Effect of Different Inclusion Level of Mulberry (*Morus Alba*) Pellet on Growth Performance and Feed Conversion Ratio of Rabbit

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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.

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ABSTRACT

The rabbit (*Oryctolagus cuniculus*) is a commercially farmed agricultural animal. In Malaysia, it was still in its infancy with the biggest challenge confronting the high cost of feeding. Most commercial pellets for rabbits were pricey which make many farmers use other alternative approaches to lower the feeding expenses by offering lucerne and chosen leaves with high protein contained. However, most of the raw lucernes included a high percentage of moisture, leading to diarrhea problems for rabbits if provided directly. The current research encompassed all the processes of producing the mulberry leaves to a fully formed pellet and testing the rabbit in a feed trial. These experiments were undertaken to investigate the efficacy of both kinds of pellets in terms of growth performance, feeding intake, and feed conversion ratio centered on rabbit growth performance. Different diets were allocated into groups, including the control group (100% commercial pellet), treatment 1 (100% mulberry pellet) and treatment 2 (50%mulberry leaf pellet, 50% commercial pellet). Nutritional contents of both pellets were assessed, which include dry matter (DM), moisture, crude protein (CP), crude fat (ether extract), and ash contents. The growth performance measures include average weekly body weight increase, which was 1466.67, 1923.33 and 1573.33 for control, treatment 1 and treatment 2 correspondingly. Average feed intake was control (94.60), T1(97.31) and T2(97.54) correspondingly. The feed conversion ratio for the control, treatment 1 and treatment 2 were 6.06, 5.18 and 6.49, respectively. The present result may enable the farmers to minimize the feed cost and increase the quality of the growth performance.

Keywords: Rabbit, Mulberry Pellet, Premium Rabbit Pellet, Growth Performance, Feed Conversion Ratio, Proximate Analysis

Kesan Tahap Kemasukan Berbeza Pelet Mulberi (*Morus Alba*) Terhadap Prestasi Pertumbuhan Dan Nisbah Penukaran Pakan Arnab

ABSTRAK

Arnab (*Oryctolagus cuniculus*) merupakan salah satu haiwan penternakan yang diternak oleh petani. Industri arnab di Malaysia masih berada di dalam peringkat yang baru dan masalah utama yang dihadapi oleh penternak arnab di Malaysia adalah kos makanan yang masih tinggi. Disebabkan itu, ramai petani memilih untuk mengurangkan perbelanjaan makanan arnab dengan memberi alternatif lain seperti daun dan tumbuhan yang mengandungi protein yang tinggi. Namun, kandungan air yang tinggi pada daun menyebabkan arnab menerima komplikasi cirit. Oleh hal yang demikian, di dalam kajian ini telah melibatkan proses-proses menjadikan daun mulberi kepada bentuk pelet bersama formulasi makanan yang lengkap dan diberi pada arnab sebagai makanan percubaan**.** Kajian-kajian ini dilakukan untuk menentukan keberkesanan kedua-dua jenis pelet komersial dari segi prestasi tumbesaran, pengambilan makanan, dan nisbah penukaran makanan yang difokuskan pada prestasi tumbesaran arnab tersebut. Diet yang berbeza telah diberikan kepada tiga kumpulan iaitu kumpulan kawalan (100% pellet komersial), rawatan 1 (100% pellet daun mulberi) dan rawatan ke 2 (50% pellet daun mulberi, 50% pelet komersial). Analisa makmal kedua-dua pelet dijalankan untuk menentukan jirim kering (DM), kelembapan, protein kasar (CP), lemak kasar (ekstrak eter), abu, dan kandungan karbohidrat lengkap. Parameter prestasi pertumbuhan arnab adalah purata berat badan harian sebanyak 1466.67, 1923.33 dan 1573.33 untuk kumpulan kawalan, rawatan 1 dan rawatan 2. Purata pengambilan makanan adalah kawalan (94.60), rawatan 1 (97.31) and rawatan 2 (97.54) masing-masing. Nisbah penukaran makanan untuk kontrol, kawalan 1 dan kawalan 2 masing-masing adalah 6.06, 5.18 and 6.49. Hasil kajian ini mampu mewujudkan idea dan potensi untuk para penternak mengurangkan belanja pemakanan dan kualiti tumbersaran arnab.

Kata kunci: Arnab, Makanan Pelet Komersial, Pelet Kambing Komersial, Pelet Arnab Premium, Prestasi Tumbesaran, Nisbah Penukaran Pakan

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF SYMBOLS AND ABBREVIATION

Reference No.

