goats should be provided a nutritious diet. Although genetics influence the volume and composition of milk produced, nutrition has a stronger impact. The quality of the breastfeeding goats' nutrition has an impact on birth weight and the survival of their young. Grain blends can be given to lactating goats to augment their diet and provide additional energy and protein. Grain should be fed in moderation because it might cause health issues such indigestion, acidosis, and reduced milk supply. To avoid issues, feed should be supplemented with elements that will assist the nursing goat operate better.

2.2 DAIRY GOAT INDUSTRY IN MALAYSIA

In comparison to other emerging countries such as India, China, Thailand, and Indonesia, Malaysia has a modest goat population. In 2005, Malaysia had a population of 428,263 (about half the population of Montana) people, with around 200,000 of them being smallholder farmers (Aziz, 2007). Malaysia's goat population increased to 439,667 persons in 2015. Although the goat population increased by 2.7 percent, the increase was insignificant, and local demand could not be supplied. As a result, the government encouraged the import of live goats from other countries, and in 2007, 102,445 heads of live imported goats (DVS, 2012) were carried into Malaysia. In 2013, however, the number of surviving goats imported fell to 82,821. (Table 1). This is due to the government's objective of boosting smallholder participation in goat farming to minimise reliance on imports and address the domestic output gap (Jamaluddin, 2012). In comparison to the commercialised pig and poultry industries, the ruminant business, particularly the goat industry, was stagnant and trailing. While the first has acquired domestic autonomy, owing to the private sector's active involvement, the goat industry is still dominated by small-scale farmers. Despite government land development organisations' enthusiasm for growing goat and cattle output in plantation crops, the goat sector is still trailing behind in meeting local demand (Devendra 2007).

Table 1
Information of goats in Malaysia from 2011-2015

Item	2011	2012	2013	2014	2015
Goat population (Number)	479,444	462,510	434,202	429,398	439,667
Recorded slaughter of goats (Number)	37,121	37,653	64,368	67,858	66,466
Imports of live goats (Number)	102,445	110,117	82,821	80,065	50,634
Imports of mutton (Tonne)	17,805	18,007	18,400	22,116	18,143
Local production of mutton (Tonne)	3,091.5	4,806.2	4,688.8	4,546.1	4,367.3

Source: Shahudin (2017)

In 1950, the Saanen, Anglo Nubian, British Alpine, and Jamnapari breeds were imported, and dairy goat production began in Malaysia. The Saanen was the most popular variety, but dual-purpose varieties such as Anglo-Nubian, Boer, Jamnapari, and Shami goats have been available in Malaysia since 2009. In 2009, the Sarawak Agriculture Department imported 115 milking goats, including Saanen, Anglo Nubian, Toggenburg, Australian Brown, and British Alpine varieties, to suit the needs of local dairy goat farmers. There has been no official record of goat milk production and consumption in Malaysia until recently, with cow and buffalo milk continuing to dominate most of the milk production. In 2013, however, 8195 dairy goats were discovered in Peninsular Malaysia, with Johor accounting for half of the milk population (Shanmugavelu & Nizamuddin, 2013). On the local market, fresh goat milk accounts for the majority of dairy goods. Fermented goat milk and goat's milk medications, such as soap and shampoo, are also available. While official data on goat milk in Malaysia is limited, there is a significant increase in demand for goat milk because of increased public health claims.

2.3 ISSUES AND CHALLENGES FACED BY THE FARMERS

The reliance on imported stocks for local demand is one of Malaysia's dairy goat farmers' challenges (Jamaluddin, 2012). To solve the problem, the Jermasia goat breed was created in the 1980s, which is a cross between the German fawn and the Katjang breed. The University of Malaya and the Department of Veterinary Science collaborated on the creation of this dual race (DVS). Nonetheless, a modest number of goats are still insufficient to supply local demand under this initiative. Malaysia's Malaysian Livestock Breeding Policy was created in 2013 to support the growth and sustainability of dairy goat production.

The goal was to make it possible to breed high-quality animals using good genetic concepts and procedures that suit the needs of a profitable and sustainable livestock sector as well as market demands (DVS, 2013). Since then, the DVS has launched a slew of initiatives aimed at boosting the growth of milk goat production. The DVS built the National Boer Breeding Centre (NBBC) in Pondok Tanjung, Perak in 2013 to harness the excellent attributes of the Boer breed, which was selected systemically in South Africa. This centre also provides a systematic breeding programme through the application of breeding technologies, as well as training and incubation programmes, to ensure that technology and knowledge can be passed on to commercial goat farmers and that production quality is consistent.

2.4 FEEDING PROGRAMME

Locally available forage and commercially concentrated feeds are used in the common feeding practice of small farmers in Malaysia. Common forages are Guinea grass, Napier grass and Bracharia, whereas goats are usually fed vegetables species such as Lucaena, Gliricidia, or Mulberry spp (Shanmugavelu & Nizamuddin, 2013). The challenge to maintain a balanced diet during the whole year for animals is the major constraint to developing dairy goat production (Islam, 2000). This is due to lack of weeds, a hot and humid climate, limiting the ability of ruminants to grow quality grass (Rahman, 2015).

To overcome the problem, farmers have been extensively using concentrate (goat pellets) and low quality fodder. Different agro-industry by-products have been used as feed in recent years like palm oil, rice straw and soybean waste. Malaysian annually generates 2 million tons of agro by-products. It was accepted and widely practised by small farmers in Malaysian that agricultural by-products. It was accepted and widely practised by small farmers in Malaysian that agricultural by-products were used as a source of food for animals. The health and productivity of all animals depends on balanced nutrition and is the basis of successful production system. A well-planned preventive health programme with no proper food programme cannot overcome nutritional problems (Hart, 2008). Furthermore, nutrition reflects the total production and profit of a farm as the easiest aspect of farm management (Morand-Fehr, 2005). Goat nutrition is therefore essential for successful production of goat (Abubakr, 2015).

Most farmers have limited knowledge of systemic feeding, which takes all the food requirements necessary based on the goats stage into account (Devendra, 2013). Only 59% of smallholder livestock farmer in Malaysia understand, according to a study by Abdullah (2015), the importance of good livestock feeding. The use in the various stages of goat growth do not include the use and minimization of nutrients, such as protein, carbohydrate and fat. Goats have four stomach compartments, three with microbes that break feed down. The microbes should be supplied with optimum energy, protein, fibre, minerals and vitamins to promote correct fermentation of the stomach. To fulfil the minimum daily requirements, each nutrient should be given in the right proportion. Either percentage or gram per kilogram of the total ration, which includes the minimum daily requirement for each nutrient group, is the basis of the nutrition requirement. Energy and protein are the most important nutrients that goats need to develop new tissues in order to grow or replace tissue (Mowlem, 1992). To increase the quality of the pellet and give benefits to the health of the goats, sodium bicarbonate is the ingredients will be added. This research is to determine which level of the ingredients, soda bicarbonate, needed to make sure the total mixed ration pellet quality can be increased.

2.5 Sodium bicarbonate

Sodium bicarbonate, also known as baking soda or bicarbonate of soda (IUPAC name: sodium hydrogen carbonate), is a chemical compound with the formula $NaHCO_3$. Nahcolite is the natural mineral form. Because it has been around for a long time and is widely used, the salt is known by many different names, including baking soda, bread soda, cooking soda, and bicarbonate of soda. It is one of the E number food additives which is E500. It also can be used as mild disinfectant. Sodium bicarbonate has an inadequate disinfectant properties (Malik & Goyal, 2006, William et al. 2000) and may be effective against some organisms as fungicide (Zamani et. al, 2007).

Baking soda also absorbs musty odours (Altman, 2006). Some mouthwashes contain sodium bicarbonate as an ingredients. It has anti-caries as well as abrasive property (Storehagen et. al, 2003). It cleans the teeth and gums mechanically, neutralises acid production in the mouth, and act as an antiseptic to help prevent infections (Iqbal et. al, 2011). Sodium bicarbonate is used as a ruminant feed supplement, specifically as a rumen buffering agent (Paton et. al, 2006). Baking soda is frequently claimed to be an effective odour remover (Raymond, 2016) and it is frequently recommended to put in the refrigerator to absorb odour (Vicki et. al, 2009).