°C	Degree Celcius
ANOVA	One-way Analysis of Variance
CF	Crude fibre
CP	Crude Protein
Kg	Kilogram
DM	Dry Matter
EE	Ether extract
H_2SO_4	Sulfuric Acid
H_3BO_3	Boric Acid
HCL	Hydrochloric Acid
M	Molarity
Ml	Mililitre
N	Normality
NaOH	Sodium hydroxide
NFE	Nitrogen free extract
VFA	Volatile fatty acid
FCR	Feed conversion ratio

LIST OF EQUATIONS

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Rabbit is an agricultural animal produced for income by farmers. Rabbits are herbivores with mono-gastric stomachs. It can be fed full feed, normally in the form of pellets. In Malaysia, most rabbits depend on commercial pelleted feed. Aside from the Flemish Giant, Rex, Angora, and Chinchilla, the most common rabbit bred by farmers is the New Zealand White rabbit (Tistiana et al., 2020). Rabbit has now become an important food source for humans because it can produce meat that is high in nutrients and a better source of protein than other

meat sources. Rabbits are a possible meat-producing animal in developed countries due to their short generation interval, low investment requirements, and low feed demand. Moreover, Jusoh & Nur (2018) stated that rabbits have a small body size, a fast growth rate, a high reproductive capacity, and the ability to use forages so they are easily raised by farmers.

The feed is a critical element for successful rabbit production. As feed accounts for the greater part of production expenses in animal agriculture and may account for up to 70% of overall costs depending on investments, Thus, feed efficiency is a critical factor for enhancing farm sustainability, both economically and environmentally. Protein and energy are the most important dietary needs of rabbits in small-scale rabbit farming. Since rabbits are corophages, their feed is processed twice, so they eat during the day and produce and ingest soft fecal pellets at night. However, the need for high-quality rabbit production at lower prices has led to the use of alternate feed options such as tropical plants and legume herbages in rabbit diets (Jusoh & Nur, 2018). Since most rabbit pellets are expensive, several farmers opted to use other readily accessible and inexpensive feed, such as legumes plant like Mulberry leaves as an option to minimize feeding costs. However, there is some debate about the mulberry leaves' ability to fully substitute commercial rabbit pellets in rabbit production. Therefore, a research study was conducted to compare the chemical analysis,

growth performance, feed consumption, and feed conversion ratio of rabbits fed those two different pellets.

1.2 Problem Statement

Rabbit needs to balance the proportion of nutritional properties with high protein content and low cholesterol. However, the rabbit industry in Malaysia is still being slow in progress and performed in small-scale business. Like other husbandry sides, the major challenge faced by rabbit farmers in Malaysia mostly on feeding cost. Most of the premium pellets for the rabbit is pricey. As for that, there are many farmers decided to give suitable plant leaves as an alternative to reduce the feeding cost. Mulberry However, both nutrient compositions of the feeds need to be investigated and compared further for determining their effectiveness in improving feeding intake, growth performance, and feed conversion ratio of rabbits.

1.3 Objectives

- To assess the nutritional values of Mulberry leaf before and after pelleting process
- To evaluate the effect of Mulberry pellet on the feed intake, growth performance, and feed conversion ratio of rabbits.

1.4 Hypothesis

Ho: There is no difference between two different pellets on the feed intake, growth performance, and feed conversion ratio of rabbits.

H1: There is a significant difference between two different pellets on the feed intake, growth performance, and feed conversion ratio of rabbits.

1.5 Scope of Study

One of the most significant and necessary aspects of farm management is feed. Commercial feed is of the highest quality available to farmers, yet it is not financially feasible for them. Mulberry leaves are now well recognized for their ability to replace commercial pellets on the market due to their nutritious composition and cost-effectiveness. The nutritional value of this designed pellet was studied using proximate analysis to evaluate the dry matter, crude protein, crude fiber, crude fat, ash, and moisture contents in two distinct states of mulberry pellets: TMR loose form (before palletization) and solid mulberry pellets (after pelletized). After a period of 7 days of adaption, the economic analysis that was applied in each dietary treatment group was observed in 5 weeks. The research was carried out at Animal Laboratory and Rabbit Barn in the University Malaysia Kelantan, Jeli.

1.6 Significance of study

Feed is the crucial part in most of farm management. Most of the commercial feed for rabbits are not cost effective toward the farmer hence make

the farmer keep changed the feed if there are any contradictions. As for that, most of the farmers tend to give the rabbit raw plants and leaves to replace and top up the commercial pellets of rabbit as an alternative.

Also, this study provided research information regarding each of the pellet quality and its nutritive value for study references. There was no study that used to compare the effectiveness of these two different pellets on the growth performance of rabbit. So, this study provided the data about the feed intake, benefit cost ration and feed conversion ratio between both different pellets

1.7 Limitations of study

Due to the pandemic of Covid-19 outbreak and MCO (Malaysian Government Control Order), full determination and comparison of economic value and benefit cost ratio from the application of mulberry pellet in the feed trial cannot be observed due the limitation of the time to run this project.