2.6 Sodium bicarbonate as mild disinfectant

Baking soda has been shown to be virucidal and to inhibit the growth of several fungi, but the mechanism of action is unknown (Palou et. al, 2009, Malik et. al, 2006). It has also been shown to boost the effectiveness of other antifungal agents in controlling mould growth on produce, but its antifungal spectrum may be limited (Palou et. al, 2010, Yao et. al, 2004, Hang et. al, 2003, Wan et. al, 2003, Casals et. al, 2010). Furthermore, given that in a neutral solution the pH of baking soda is balanced at a maximum of around pH 8.34, its pH alone is not sufficient to inhibit the growth of many foodborne microorganisms (Arslan et. al, 2009).

2.7 Total mixed ration

Total mixed ration (TMR) is a way of feeding the lactating goats and cattle. Every cow can consume the nutrient level needed in each bite in order to fuel a TMR diet. Good quality forages, grain balance and protein, vitamins and minerals should include a lactating goat's and cattle's ration. TMR is effective because the feed is balanced and thoroughly mixed at the same time. Goats have a bad custom in what they eat selectively.

This can be a problem, particularly when feed intake falls in summer. The milk yield and quality will be affected by unbalanced nutrient consumption (Food and Fertilizer Technology Centre, 2002). This may lead to problems like subacute ruminal acidosis, also impacts on their neutral detergent fibre (NDF).

Many versions, mostly partial TMR versus complete TMR, were originally produced. Partial TMR was typically used when in the parlour or through separate concentrates feed stations, in group housing and feeding. As described above, several concentrates feeding systems have been developed (Coppock et. al, 1981). A USDA National Animal Health Monitoring System survey (2014) found that nearly neighbouring 90% of large cattle (>500 cows) were TMR-fed compared to <20% for small herds (30-99 cows/herd). Nationally, the trend towards TMR feeding took places step by step instead of immediately.

It's not entirely true that every diet bit is the same with a TMR. The selection of feed components with TMR is considerably minimised but not entirely avoided. When you try resolve a problem of a herd that has a high incidence of some disorder, this aspect of TMR feeding can be valuable. For example, DeVries et al. (2007) reported in an experiment designed to evaluate feed grading that cows adjusted their grade behaviour quickly if subject to a dietary change and showed more grading for short, NDF and long particulate matter, and physically effective NDF when fed a low-fuel diet.

Each bite is more nutritionally balanced than if it is fed separately. Cows also eat TMR diets slower than they are likely to eat concentricity, and in a short time they can consume only a small amount of concentrate. These factors also relate in part to the number of times fed daily, stocking density, the design of eating barriers (for example, open bunk versus headlocks), and the social behaviour of cows (Huzzey et. al, 2016). Feeding minimises the effects of excess stocking and social dominance of cows more often than when concentrates and forages are fed separately, even though this is less of an issue in TMR feeding.

Research shows that milk production is increased and the efficiency of ME to milk in cows fed TMR is improved in comparison with cows fed dietary components in food (Holter et. al, 1977). Several acid-bound trials have shown that cows can categorize variations in particle size for a minimal acidosis (e.g. Keunen at. al, 2002, DeVries et. al, 2008). In addition, during incidents of and recover from periods of low ruminal pH, TMR plus supplementary long hay may maintain DMI (Keunen et. al, 2002, Kmicikewycz and Heinrichs, 2014). Additional aspects such as particle size, moisture levels, mixing systems, separating of ingredients, and order were used in the use of TMR feeding of adding mixer batch ingredients.

2.8 Pelleting Process

Depending on the feed matter and its moisture content, mouldability was evaluated. When the fathom and protein content was high, the mouldability of each ingredients was excellent, while the hardness following moulding was high when the materials were difficult to mould due to the high fibre content. However, when the combination feed ratio exceeded 90%, hard pellets like wood pellets by denaturation of lignin were not considered to be an easy thing to do. Mouldability was evaluated in the event that humidity content was best suited to the mixing of the mixed feed and hay in 15~25% depending on the feeding material's moisture content. It was not possible to mould with less than 15% of the moisture content and due to the high temperature and feed separation, additional dry pulverisation resulted in dust. Furthermore, because of pellet form and atheroma hardness it was judged that the humidity content of 25% or more was difficult to use.

The shaker box method demonstrates the value of providing enough but not too much larger particles, can suggest over or under mixing, and can reveal nutritional management issues in diets with otherwise appropriate nutrient compositions (Maulfair and Heinrichs, 2013). When dry hay is included in the TMR, this can be a big concern. For example, the shaker box method will help decide how much cutting is required to reduce particles to a size that allows for adequate TMR mixing without causing acidosis

(Keunan et. al, 2002, Kmicikewycz & Heinrichs, 2014), other digestive upsets, or milk fat depression (Bhandari et. al, 2007).

The TMR feeding systems have led to the production of mixer wagons and a number of feeding process factors. Mixing time, ingredient input order and mixer wagon style can become factors. Longer mixing time could reduce particle size to such a degree as to cause milk fat depression and other health problems. The ingredients required in small quantities can cause an uneven distribution of these ingredients (e.g. vitamin or mineral premixes) too early. More heavy and lightweight ingredients sink and float. For example, maize silage is 33% thicker than alfalfa silage when it is applied to feeds, and the mineral mixture may be 2-3 times denser than the protein or kernel mix.

Low density, long particle length ingredients such as hay should generally be added first, followed by small particle size high-density ingredients sinking. The majority of vertical mixer wagons allow the addition of unprocessed hay as the first component, but care should be exercised to ensure that the particle length is not reduces excessively. While horizontal mixers with knives also permit the integration of unprocessed hay, the mixing uniformity can be improved when hay is previously processed.

2.9 Pellet Quality

Physical pellets quality is defined as the capacity of pellets to withstand fragmentation and abrasion while handling them mechanically and pneumatically, with no breakdown or access to feeding stuffs without generating a high percentage of fines (Cramer et. al, 2003, Amerah et. al, 2007). Two phenomenon can lead to the attrition of pellets, namely fragmentation consists of fracturing pellets into less than a fracture zone and fines, while abrasion involves fracture on the edges or particle surface uniformity (Thomas & van der poel, 1996). Pellet durability and pellet hardness parameter can be used to evaluate physical quality of pellets.

Greater durability of the pellets means that until feeding, the pellets most likely will remain intact. Hardness testing is an alternative way to measure pellet breakdown resistance due to pressures in large containers. Hardness is determined by the use of equipment that measures the required pellet crushing force. The "Kahl" device is the most common device for pellet hardness measurement in the industry. A pellet is inserted among two bars in the Kahl device, and the force needed to fragment the pellet is determined by increasing static pressure through the spring (Thomas & van der poel, 1996). Although the overall PDI and pellet hardness improvements are notable for pelleting process manipulations such as increasing temperature conditioning (Abdollahi et. al, 2010b, 2011, 2012a), it was proven in the same direction, by a close review of these data, that the magnitude of improvement in pellet diameter was greater in most of the studies and/or the addition of pellet ties to and/or moisture (Abdollahi et. al, 2012a) and the increased pellet diameter and length (Abdollahi et. al, 2012).

Thus, the effect of various treatments on the ability of pellets to withstand fragmentation can be hypothesised more strongly than the resistance to abrasion. Then it is possible that some manipulations' positive effects on pellet strength as a pellet quality parameter may not be when only the PDI is identified, recognised. Reported various pellet hardness for pellets with similar durability (Parsons et. al, 2006). As pellet quality is generally determined by durability tests in most feed mills, it can be suggested that the measurement of both PDI and pellet hardness should be considered to gain a better understanding of the effects of different handling of physical pellet quality.

2.10 Important Parameters for Pelleting Process

Broiler feed was also most frequently pelleted and exposed to pressure and heat from mixer added exogenous enzymes. Such conditions have often led to denaturation and inactivation of mixer-added exogenous enzymes. The aim of the present experiments was to define the connection among the parameters monitoring during the pelleting process, such as the temperature change between the hot pellets and the conditioned mash

(ΔT), the pellet durable index (PDI), and pellet mill energy consumption (PMEC) and the stability of a mixer-added xylanase throughout the pelleting process.

To produce a range of values for the following values for the following values, ΔT, PDI, and PMEC, diets have been pelleted at a constant temperature of 82℃ with a range of fat concentrations and grades of saturation by two fatty mills with varying length to diameter ratios. As – in relation to unconditioned and conditioned mash – it was found that xylanase recovery in pellet was increased by – in ΔT, PDI, and PMEC (P=0.001). In combination with selected controlled factors, a multiple regression pattern was created if selective parameters were monitored during pelleting.

This data indicated that PDI practises can have a negative impact on the stability of thermosensitive mixer-added exogenous enzymes during the pelleting process and that predictive models can be created to better forecast the effects of feed production to enhance pellet durability. Exogenous enzymes in broiler diets are used regularly, with the most common phytases and non-starch polysaccharide degradation enzymes (Amerah et. al, 2011). The main reason for using feed additives was the increase in feeding value in raw materials by reducing the variability of apparently similar nutrient content. The use of exogenous enzymes has resulted in better efficiency both in flocks and between flocks (Bedford, 2000).

Although they are not fully knowledgeable about all the factors affecting exogenous enzymes efficacy, they have been reasonably successful as additives that reduce feed formula costs and improve animal performance (Cowieson et. al, 2005, Amerah et. al, 2008, Garcia et. al, 2008). While exogene enzymes tend to be more common, a predilection for intensified conditioning is now also becoming common (Cutlip et. al, 2008, Fahrenholz, 2012, Loar et. al, 2014) in order to produce sterile feed for controlling pathogens (Jones et. al, 2004, Doyle and Erickson, 2006). The result was increased time for mash conditioning by means of equipment such as double-sided conditioners and sanitizers, together with the aim of increasing the temperature of mash conditioning.

During the pelleting process a denaturation and loss of function was reported to involve mixer-added exogenous enzymes, which are functional protein. Its denaturation occurred due to exposure to the humid environment, which was a result of pressure and heat (Thomas et. al, 1998). Three levels of control have existed during the pelleting process that have determined enzymes' overall exposure to pelleting conditions. Mash-conditioning room, pellet mill die and pellet cooler were included in the controls (Mascrell and Ryan, 1997).

Loss of enzyme activity in the conditioning chamber, which is frequently reported in previous publications, was principally a consequence of the conditioning temperature and time (Inborr and Bedford, 1994). The most likely effect of pellet cooling was the activity of the enzyme, if all measures were implemented quickly to reduce pellet temperature and humidity. In previous research the die of the pellet mill was little evaluated in terms of enzyme action, which most often places the highest pressure and temperature in the pelleting process.

It was suggested that when trying to model the response from broilers to the feeding of an enzyme, grain type, time and temperature, moisture and age of birds be considered (Amerah et. al, 2011). Other factors, such as feed formulation and pellet mill die specification, can also be considered by current authors to play an important role in the mixing stabilisation of the exogenous enzyme, thus affecting the effectiveness of the enzyme in vivo. In the present experiments, factors were manipulated to create a range of heat and pressure levels that would occur during the pelleting process in the pellet mill with a mixer-added exogenous enzyme. These factors included different concentrations of MAF, MAF sources with different saturation degrees and L: D pellet mills. The purpose of these factors was to set the PDI, ΔT, and PMEC values to evaluate their links with the post-pellet activity of the enzyme.

CHAPTER 3

METHODOLOGY

3.1 Sample Collection

TMR pellet was formulated and prepared at University Malaysia Kelantan animal laboratory. Ingredients used to make TMR pellet was bought in locally in Jeli and Tanah Merah area.

3.2 Sample Preparation

Napier grass and stem were cut into smaller pieces and put in tray. Napier grass and the stem then dried in the oven for 48 hours at 70°C. The dried leaves and stem then grinded using blender and grinder. Other ingredients that need to be powdery were grinded using grinder at animal laboratory. The ingredients then were mixed using mixer and put in a zipper bag for a better storage.

3.3 Experimental design

Two different forms of TMR were investigated; conventional TMR and pelleted TMR. The ingredients of both conventional TMR and pelleted TMR was Napier grass, PKC, soybean meal, soybean hull, molasses, PFAD, mineral premix, salt, and sodium bicarbonate as binding agent.

Table 3.3.1: The Composition of Formulation (%) of Lactating Goat Pellet With 1.5% Sodium Bicarbonate

INGREDIENTS	**CONVENTIONAL TMR (%)**	**TMR PELLET (%)**
Napier grass	59.1	59.1
PKC	8	8
Soybean meal	9.7	9.7
Soybean hull	17.4	17.4
Molasses	2.9	2.9
PFAD	0.9	0.9
Mineral premix	0.3	0.3
Salt	0.2	0.2
Sodium bicarbonate	1.5	1.5
TOTAL	**100**	**100**

3.4 Determination of Proximate Analysis

Proximate analysis is the quantitative analysis of macromolecules in feed. Proximate analysis consist of determination of dry matter, crude protein, ash, crude fibre, crude fat, and moisture content.

3.4.1 Determination of Dry Matter Content

The samples were weighed in the porcelain crucible using balancing scale with four decimal places. The porcelain crucible was weighed first and the weight was recorded. Approximately 1 gram of each of the sample were weighed and put in the crucible. Weight of the sample was recorded. Then, the samples were put into the drying oven for 24 hours at 103°C. After 24 hours, the samples were taken out from the oven and was placed in the desiccator to avoid moisture absorption from the air. Every samples were weighed and the weight was recorded. The determination of dry matter of these samples were known by calculating the value using the formula below:

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

Where,

%DM	=	Percentage of DM
W1	=	Crucible weight (g)
W2	=	Sample weight (g)
W3	=	Final weight (g)

3.4.2 Determination of Ash Content

Clean porcelain crucibles were taken and place in the oven to make sure no moisture in the crucible to avoid false sample. The crucible is dried at 105℃ for 20 minutes. The crucible was put in the desiccator to let it cool down to avoid it from absorbing moisture from the air. The crucible was weighed on the balancing scale. The weight then recorded. Approximately 1g of the sample were taken and weighed in the crucible on the balancing scale. The weight then recorded. The crucible was closed to avoid moisture absorption. The muffle furnace was turned on first. The crucible then was put in the furnace. The temperature was set at 700℃ for 24 hours. After the burning was finished, the crucible was taken out. The power of the furnace was turned off before the crucible was taken out. The crucible then cooled down in the desiccator for 20 minutes. After cooling down, the sample was weighed on the balancing scale. The weight then recorded. The determination of ash content of these samples were known by calculating the value using the formula below:

$$Ash\ \% = \frac{W_2 - W_1}{W_s} \times 100$$

W_1 = Weight of crucible (g)

W_2 = Weight of crucible with ash (g)

Ws = Weight of sample (g)

3.4.3 Determination of Moisture Content

The samples moisture content were determine using MX-50 moisture analyser in UMK Jeli animal laboratory. The weight of the samples were determine based on the table provided in the laboratory. Different sample has different timing and weight needed. Result was displayed on the analyser display screen. The result was recorded.

3.4.5 Determination of Crude Fibre Content

The samples was weighed approximately 1g. For fibre analysis using FOSS – Fiber Analyzer – The Fibertec™ 8000, the laboratory assistant suggest us to use the residue from fat analysis to be used in the machine. This is to avoid fat clogged in the crucible. Approximately 1 scoop of celite powder was put in each crucible. After put in the celite, samples were placed in the crucible. Sulphuric acid and NaOH solution were poured inside a tank in the machine by lab assistant. The machine then run for analysis for 2 hours.