CHAPTER 2

LITERATURE REVIEW

2.1 Rabbit

Rabbit (*Oryctolagus cuniculus*) is a high-protein meat with lower cholesterol and triglyceride (fat) levels. Additional features of rabbit that can be develops as products are skin and feathers, feces (droppings), and urine (Santoso & Sutarno, 2009). Furthermore, Sajimin and Raharjo (2004) reported that rabbits produce high quality manure, which can create synergistic interactions between livestock and crops by improving farming system sustainability and soil fertility simultaneously (Samkol & Lukefahr, 2008).

Being as a small ruminant also give benefit that led to the results of low labor costs and investment, all of which become barriers for small farmers (Raharjo, 2016). They can be farmed intensively on small plots of land, highly productive animals and achieve slaughter weight very quickly, resulting in fast returns on capital investment (Abu, 2008; Oseni, 2012). Rearing rabbit also will help deprived urban dwellers and resource-poor rural dwellers fulfill a portion of their overall protein consumption while also earning extra money. If properly handled, the rabbit can be a potential money-maker (Abu, 2008). Rabbits have the ability in converting 20% of the proteins they consume into edible meat in effective processing processes (Raharjo, 2016).

2.2 New Zealand White

New Zealand white rabbits are one of the most popular rabbit breeds chosen for commercial and scientific purposes around the world. New Zealand White (NZW) originated in the United States of America. WS Preshaw was the first human to breed the NZW rabbit to make a superior meat producer rabbit in 1916. Its existence was uncertain, but the Angora rabbit was thought to have

played a part in its formation (Brahmantiyo et al, 2018). Aside from that, (Lebas et al, 1986; Brahmantiyo et al, 2018) have identified this rabbit as being pure white with red eyes and weighing 4.1-5.0 kg as an adult. New Zealand White rabbits (NZW) develop rapidly, with adults weighing 4.5 to 5 kg and babies weighing 10-12 rabbits (Santoso & Sutarno, 2009).

The total litter size was 8.5 kits, the life litter size was 8.0 kits, and the weaned litter size was 6.5 kits at 144 days. According to Brahmantiyo et al, (2018), the NZW rabbit was a commercial meat source. It had a high growth rate, a good carcass consistency, a high fertility rate, and a good maternity rate. Furthermore, Brahmantiyo et al, (2018) reported that the NZW rabbit had a pregnancy rate of 89.9 percent, a pregnancy period of 31.6 days, a calving interval of 37.8 days, a dam body weight at the first birth of 3.1 kg, a litter size of 9.1 heads, a weaned litter size of 7.2 heads, a weaned body weight of 550 g/head, mortality from the birth to weaned by 16.9%.

Developing rabbits is a promising prospect for addressing the issue of meat scarcity as a protein source to ensure consistent food access at the community level (Santoso & Sutarno, 2009).

2.3 Rabbit production worldwide

In 2013, there were 1.178 billion rabbits killed worldwide, providing around 1.7816 million tons of meat (FAO Statistics, 2015). Figure 2.3 below shows that Asia has the largest share (52 %), led by Europe (29 %), the Americas (13 %), and Africa (6 %) (Raharjo, 2016).

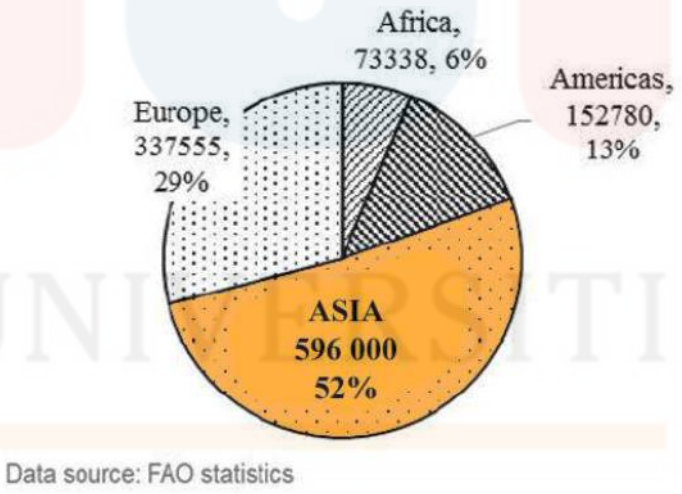

Figure 2.3: Numbers of slaughter rabbits and the regions share in year 2013.

(Data Sources: FAO Statistic, 2015)

The number of slaughtered rabbits is steadily rising, indicating that rabbit meat is becoming more common. The Asian countries then had a larger share than other regions. China, which accounts for 40 – 42% of world output in Asia, is the main production (Raharjo, 2016).

According to Finzi (2000), most smallholder rabbit units that have been developed are characterized by a few categories, which are a few breeding rabbits in backyards, the use of local equipment and materials for hutches, the feeding of fresh forages and kitchen wastes, the integration of rabbits with other farm components, the sharing of family labor, and finally the consumption of rabbits by the household. (Lukefahr, 2008) also stated that large rabbit programs have been developed by non-governmental organizations (NGO's) and governmental with the aim of alleviating poverty in families. Essentially, it is based on four factors: low cost to the program for breeding stock, low investment and maintenance costs to producers, early benefits to farmers and loan returns to the program, and a faster pace of project multiplication.

2.3.1 Asia

Rabbit farming is traditionally started in developing Asian countries to improve the food intake of poor families in villages. Rabbit raising is truly fit to raise in villages where all of those materials are available because rabbits are small, readily fed with local forages such as pasture, hay, vegetable waste, and by-product feeds, easy to raise, and rear in large numbers (Mikled et al., 2008; Binh, 2012; Raharjo, 2016). The development and advancement of rabbit production in Asian countries varies by region.

However, China has been the most rapid in improving rabbit production, and it is now the world's largest producer of rabbit meat (Gao, 2013; Raharjo, 2016). It is worth nothing that by the 1990s, rabbit production and consumption in Southeast Asian countries had already reached a significant level, which includes transactions of export from China and imports from Japan, Singapore, and Sri Lanka (Lebas et al., 1997; Raharjo, 2016). The expected production and consumption figures for ASEAN countries were unusually high.

Table 2.3.1: Rabbit production parameters for 10 countries in Southeast Asia.

Table 1. Rabbit production parameters for ten countries in southeast Asia[1]

Country	Production, 000 t	Exports, 000 t	Imports, 000 t	No. does, 000	No. does/ 1000 inhabitants	Per capita consumption, kg	Value production, $/1000 of TGNP
Brunei	0.1	0.0	0.0	13	44.6	0.36	0.14
Cambodia	0.5	0.0	0.0	57	6.7	0.06	1.94
India	7.5	0.0	0.0	367	0.4	0.01	0.08
Indonesia	50	0.1	0.0	2,698	14.8	0.27	1.42
Laos	0.5	0.0	0.0	57	13.3	0.12	1.94
Myanmar	3.0	0.0	0.0	363	8.5	0.07	0.60
Philippines	18	0.0	0.1	1,609	25.6	0.29	1.35
Singapore	0.0	0.0	1.0	1	0.2	0.33	0.00
Thailand	18	0.0	0.0	1,028	17.7	0.31	0.66
Vietnam	7	0.0	0.0	545	8.1	0.10	3.24
World	1,614	91.7	91.1	64,200	11.9	0.301	0.24

[1] *Adapted from Colin and Lebas 1996*

Sources: Lukefahr (2007)

Most Asian countries operate their rabbit farming on a micro- and small-scale scale. Also, China, the world's largest rabbit-producing country, relies on small-scale farming, which accounts for more than 90% of the country's rabbit supply (Raharjo, 2016).

2.3.2 Rabbit industry in Malaysia

The rabbit industry is relatively new in Malaysia, but it has grown in popularity because of numerous government campaigns and incentives aimed at encouraging the growth of this industry (Gunalan et al., 2019). The rabbit industry developed as a companion animal in the 1980s, and by the early 1990s, the rabbit had been reared as an alternative to livestock meat. After 20 years of growth, the sector has become self-sustaining and autonomous as a small market existential, a community group has developed, and a promotion event has begun. Rabbit meat has also seen interest, with a few marketers participating in “Satay” processing demanding nearly 1,200 kg each month.

This statistic shows that demand exceeds supply. Initially developed as poverty eradication programs in rural areas, this industry has been picked up as a commercial scale development. The government intends to see that rabbit meat should replace up to 20% of poultry meat intake.

Table 2.3.2: Rabbit Population in Malaysia (according state).

State	Population	Percentage
	30	0.12%
Kedah	2,616	10.47%
Penang	412	1.65%
Perak	1,782	7.13%
Selangor	2,876	11.51%
Negeri Sembilan	3,651	14.61%
Malacca	205	0.82%
Johor	3,683	14.74%
Pahang	2,958	11.84%
Terengganu	533	2.13%
Kelantan	57	0.23%
Sarawak	4,825	19.31%
Sabah	1,193	4.77%
FT Labuan	87	0.35%
FT Kuala Lumpur	79	0.32%
Total	24,987	100.00%

Source: MARBA (2019)

Table 2.3.2 depicted the current statistic of the rabbit population in Malaysia. The overall population is 4,764 people (including 1390 male kitten and 1392 male kitten). The number of farmers varied depending on the source of the data. According to MARBA statistics, there are 44 farmers, and other data indicates that there are 97 farmers (source from GAPS). In 2018, there were 11 farmers who registered with DVS, totaling 1459 head.