After 2 hours, the crucibles then were put in the oven at 105℃ for another 2 hours. After dried for 2 hours, the crucibles then were taken out from the oven and put in the desiccator for 20 minutes to let it cool down. After 20 minutes, the crucibles then were weighed using a balancing scale, and the weight recorded as initial weight. The crucibles then put in the furnace for 3 hours at 550℃.

After 3 hours, the crucibles were taken out and put in the desiccator to let it cool down for 20 minutes. After 20 minutes, the crucibles then weighed using balancing scale. The weighed of the crucibles were recorded as final weight. The determination of crude fibre content of these samples were known by calculating the value using the formula below:

$$Crude\ fibre\ \% = \frac{W_1 - W_2}{W_s} \times 100$$

W_1	=	Weight of crucible with fibre
W_2	=	Weight of crucible with ash
Ws	=	Weight of sample

3.4.6 Determination of Crude Protein Content

1g of each samples were taken and weighed on the balancing scale. The Kjeldahl flask was labelled with the name of the samples. The samples then put into the Kjeldahl flask. 2 tablets of Kjeldahl catalyst, were put in the flask contained samples. 12ml of concentrated sulphuric acid was measured using 25ml measuring cylinder and put in the samples flask. The flask then shaken gently to mix the acid with the sample and catalyst. After mixing, the flask then placed on the digestion unit carefully. The temperature was set at 400℃ and the samples were digested for 2 to 4 hours. The water circulation pump and fume cupboard was turned on. When the samples colour turned to clear and green colour of the samples, the digestion process was finished. The unit was turned off and the flask let cooled down at room temperature for 45 minutes. 80ml of distilled water was measured using 100ml measuring cylinder and put in the cooled sample flask. Then, 50ml of 10N NaOH measured using 50ml measuring cylinder was poured in the sample flask.

30 ml of 4% boric acid was prepared as receiver and used during distillation. Boric acid preparation was freshly done during the waiting for digestion. 10g of boric acid powder were weighed on balancing scale. 200ml of distilled water were poured in a 500ml beaker. Boric acid powder then put in the 200ml distilled water and was stir using magnetic stirrer on magnetic stirrer hot plate. After the boric acid powder completely diluted, the solution then put in 250ml measuring cylinder and add another 50ml distilled water. 2.5ml bromocresol green and 1.75 methyl red was put in the 4% boric acid solution. Red-pink colour solution was obtained. 30ml of 4% boric acid was measured using 50ml measuring cylinder and poured into each 250ml conical flask. The conical flask then was placed in the distillation unit where the distillate collection was collected. Red-pink solution was changed to green colour solution showed the presence of nitrogen.

0.1N HCl was measured in the burette for titration. After distillation done, the receiver then titrated. The colour changed from green to light pink showed the titration is done. The reading of HCl was taken for calculation. Calculation was performed to calculate the protein content. The determination of crude protein content of these samples were known by calculating the value using the formula below:

$$N\% = \frac{V_1 \times n_1 \times F_1 \times MWn}{Ws \times 10}$$

$$Crude\ protein\ \% = N\% \times Factor \times F_2$$

V_1	=	0.1N HCL volume (titration final reading)
n_1	=	Normality of HCL
F_1	=	Acid factor
MWn	=	Molecular weight of Nitrogen
Ws	=	Sample weight
N%	=	Nitrogen percentage
F_2	=	Dilution factor
Factor	=	Value of the sample tested

3.4.7 Determination of Crude Fat

Approximately 1g of samples were weighed using balancing scale. Small quantity of cotton wool was put in the bottom of the cellulose thimble. 90mm filter papers were rolled into a cone and placed in the cellulose thimble. Weighed samples then were put in each cellulose thimbles and close with small quantity of cotton wool on top of the sample. The thimble then put in the FOSS – Fat Analyzer - ST 255 Soxtec™.

Aluminium cups were dried in the oven at 105℃ for 15 minutes to make sure there is no moisture in the cups. The cups then let cool down in the desiccator for 20 minutes. After 20 minutes, the aluminium cups then weighed using balancing scale and the weight recorded as initial weight. 80ml petroleum ether was pumped into the aluminium cups. The cups then placed in the fat analyser machine after putting the cellulose thimble.

Petroleum ether residue was flushed out first from the machine. The machine then turned on and both gear were moved downward to immerse the thimbles. The machine then was started by pressing the round 'O' button first, until its beeping. After the first beeping, button with clock symbol then was pressed. After 20 minutes, the machine will beeping and the left gear moved 1 level upward. Clock symbol then pressed again, and same method was done. The timer was continue at 15 minutes, 10 minutes and 2 minutes. The gear moved 1 level up every time after beeping.

When the analysis done, right gear then moved upward to bring up the cellulose thimble. Aluminium cups were taken out and put in the oven at 105℃ for 20 minutes. After 20 minutes the aluminium cups put in the desiccator to let it cool down for 20 minutes. The cups then weighed using balancing scales and the weight were recorded as final weigh. The residue of the samples were put in the oven for 30 minutes at 105℃, to let it dry to be used for fibre analysis. Calculation was performed to find the crude fat percentage. The determination of crude fat content of these samples were known by calculating the value using the formula below:

$$Crude\ fat\ \% = \frac{W_2 - W_1}{W_s} \times 100$$

W_s	=	Weight of sample (g)
W_1	=	Weight of aluminium cup (g)
W_2	=	Weight of aluminium cup with fat (g)

CHAPTER 4

RESULT & DISCUSSION

4.1 The TMR Pellet Ingredients

Table 4.1.1 shows the ingredients used in making the TMR pellet. The TMR pellet contain 1.5% sodium bicarbonate as binder. Sodium bicarbonate is one of the binder that can be used in binding pellet.

Table 4.1.1 TMR Pellet Ingredients

Ingredients	Percentage (%)	Weight (kg)
Napier grass	59.1	5.91
PKC	8	0.8
Soybean meal	9.7	0.97
Soybean hull	17.4	1.74
Molasses	2.9	0.29
PFAD	0.9	0.09
Mineral premix	0.3	0.03
Salt	0.2	0.02
Sodium bicarbonate	1.5	0.15

Sodium bentonite is primarily utilised as a pellet binder in poultry feed. It is commonly agreed that a ration containing 1 to 2% sodium bentonite not only serves as a pellet binder but also increases the hardness of pellets (Kurnick and Reid, 1960; Quisenberry and Bradley, 1964; Scott et al., 1976). In this TMR pellet, 1.5% of sodium bicarbonate is used the binder. It is the middle ration value based on a research paper, with range from 0.5% to 2% level of sodium bicarbonate. 1.5% of sodium bicarbonate is the optimum level as the moisture content is the lowest. Other than used as binder, sodium bicarbonate also helps in increasing milk yield, rumen buffering agent and it has also been shown to boost the effectiveness of other antifungal agents in controlling mould growth on produce, but its antifungal spectrum may be limited (Palou et. al, 2010, Yao et. al, 2004, Hang et. al, 2003, Wan et. al, 2003, Casals et. al, 2010). This helps in controlling the spoilage of TMR pellet and can be stored longer.

Pellet integrity can be investigated more fundamentally by looking at particle binding, which can be achieved through solid-solid bonding between diet ingredients particles, the use of liquids (e.g. molasses), or the use of particular pellet binders. Solid-solid interactions between particles, capillary forces in a three-phase system of water, air and solid material, also known as 'liquid necking', adhesive- and cohesive forces between particulates and binders, and interactions between particles due to folding and plying are the general mechanisms for binding feed particles.

Sintering, recrystallization, or crystal growth of some substances, chemical reactions, and melting of thermoplastic materials and then solidifying into a crystalline state are examples of solid-solid interactions (Rumpf, 1958). Bonds between solid-solid contact particles are formed mostly during drying/cooling process, depending on the conditions.