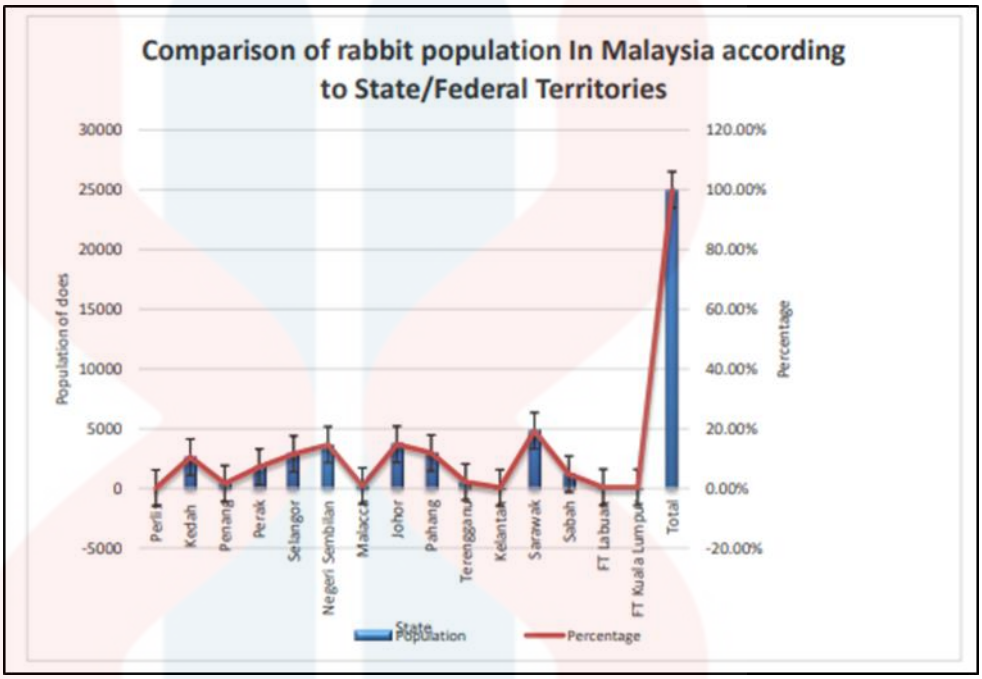

Figure 2.3.2: Comparison on the population of rabbit according to state in Malaysia (Source: MARBA, 2019; Gunalan, 2019).

Figure 2.3.2 shows a comparison of rabbit populations in Malaysia depending on the number of does. Selangor state is the 5th largest population of rabbit does for meat production. There were also more niche markets in the Klang Valley area, such as Satay Hj. Samuri, burger manufacturing, among other downstream operations.

In Malaysia, on the other hand, the farming size is typically small, with less than 300 does per farm (Alimon, 2013), but the operation is completely

commercial. East Asia Rabbit Ranch, a large rabbit farm in Malaysia, reportedly has over 30,000 rabbits (Alimon, 2013; Raharjo, 2016).

2.4 Rabbit feeding

Rabbit nutrition and the guarantee of farm feed security is critical for the survival of smallholder rabbit units. Based on observations in the region, it has been determined that low productivity is primarily affected by inadequate food management. The rabbits are usually fed only green forage without any concentrates or other feedstuffs. In general, they are given just pelleted feed. That feed must have all the nutrients the rabbits need in acceptable quantities and in correct balance, as well as be pleasant and well accepted by the rabbits.

As a result, the rabbit's growth rate of body weight is not optimum, resulting in poor slaughter weight and carcass consistency. Conditions like this can be changed by using feed additives that increase food quality so that it can fulfill simple living and manufacturing needs. The problem with maintenance execution, however, is the scarcity of raw materials, especially soybean meal (Santoso and Sutarno, 2009).

In practice, rabbits may be fed full feed, usually in the form of pellets. Feeding full feed in the form of pellets could solve the issue of choice, which prevented the rabbit from selecting a more preferred feed ingredient. Previous studies suggested that pelleted feed was superior to mash feed in rabbits, but average daily benefit did not vary when pellet feeds of 2.1 and 6.5 cm were eaten (Tistiana et al 2020).

2.5 Nutrient requirements of rabbits

Nutrition, fibre, fat, vitamins, minerals, and water are the essential foods for rabbits. Rabbits, as pseudo-ruminants, need a considerable number of forages as a cheap source of fibre.

Rabbits' crude protein requirements range from 12 to 18 % dry matter (DM) and often differ according to life stage. The requirement for each age group began during conception and lactation, when 18% DM protein is needed, followed by development at 15% to 16% DM protein and maintenance at 13% DM protein. Excessive protein levels can promote *Clostridium sp.* formation, potentially resulting in enteritis (Carpenter et al., 2010).

Carbohydrates are a significant source of nutrition for rabbits. Most rabbits' carbohydrate requirements are met by fibre. A diet rich in grain or fermentable fibre, such as oats and corn, may result in enteritis, whereas a diet high in non-digestible fibre, such as timothy grass hay and alfalfa hay, can help avoid enteritis and obesity (Vicky, 2011). Non-digestible fibre is essential for dental health in rabbits since it aids in tooth wear and stimulates gut motility. Unlike poultry or swine, rabbits need high-fibre diets that are bulky and low in density (Lukefahr, 2004).

It is well established that rabbits, like other non-ruminants, may incorporate dietary fatty acids into lipids in adipose and muscle tissue. Bacteria in the cecum generate volatile fatty acids (propionate, butyrate, and acetate), which are ingested into the bloodstream and used as energy. Rabbits need at least 12% percent DM crude fibre for lactation, 14% DM for gestation, and 15% to 16% DM for growth and maintenance, depending on life stage: 12% DM for lactation, 14% DM for gestation, and 15% to 16% DM for growth and maintenance (Carpenter et al.2010). Fibre content ranging from 18% to 25% DM is ideal for pet rabbits. According to Carpenter et al. (2010), low-fibre diets will reduce GI motility, potentially contributing to food and hair retention and the development of hairballs (*trichobezoars*).

Rabbits use fat for nutrition to consume supplements that are fat-soluble. Most foods produce DM fat of between 2% and 5%, which may come from a vegetable diet of rabbits. More fat in the diet typically leads to higher intakes of digestible energy (DE) as well as greater growth and feed efficiency.

In the diet, rabbits consume all calcium; extra calcium as calcium carbonate is excreted by the kidneys into the urine, which is present in milky texture. Excess calcium carbonate in the kidneys, ureters and blood may trigger crystals and uralites to develop. Rabbits thus need a calcium level of 0.5% to 1% DM (Carpenter et al., 2010).

Alfalfa, therefore, is a high-calcium vegetable with grains having a high level of phosphorus; thus, alfalfa and grains provide a sufficient diet of calcium and phosphorus in order to cultivate rabbit kits but being an excessive amount for grower-stage rabbits. Minerals are added to commercial rabbit feed. Rabbits do not have mineral salt blocks, though, if a commercial diet is fed (Carpenter et al., 2010).

2.6 Mulberry

Mulberry (*Morus alba L.)* is indigenous to northern and central China. It is grown in a variety of climates since it is very adaptable and can thrive in adverse situations (Li RX et al, 2018) (Singhal et al, 2010). It is grown throughout the majority of the world's regions, including East Asia, Southeast Asia, Europe, Africa, and America (Boubaya et al, 2011). Previous research **(Cai et al, 2019)** has revealed that mulberry leaves are abundant in nutrients, particularly crude protein (20% of dry matter). This might enhance the healthy and sustainable growth of animal husbandry, resulting in greater economic, social, and environmental advantages. As a result, there is significant potential for the development and use of mulberry leaves as livestock and poultry feeds.

Mulberry leaves, according to Sanchez (2000), are very appealing and readily digested (70-90%) for herbivores and may also be given to monogastric. Mulberry leaves contain 82.7%–95.5% of carbohydrate, 24.6%–32.3% of neutral detergent fibres (NDF) and 15%–28% of crude protein (CP), like legume forages in chemical composition (Sanchez, 2000). Mulberry leaves could be an exceptional forage for ruminants because of their high protein and nutritional value, as well as lower fibre and tannin contents (Wang et al, 2012). Moreover, mulberry leaves have high total digestibility in vivo (in goats) and in vitro (80%–

95%) (Sanchez, 2000), and even higher digestibility than alfalfa hay and oat hay in sheep (Doran et al, 2007). Therefore, mulberry leaves have been gradually used as a protein source in replacing concentrates in rabbits as well as other ruminants such as dairy cattle (Sanchez, 2000), beef cattle (Huyen et al, 2012) and goat diets (Anbarasu et al, 2004).

2.7 Pellet

Rabbits typically consume a pelleted commercial feed that is nutritionally balanced (protein, vitamins, minerals, and energy). Corn, alfalfa, protein supplements, and minerals, as well as mineral supplements, are included in these diets (wheat mill and barley by products). When greens are added to a pelleted diet, they lower the number of pellets by half without impairing rabbit growth. However, since fresh greens contain around 80% to 90% water, rabbits cannot be reared on these materials because they are not nutrient-dense.