Buffers have not been included to diets comprising other types of forages in any trials. Different outcomes may be obtained using forages or feedstuffs with a high "natural" buffering capacity or finely ground, pelleted forage (Wheeler T. B. et al., 1980). Sodium bicarbonate given to the goats as buffer to avoid acidosis.

4.2 Chemical Composition

Table 4.2.1 shows the chemical composition of the TMR mixture and TMR pellet. After the mixture turned into pellet, the chemical composition definitely will have some difference. There are 6 types of chemical composition that have been analyse and run in the SPSS software. In mixture, the CP is 10.3340, the moisture is 9.84, the ash is 4.9192, the DM is 88.7268, the CF is 23.2561, and the EE is 3.0667. In pellet, the CP is 11.4905, the moisture is 5.9367, the ash is 5.7378, the DM is 88.5021, the CF is 13.9969, and the EE is 4.1067.

Table 4.2.1 Chemical Compositions of TMR Pellet and TMR Mixture Based on Mean±SD

TMR	Proximate Analysis					
	CP (%)	**Moisture (%)**	**Ash (%)**	**DM (%)**	**CF (%)**	**EE (%)**
Pellet	11.4905 ± 1.37	5.9367 ± 0.361	5.7378 ± 2.193	88.5021 ± 7.343	13.9969 ± 0.389	4.1067 ± 4.723
Conventional	10.3340 ± 0.496	9.84 ± 0.113	4.9192 ± 1.149	88.7268 ± 2.662	23.2561 ± 2.135	3.0667 ± 2.077
P value	0.351	0.001	0.758	0.956	0.021	0.804

CP = Crude Protein, DM = Dry Matter, CF = Crude Fibre, EE = Ether Extract (Crude Fat)

There is no significant value in CP, ash, DM, and EE between TMR pellet and mixture, but there is a significant value in moisture and CF ($p<0.05$). The CF in pellet is lower than in mixture.

4.2.1 Crude Protein and Crude Fibre

In this analysis, the crude protein percentage in pellet is higher than in mixture ($p>0.05$), and the crude fibre percentage in pellet is lower than in mixture ($p<0.05$), based on the table above. Peterson RO (1962) discovered that pelleted TMR had a higher crude fibre digestibility (Table 4.4) than non-pelleted rations. Feed processing involves a combination of shear, heat, residence time and water, partial denaturation of the proteins in the feed can occur (Thomas et al., 1998), increasing digestibility (Voragen et al., 1995). Heating enhances protein digestibility by inactivating enzyme inhibitors and denaturing the protein, which may reveal additional enzyme attach sites (Camire et al., 1990).

The aleurone layer of cell walls of cereals, which contains considerable amounts of nutritive components, was available in pellets because the cell walls of feed ingredients were damaged during pelleting. This conclusion is further supported by Saunders et al. (1969) findings. Murdock et al. (1951) found that fine ground dehydrated alfalfa had lower total digestion nitrogen (TDN) and lower crude fibre digestibility than coarse ground dehydrated alfalfa in trials with yearling sheep. They also discovered that when compared to ground dehydrated alfalfa, pelleted dehydrated alfalfa had greater crude fibre and TDN digestibility.

When comparing pelleted feed to loose feed, Luimes P. (2014) discovered that pelleted feed resulted in higher growth in sheep. Neal (1953) investigated the effect of pelleting on low-quality roughage and found that lambs given a pellet consisting of low-quality alfalfa and sorghum grew quicker and efficiently than lambs fed a non-pelleted ration of high-quality alfalfa and sorghum grain. Total live weight increase, daily live weight gain, and food conversion rations (FCR) were substantially greater ($p<0.05$) in the pelleted TMR group than the loose TMR group, indicating efficient feed consumption in the pelleted TMR group (Islam R et al., 2017).

Increased digestibility of feeds through the pelleting process, increased palatability, including more feed consumption and lower energy losses in digestion could be some of the reasons for this increased feed utilisation efficiency (Peterson, 1962). In other experiment, Blaxter et al. (1964) discovered that lambs fed loose feed produced more methane gas and heat losses than lambs fed pelleted ration.

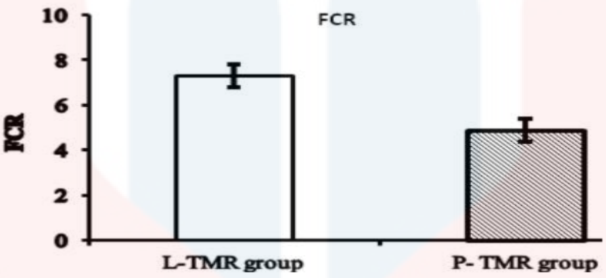


Figure 2. Graphically shown feed conversion ratio (FCR) of sheep under two dietary treatments; striped bar indicates P-TMR and solid bar indicates L-TMR group, L-TMR=Road side grass, rice straw wheat bran, wheat bran, mustard oil cake, molasses, common salt, P-TMR=Pelleted form of L-TMR using 6 mm die.

Source: Effect of Pellet from Total Mixed Ration on Growth Performance, Blood Metabolomics, Carcass and Meat Characteristics on Bangladeshi Garole Sheep.

Reference: Islam, R., Redoy, M., Shuvo, A., Sarker, M., Akbar, M., & Al-Mamun, M. (2017). Effect of pellet from total mixed ration on growth performance, blood metabolomics, carcass and meat characteristics of Bangladeshi garole sheep. *Progressive Agriculture, 28*(3), 222-229. doi: 10.3329/pa.v28i3.34659

4.2.2 Moisture

Moisture in pellet is lower than in mixture because there is loss of water content during the pelleting processes. The heat causes the loss of moisture in pellet. Pellet should have less moisture to make sure it does not spoil or damage easily during storage, so the pellet can last longer.

From the table above, the moisture content in pellet is lower than in mixture. The pellets should have a low total moisture content, preferably between 10 and 12%, which allows them to be stored without overheating or spoiling. These pellets could supply consistent nutrients while reducing sorting, overheating, and waste (Ali Z, 2011). Low moisture pellets contain hard, physically bound ingredients that animals cannot sort during feeding. As a result, the risk of ingredients sorting that is present in traditional entire mixed ration feeding can be fully eliminated. Overheating is prevented in total mixed ration pellets with low moisture (10-12%) since mould and yeast have a limited ability to propagate on this moisture. As a result, overheating is avoided, resulting in proper utilisation of feed resources without waste (Ali Z, 2011).

Total mixed ration pellets may improve animal performance while reducing the issues associate while reducing the issues associated with traditional total mixed ration mash. These pellets can be fed to small or large herds, with no need to sift the components, and may boost growth and milk output. TMR dry pellets can give a steady supply of dry matter and nutrients. More milk production may be expected because of improved nutritional consumption.

4.2.3 Ash

The overall mineral content of a forage or diet is referred to as ash. In a forage testing laboratory, measuring the ash level of a forage or TMR is simple and inexpensive. In general, a procedure analogous to cremation is used to determine the ash content of forage or TMR. Many endogenous minerals have nutritional benefit for lactating dairy ruminants, and we typically desire them to have high values, such as calcium, to avoid supplementing costs.

Supplemental premixes, salt, and buffers would be the most significant contributors to this category. Ash or minerals have no protein, calories, energy, or nutrients that a dairy cow may ferment in their stomach. In forage testing laboratories, we assess ash content of forages and TMRs to estimate energy and calculate non-fibre carbohydrate content. TMRs typically have an ash content of 9% dry matter, which includes endogenous minerals, exogenous minerals, and supplementary minerals. TMR ash levels have reached 17% ash in exceptional circumstances.