In general, considering the physical aspects, it was advised to utilise pelleted feed with a diameter of 3 to 5 mm and a length of 6 to 13 mm (Gidenne and Maertens, 2017). If the rabbit's length is longer, they may waste feed because when they chew the pellets, some of the feed may fall and pass through the grid

floor. Pellet durability and hardness must be improved as it will limit losses as tiny particles, but too hard pellets can restrict feed intake, especially for young rabbits aged 3 to 6 weeks, and this may result in a lower FCR (Gidenne and Lebas, 2005).

Palletisation is the primary feed processing step in the manufacture of rabbit feeds. Rabbits have a considerable preference for pelleted feed versus mash-based diets. Pellets should be dense and hard, with a low fine content. Pelletizing enables the mixing of a range of feedstuffs and then cohesively binding them into a compact, uniform package. Because the animals are incapable of separating the elements, they consume the full balanced ration.

Pelletizing is a procedure that begins with the mixing of the feed components and ends with their passage through a pellet die. This is a chamber with holes in it through which the feed is pushed. Knives slice off pellets of the appropriate length as they exit the die. The feed pellet's diameter is governed by the size of the die's perforations. The smaller the die size, the more energy is needed to pelletize the feed and the faster the feed may be pelletized. Steam is often introduced into the mixture before it reaches the pellet die to increase the pace at which feed may travel through the mill. Steam both heats and moistens the air.

2.8 Commercial Pellet in Malaysia

Rabbit meat is still unfamiliar to Malaysians, and commercial feed remains prohibitively costly due to producer overhead costs and low volume. Many firms are not interested in formulating or producing rabbit pellets, even if they are, the manufacturing costs are high. As a result, a few industry players, such as Cooperative, are in discussions to allow them to formulate and commercialize their own feed to participants, ensuring the industry's long-term viability. Malaysians are also unfamiliar with rabbit meat, and the expense of commercial feed is still prohibitively costly due to vendor overhead costs due to the limited scale. Many companies are not interested in formulating or producing rabbit pellets, even if they are, the manufacturing costs are high. As a result, a few industry players, such as Cooperative, are in talks to allow them to formulate and sell their own feed to members, ensuring the industry's long-term viability.

2.9 Premium Rabbit Pellet

Pet stores line their shelves with items that claim to be "gourmet," "premium," "fortified with antioxidants," or "all natural." Farmers, on the other hand, ought to look at the nutritional analysis and ingredients list on the back of the packages to get an accurate understanding of how healthy a meal is. The most essential element is fiber, since the greater the fiber level (look for at least 18%), the healthier the diet would be for rabbit digestion. Then, to sustain their fast development, a stable adult rabbit requires a protein level of 12% -14%, whereas young rabbits (under five months) need a higher protein level of about 16%. Calcium should be between 0.5% and 1.0%, and phosphorus should be between 0.4% and 0.8%. The ratio between the two is also significant (which should be 1.5-2:1 calcium to phosphorus). Fat as an integral component should be about 2.4-5 percent. Vitamin D 1000 IU/kg, Vitamin E 50 IU/kg, and Vitamin A 10,000 IU/kg, for example, should have been given (The Rabbit House, 2017).

Furthermore, farmers must be mindful of the mentioned grasses that might appear on the packaging (such as timothy, alfalfa, fescue, hay, or forage) before cereals are planted (e.g., wheat, oats, corn, or maize). Since grass is higher

in fiber and lower in protein than cereals, grass-based diets usually offer a better nutritional balance.

2.10 Feed requirement and feed conversion

The overall food requirements for producing successful livestock output rely on the dietary composition. The higher the energy content (TDN) of the feed, the lower the weight gain per unit is required. Dietary fibers constitute the key component of rabbit feed (even percent of DM intensive production) and are dependent on the analysis technique, ranging from 15% to 50% (Table 2.10). Its need for fiber throughout the post-weaning period is more pronounced. Conversion of feed is the weight of the eaten feed divided by the weight of the increase in body weight. Weaning rabbits can eat about 3 kilograms of feed per kilograms and between 1.6 and 1.8 kilograms of feed per kilogram. Rabbits are as effective for transforming nutrition and energy into meat as broiler chicken (Cheeke et. al, 2000).

Table 2.10: The current amounts of fiber in a full rabbit feed based on the empirical process.

	% DM
Residue analysis	
Crude fibre	14–18
Acid detergent fibre (ADF)	16–21
Neutral detergent fibre (NDF)	27–42
Water insoluble cell-wall (WICW)	28–47
Total dietary fibre (TDF)	32–51
Other feed constituents	
Starch	10–20
Crude protein	13–18

Source: Gidenne, (2003)

2.11 Rabbit Meat

Several tests have shown that rabbit meat has a high nutritious value as compared to other meats (Combes, 2004; Dalle Zotte, 2004; Hernández and Gondret, 2006). Aside from water, the main components of meat are proteins and lipids. Rabbit meat is a lean meat rich in proteins of high biochemical importance and high amounts of basic amino acids (Dalle Zotte, 2004). Furthermore, meat is a good source of micronutrients that are easily absorbed, such as vitamins and minerals.