4.2.4 Dry Matter

Adding water to dry TMR has long been thought to be a good management strategy for reducing the quantity of feed sorting (Shaver, 2002). Leonardi et al. (2005) found that increasing TMR dry matter content from 80% to 64% by adding water resulted in less feed sorting against long particles and more feed sorting in favour of short particles, increased NDF intake, and higher milk fat percentage. Surprisingly, the ration utilised in that study was substantially drier than what is generally fed to high-production dairy herds (40-60% DM; Eastridge, 2006), especially those that do not use dry forages in their TMR. It has previously been suggested that higher moisture TMR are more susceptible to spoilage as the ambient temperature rises (Eastridge, 2006).

Instead of adding water into loose TMR, we can convert the loose TMR to pelleted TMR. Adding water causes the TMR to spoil easily, despite they get enough nutrition for milk production. They cannot completely sorting the TMR given in pellet, thus, they will consistently get enough or extra nutrition needed, without decreasing the DM percentage. There is almost no change in the content of total mixed ration pellets, and they can provide a consistent amount of dry matter. TMR pellets with higher dry matter content make it easier to feed the animal more accurately. Due to the compact shape of pellets, unlike loose TMR in mash form, which has difficulty segregating ingredients, pelleted TMR may not be separated.

TMR dry pellets might provide a more uniform dry matter and nutrient intake. Furthermore, increased milk production may be expected as a result of improve food consumption. Ingredients and nutrients contained in it do not decay under normal temperature circumstances or even at higher ambient temperatures due to the lower moisture content. There is little risk of feed rotting since it includes low moisture, which inhibits mould and yeast growth.

4.2.5 Crude Fat

An ingredients or feed's fat content can refer to either natural fat or fat that has been added. Both are beneficial to raising output rates. The quality of the pellets could be jeopardised. Added too much fat, usually 2% or more, can substantially degrade the quality of the pellets. Animal fat or vegetable fat might be used as an additional fat source. Currently, animal fats are the most often employed in commercial feeds. This is why crude fat in pellet is slightly higher than in mixture.

Added fat in compound animal feed has been shown to have a negative impact on pellet hardness and durability (van Vliet, 1981). Fat's hydrophobic nature may interfere with the binding properties of water-soluble components in the feed because most binding of feed particles involves water or, when involved, solubilized starches, proteins, and fibres. Furthermore, additional fat act as a lubricant between particles and between the feed mash and the wall, resulting in lower pelleting pressure. This will beneficial. In many situations, this has already resulted in reduced pellet quality. Different qualities of a raw material ingredient may also be changed because of fat addition.

Natural oils and waxes are released from the interior of (plant) cell walls during the blending of the feed mash with heat, according to the authors (Von Sybel and Wittmann, 1960; Schwanghart, 1970). On cooling, these oils and/or waxes would concentrate at the contacting sites of two particles, forming a solid (waxes) or liquid necking (oil or water) binding point between particles (Friedrich, 1977). This would improve the hardness and durability of pellets. Because water and fats are incompatible, the number of linkages formed by waxes and fats on one side and water on the other would be optimal. The number of bonds is determined by the concentration in a specific, unknown range.

CHAPTER 5

CONCLUSION

In conclusion, there is not much significant difference between loose TMR and pelleted TMR in their nutrition facts. There is only some differences in crude fibre and water content after and before the ingredients being pelleted. The changes amount of water content and crude fibre is because of the chemical reaction and lose of water when the ingredients put into heat during pelletized. Pelleting TMR is one of the ways to avoid goats and other ruminants from sorting their feed. Pelletizing TMR also helps in longing the shelf life and safe from spoilage and moulding as the moisture content is lower than loose TMR. The animals will still getting the same amount of nutrition as the loose TMR. Additional of 1.5% sodium bicarbonate as binder for this TMR helps in pellets durability because it does not cause the pellet to fragile easily during storage. Sodium bicarbonate also have their own benefits on the growth of yeast and mould of the pellet.

CHAPTER 6

RECOMMENDATION

I recommend to check the mineral analysis in both loose and pelleted TMR to know the mineral content. The formulation need to be fixed at the salt and mineral premix percentage as they need to be more than 1%.

REFERENCES

Ahn, J., Kil, D., Kong, C., & Kim, B. (2014). Comparison of Oven-drying Methods for Determination of Moisture Content in Feed Ingredients. *Asian-Australasian Journal Of Animal Sciences*, *27*(11), 1615-1622. doi: 10.5713/ajas.2014.14305

Abdollahi, M., Ravindran, V., & Svihus, B. (2013). Pelleting of broiler diets: An overview with emphasis on pellet quality and nutritional value. *Animal Feed Science And Technology*, *179*(1-4), 1-23. doi: 10.1016/j.anifeedsci.2012.10.011

Ali, Z. (2022). GB2490530A - Total mixed ration pellets for cattle, sheep, goats and camels - Google Patents. Retrieved 25 January 2022, from https://patents.google.com/patent/GB2490530A/en

Behnke, K. (2021). FACTORS INFLUENCING PELLET QUALITY. Retrieved 2 May 2021, from https://www.semanticscholar.org/paper/FACTORS-INFLUENCING-PELLET-QUALITY-Behnke/43d91d59f6cda3cf69aa6f12e61ac1c33b832ec7

Behnke, D., & Beyer, D. (2021). EFFECT OF FEED PROCESSING ON BROILER PERFORMANCE. Retrieved 2 May 2021, from https://www.semanticscholar.org/paper/EFFECT-OF-FEED-PROCESSING-ON-BROILER-PERFORMANCE-Behnke-Beyer/630c55855a65dc0d95110e99555a7a1adcddd66c

Calberry, J., Plaizier, J., Einarson, M., & McBride, B. (2003). Effects of Replacing Chopped Alfalfa Hay with Alfalfa Silage in a Total Mixed Ration on Production and Rumen Conditions of Lactating Dairy Cows. *Journal of Dairy Science*, *86*(11), 3611-3619. doi: 10.3168/jds.s0022-0302(03)73967-8

Devendra, C., & Liang, J. (2012). Conference summary of dairy goats in Asia: Current status, multifunctional contribution to food security and potential improvements. *Small Ruminant Research*, *108*(1-3), 1-11. doi: 10.1016/j.smallrumres.2012.08.012

Gryczová, E. & Kubova Dvorackova, Katerina & Rabiškova, M.. (2009). Evaluation of pellet friability. Ceska a Slovenska Farmacie. *58*. 9-13.

Hadjipanayiotou, M. (1982). Effect of Sodium Bicarbonate and of Roughage on Milk Yield and Milk Composition of Goats and on Rumen Fermentation of Sheep. *Journal of Dairy Science*, *65*(1), 59-64. doi: 10.3168/jds.s0022-0302(82)82153-x

Hoffman, P. (2022). Ash Content of Forages. Retrieved 25 January 2022, from https://fyi.extension.wisc.edu/forage/files/2014/01/ASH05-FOF.pdf

HOLLISTER, A., & KIENHOLZ, E. (1980). Sodium Bentonite in Diets for Growing Ducks. *Poultry Science*, *59*(9), 2160-2162. doi: 10.3382/ps.0592160

Islam, R., Redoy, M., Shuvo, A., Sarker, M., Akbar, M., & Al-Mamun, M. (2017). Effect of pellet from total mixed ration on growth performance, blood metabolomics, carcass and meat characteristics of Bangladeshi garole sheep. *Progressive Agriculture*, *28*(3), 222-229. doi: 10.3329/pa.v28i3.34659

J. M. Boac, M. E. Casada, & R. G. Maghirang. (2008). Feed Pellet and Corn Durability and Breakage During Repeated Elevator Handling. *Applied Engineering In Agriculture*, *24*(5), 637-643. doi: 10.13031/2013.25262

Jamaluddin, A. K. (2012). Challenges Facing Dairy Goat Farmers in Malaysia. *Proceedings of the 1st Asia Dairy Goat Conference, Kuala Lumpur, Malaysia*, 24-25.

Kmicikewycz, A., & Heinrichs, A. (2022). Feeding lactating dairy cattle long hay separate from the total mixed ration can maintain dry matter intake during incidents of low rumen pH.

Li, B., Sun, X., Huo, Q., Zhang, G., Wu, T., & You, P. et al. (2021). Pelleting of a Total Mixed Ration Affects Growth Performance of Fattening Lambs. *Frontiers In Veterinary Science*, *8*. doi: 10.3389/fvets.2021.629016

Lei, Y., Li, X., Wang, Y., Li, Z., Chen, Y., & Yang, Y. (2017). Determination of ruminal dry matter and crude protein degradability and degradation kinetics of several concentrate feed ingredients in cashmere goat. *Journal Of Applied Animal Research*, *46*(1), 134-140. doi: 10.1080/09712119.2016.1276916

Möller, J. (2010). Cereals, cereals-based products and animal feeding stuffs - determination of crude fat and total fat content by the Randall extraction method: a collaborative study. *Quality Assurance And Safety Of Crops & Foods*, *2*(4), 197-202. doi: 10.1111/j.1757-837x.2010.00077.x

Maltz, E., Silanikove, N., Karaso, Y., Shefet, G., Meltzer, A., & Barak, M. (1991). A note on the effects of feeding total mixed ration on performance of dairy goats in late lactation. *Animal Feed Science And Technology*, *35*(1-2), 15-20. doi: 10.1016/0377-8401(91)90095-a

Park, Y. (2007). Impact of goat milk and milk products on human nutrition. *CAB Reviews: Perspectives In Agriculture, Veterinary Science, Nutrition And Natural Resources*, *2*(081). doi: 10.1079/pavsnnr20072081

Pope, J., Brake, J., & Fahrenholz, A. (2020). Parameters monitored during the pelleting process and their relationship to xylanase activity loss. *Animal Feed Science And Technology*, *259*, 114344. doi: 10.1016/j.anifeedsci.2019.114344

Schingoethe, D. (2017). A 100-Year Review: Total mixed ration feeding of dairy cows. *Journal Of Dairy Science*, *100*(12), 10143-10150. doi: 10.3168/jds.2017-12967

Shahudin, M., Abdul Ghani, A., Saad, M., Abu Bakar @ Zakaria, M., Abdullah, F., Haron, A., & Abu Hassim, H. (2021). The necessity of a herd health management programme for dairy goat farms in Malaysia. Retrieved 2 May 2021, from https://core.ac.uk/display/153834008

Thomas, M., van Vliet, T., & van der Poel, A. (1998). Physical quality of pelleted animal feed 3. Contribution of feedstuff components. *Animal Feed Science And Technology*, *70*(1-2), 59-78. doi: 10.1016/s0377-8401(97)00072-2

Teshome, D. (2022). Effect of Total Mixed Ration on Dry Matter Intake, Milk Yield and Composition of Early Lactating Jersey Cows. Retrieved 25 January 2022, from https://www.iiste.org/Journals/index.php/JBAH/article/view/36940

Wheeler, T., Wangsness, P., Muller, L., & Griel, L. (1980). Addition of Sodium Bicarbonate to Complete Pelleted Diets Fed to Dairy Calves. *Journal Of Dairy Science*, *63*(11), 1855-1863. doi: 10.3168/jds.s0022-0302(80)83151-1

(2021). Retrieved 2 May 2021, from http://unaab.edu.ng/wp-content/uploads/2009/12/459_ANN509%20Lecture%20Note%20_A_.pdf

(2022). Retrieved 25 January 2022, from https://www.cpm.net/downloads/Animal%20Feed%20Pelleting.pdf

APPENDIXES

STATISTICAL ANALYSIS – T-TEST & ONE WAY ANOVA

i) T-TEST

PROTEIN T-TEST TABLE

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Pellet	11.4905	3	1.37127	.79171
	Mixture	10.3340	3	.49617	.28646

Paired Samples Test

	Paired Differences					t	df	Sig. (2-tailed)
				95% Confidence Interval of the Difference				
	Mean	Std. Deviation	Std. Error Mean	Lower	Upper			
Pair 1 Pellet - Mixture	1.15650	1.66032	.95859	-2.96796	5.28096	1.206	2	.351

ASH T-TEST TABLE

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Pellet	5.7378	3	2.19274	1.26598
	Mixture	4.9192	3	1.99067	1.14932

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Pellet - Mixture	.81860	4.01366	2.31729	-9.15189	10.78909	.353	2	.758

DRY MATTER T-TEST TABLE

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Pellet	88.5021	3	7.34291	4.23943
	Mixture	88.7268	3	2.66208	1.53695

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			

Pair 1	Pellet - Mixture	-.22470	6.26027	3.61437	-15.77607	15.32667	-.062	2	.956

CRUDE FIBRE T-TEST TABLE

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Pellet	13.9969	3	.38898	.22458
	Mixture	23.2561	3	2.13482	1.23254

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	Pellet - Mixture	-9.25917	2.34366	1.35311	-15.08114	-3.43720	-6.843	2	.021

CRUDE FAT T-TEST TABLE

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Pellet	4.1067	3	4.72276	2.72669
	Mixture	3.0667	3	2.07727	1.19931

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
					95% Confidence Interval of the Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper			
Pair 1	Pellet - Mixture	1.04000	6.37960	3.68326	-14.80781	16.88781	.282	2	.804

MOISTURE T-TEST TABLE

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Pellet	5.9367	3	.36074	.20827
	Mixture	9.8400	3	.11269	.06506

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
					95% Confidence Interval of the Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper			
Pair 1	Pellet - Mixture	-3.90333	.26160	.15103	-4.55318	-3.25349	-25.844	2	.001

ii) ONE-WAY ANOVA

TMR INGREDIENTS SPSS TABLE

DRY MATTER

Descriptives

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean Lower Bound	95% Confidence Interval for Mean Upper Bound	Minimum	Maximum
sodium	3	82.1123	10.30152	5.94759	56.5219	107.7027	74.42	93.82
salt	3	88.5421	3.40704	1.96706	80.0786	97.0057	85.65	92.30
PFAD	3	92.5708	4.91706	2.83887	80.3562	104.7855	88.58	98.06
soybean meal	3	75.2329	10.33348	5.96604	49.5631	100.9027	63.63	83.46
copra meal	3	89.9734	6.16517	3.55946	74.6583	105.2885	83.94	96.26
mineral premix	3	93.4553	2.59817	1.50006	87.0011	99.9096	90.65	95.79
PKC	3	65.3260	17.91223	10.34163	20.8295	109.8224	44.64	75.67
rice bran	3	71.4565	8.43633	4.87072	50.4995	92.4135	61.80	77.41
molasses	3	80.6232	2.59688	1.49931	74.1722	87.0742	78.66	83.57
napier	3	88.1253	3.92529	2.26626	78.3743	97.8763	84.86	92.48
soya hull	3	90.9138	1.57157	.90735	87.0098	94.8178	89.44	92.56
corn meal	3	94.9555	5.08556	2.93615	82.3223	107.5888	89.47	99.52
Total	36	84.4406	11.30187	1.88364	80.6166	88.2646	44.64	99.52

ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	2998.724	11	272.611	4.445	.001
Within Groups	1471.903	24	61.329		
Total	4470.627	35			

FAT

Descriptives

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean Lower Bound	95% Confidence Interval for Mean Upper Bound	Minimum	Maximum
soybean meal	3	.803667	.3620465	.2090277	-.095707	1.703040	.4090	1.1204
sodium	3	.000000	.0000000	.0000000	.000000	.000000	.0000	.0000
salt	3	.000000	.0000000	.0000000	.000000	.000000	.0000	.0000
PFAD	3	3.104530	.2544160	.1468872	2.472526	3.736534	2.8287	3.3300
copra meal	3	4.835567	2.5837778	1.4917448	-1.582893	11.254026	2.5955	7.6622
soya hull	3	4.691000	.9659892	.5577141	2.291350	7.090650	3.6965	5.6257
mineral premix	3	.455047	.1163124	.0671530	.166111	.743983	.3338	.5657
PKC	3	16.001533	3.0407580	1.7555824	8.447872	23.555195	13.1279	19.1856
rice bran	3	10.262633	1.3343856	.7704079	6.947836	13.577431	8.7459	11.2560
molasses	3	4.953333	2.2346663	1.2901852	-.597885	10.504552	3.3200	7.5000
Napier	3	3.727933	1.6084390	.9286327	-.267651	7.723517	2.0912	5.3065
corn meal	3	1.416333	2.4531613	1.4163333	-4.677657	7.510324	.0000	4.2490
Total	36	4.187631	4.8007427	.8001238	2.563294	5.811969	.0000	19.1856

ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	741.762	11	67.433	24.941	.000
Within Groups	64.888	24	2.704		
Total	806.650	35			

MOISTURE

Descriptives

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
sodium	3	3.5833	.65760	.37966	1.9498	5.2169	3.15	4.34
salt	3	.5267	.02517	.01453	.4642	.5892	.50	.55
pfad	3	3.5033	.11015	.06360	3.2297	3.7770	3.39	3.61
soybean meal	3	9.7667	.48087	.27763	8.5721	10.9612	9.27	10.23
copra meal	3	9.7800	.45431	.26230	8.6514	10.9086	9.46	10.30
soyhull	3	10.1300	.49508	.28583	8.9002	11.3598	9.64	10.63
mineral premix	3	2.6867	.04041	.02333	2.5863	2.7871	2.65	2.73
pkc	3	6.2233	.66078	.38150	4.5819	7.8648	5.76	6.98
rice bran	3	10.1467	.40992	.23667	9.1284	11.1650	9.91	10.62
molasses	3	49.1300	.74840	.43209	47.2709	50.9891	48.57	49.98
napier	3	12.9567	.74070	.42764	11.1167	14.7967	12.48	13.81
corn meal	3	9.9233	.05132	.02963	9.7959	10.0508	9.88	9.98
Total	36	10.6964	12.34155	2.05693	6.5206	14.8722	.50	49.98

ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	5325.296	11	484.118	2041.543	.000
Within Groups	5.691	24	.237		
Total	5330.988	35			

PROTEIN

Descriptives

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean Lower Bound	95% Confidence Interval for Mean Upper Bound	Minimum	Maximum
sodium	3	.0000	.00000	.00000	.0000	.0000	.00	.00
salt	3	.0000	.00000	.00000	.0000	.0000	.00	.00
PFAD	3	.1569	.13524	.07808	-.1790	.4929	.08	.31
soybean meal	3	20.7050	1.26728	.73166	17.5569	23.8531	19.93	22.17
copra meal	3	10.1379	.72354	.41773	8.3405	11.9353	9.60	10.96
soyhull	3	10.3584	.54615	.31532	9.0017	11.7151	9.93	10.97
mineral premix	3	.0000	.00000	.00000	.0000	.0000	.00	.00
PKC	3	10.6052	.13510	.07800	10.2696	10.9408	10.46	10.72
rice bran	3	5.9684	.69554	.40157	4.2406	7.6963	5.17	6.39
molasses	3	1.6247	.40558	.23416	.6172	2.6322	1.31	2.08
Napier	3	5.9689	.37474	.21635	5.0380	6.8998	5.54	6.22
corn meal	3	1.0571	.30324	.17508	.3038	1.8104	.81	1.40
Total	36	5.5486	6.27284	1.04547	3.4261	7.6710	.00	22.17

ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1370.510	11	124.592	446.969	.000
Within Groups	6.690	24	.279		
Total	1377.200	35			

ASH

Descriptives

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean Lower Bound	95% Confidence Interval for Mean Upper Bound	Minimum	Maximum
Soybean_Meal	3	7.1308	3.38969	1.95704	-1.2896	15.5513	3.75	10.53
Sodium_Bicarbonate	3	91.4228	16.52208	9.53903	50.3796	132.4659	72.53	103.18
Sodium_Chloride	3	154.0743	71.68154	41.38536	-23.9925	332.1411	71.30	195.69
Copra_Meal	3	3.7068	1.30025	.75070	.4768	6.9368	2.26	4.79
Soya_Hull	3	4.8775	.26595	.15355	4.2169	5.5382	4.57	5.04
Mineral_Premix	3	6.5525	5.30776	3.06444	-6.6327	19.7377	.67	10.99
PKC	3	100.6073	2.66919	1.54106	93.9767	107.2380	98.75	103.67
Rice_Bran	3	31.0095	37.58898	21.70201	-62.3667	124.3857	9.25	74.41
Molasses	3	136.8444	8.71141	5.02954	115.2040	158.4847	131.38	146.89
Napier	3	3.8773	3.34991	1.93407	-4.4443	12.1989	.42	7.11
Total	30	54.0103	62.30229	11.37479	30.7463	77.2744	.42	195.69

ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	98646.051	9	10960.672	15.749	.000
Within Groups	13919.626	20	695.981		
Total	112565.677	29			

CRUDE FIBRE

Descriptives

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean Lower Bound	95% Confidence Interval for Mean Upper Bound	Minimum	Maximum
Sodium_Bicarbonate	3	37.4574	12.00104	6.92880	7.6451	67.2696	29.36	51.25
Sodium_Chloride	3	11.2800	3.33350	1.92459	2.9991	19.5608	8.85	15.08
Soybean_Meal	3	11.3376	5.55514	3.20726	-2.4621	25.1373	5.64	16.74
Copra_Meal	3	15.1442	4.32925	2.49949	4.3898	25.8987	10.20	18.23
Soya_Hull	2	62.5677	48.82869	34.52710	-376.1407	501.2761	28.04	97.09
Mineral_Premix	2	.8476	.60592	.42845	-4.5964	6.2915	.42	1.28
Rice_Bran	3	12.9366	7.40289	4.27406	-5.4532	31.3264	5.28	20.06
Napier	3	13.8211	4.01017	2.31527	3.8593	23.7829	9.85	17.87
Corn_Meal	3	14.5948	5.14934	2.97297	1.8031	27.3864	8.77	18.53
PKC	2	59.2009	.00000	.00000	59.2009	59.2009	59.20	59.20
Total	27	22.0351	21.57121	4.15138	13.5018	30.5684	.42	97.09

ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	9109.355	9	1012.151	5.757	.001
Within Groups	2988.887	17	175.817		
Total	12098.242	26			

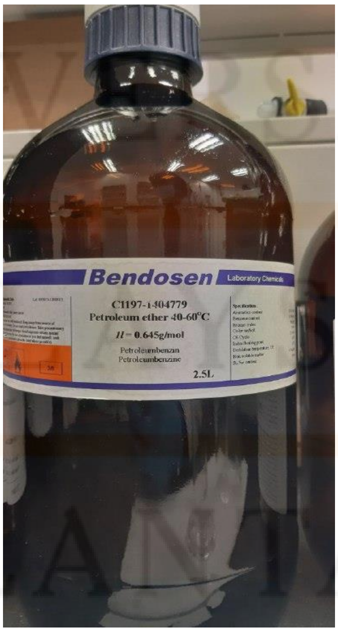
Formulation mixture

FOSS – Fat Analyzer - ST 255 Soxtec™

Drying oven

Dry matter for ingredients

FOSS – Fiber Analyzer – The Fibertec™ 8000



Petroleum ether for ether extract (crude fat)

Dried Napier grass

Fresh Napier grass and stem

Pelleted TMR

Moisture analyser

Gerhardt Vapodest 30s – Water Distillation Systems

4% Boric acid

Distillation process

Cooling down after digestion

Furnace for fibre ash

INGREDIENTS FOR TMR PELLET (10 KG)

NO.	INGREDIENTS	QUANTITY FOR PELLETIZING (KG)
1	Napier grass	5.9
2	PKC	0.8
3	Soybean meal	0.97
4	Soyhull	1.74
5	Molasses	0.29
6	PFAD	0.09
7	Mineral premix	0.03
8	Salt	0.02
9	1.5% sodium bicarbonate	0.15
	TOTAL	**10 kg**