The various productive factors, especially feeding factors, have a significant impact on the chemical composition of rabbit meat, particularly its lipid composition (Dalle Zotte, 2002). Due to its low-fat quality, rabbit meat has a lower energetic benefit as compared to red meats (Dalle Zotte, 2004). Fat level ranges from 0.6 to 14.4 percent (fat from edible meat with intramuscular and intermuscular fat content), with an overall value of 6.8 percent (Hernández and Gondret, 2006), with the loin being the leanest component of the carcass (1.2 % of lipids).

The current price range is RM 35.00 – RM 45.00/kg for a carcass weighing 1-1.2 kg on average. The farm gate price for live weight is RM 13.50 per kg. According to a DVS report titled "Malaysian Preferences for Rabbit Meat," this price is considered expensive. In addition, the supply, affordability, and approval of rabbit meat must be investigated. The meat price is high due to the high operating costs, and it is also not inexpensive. The cost of feeding, whether manufactured or domestically manufactured, is high; hence, the cost of production is greater.

Furthermore, a sustainable solution by a specific government body, such as DVS, will include farmer and breeder training, special assistance for the sector, and adequate policy making. The farming system used is intensive, and depending on the scale, it can be semi-commercial or commercial (Gunalan et.al, 2019).

CHAPTER 3

METHODOLOGY

3.1 Experimental design

This experiment had three treatments with three (3) replications for each treatment as mentioned in Diagram 3.1. All the treatments were prepared using two different types of feeds, which were the use of commercial rabbit pellets and mulberry pellets. The experiment has been conducted in UMK Kampus Jeli, Kelantan. The commercial rabbit pellets, Dolphin brand was purchased from the local supplier in Bukit Bunga, Jeli, while the mulberry pellet was processed and done in the animal lab. The complete formulation of the mulberry pellets (30kg)

was pelletized in industrial company name IOU Resources Engineering in Kota Bharu, Kelantan.

• 2 months (60 days) of New Zealand White breeds that passed from the lactation period (grower) was selected for feeding trial.

Diagram 3.1: Three different kind of treatments with short details.

Control

- 100% of commercial of rabbit pellets
- 3 of rabbits, 3 cages
- 3 males

Treatment 1

- 100% of mulberry pellets
- 3 of rabbits, 3 cages
- 3 males

Treatment 2

- 50 : 50 (50% of commercial rabbit pellets : 50% of mulberry pellets)
- 3 of rabbits, 3 cages
- 3 males

3.2 Mulberry Leaf Powder Preparation

Mulberry (*Morus alba var. multicaulis*) leaves were collected in October 2021 from two locations inside University Malaysia Kelantan; Agro Techno Park and the Faculty of Agro-Based. After drying the leaves in an oven for 24hours with 50-80°C, they were ground in the Animal Laboratory. Before grinding, the leaves and stem were separated since the feed formulation proportion only required 70% of the mulberry leaves and 30% of the stem.

3.3 Experimental site and animal

Nine (9) New Zealand White rabbits of 2 months old of rabbits have been used and they went through adaptation period for one week. All 9 males of rabbits have been used in the feeding trials. The duration of feeding trial was 35 days excluded the adaptation periods. All the rabbits were randomly allocated into 9 cages separately. The cages were constructed rectangular in shape with net measuring of ½ inch x ½ inch with a thickness of 18 gauge along 7 feet of stainless type. It will be an indoor house of rabbit farm which was located around 1000 max of rabbit with different size and age.

The cage of the rabbit has been equipped with feeder and auto-drinker. The auto-drinker was used nipple drip as waterer and the house will be equipped with good electricity and clean water direct trough pipe. The experimental site was conducted at Rabbit Barn in Universiti Malaysia Kelantan, Kampus Jeli, Kelantan. Data from the above three treatments group were compared.

3.4 Experimental diets

The diets were divided into three groups which were control, treatment 1 and treatment 2. Control group used 100% of commercial pellet of goat with brand name as Dolphin while treatment 1 used of 100% of our own formulated mulberry pellet. While treatment 2 used mix feeds with ratio 50% of commercial pellets: 50% of mulberry pellets. The common ingredient of premium commercial pellets of rabbit were contains only the finest ingredients. The complete formulation of mulberry pellet in the Treatment 1 and Treatment 2 (Table 3.4) were developed with common ingredients such as mulberry leaves and stems, molasses, starch, and Sodium Bicarbonate as pellet binder.

Table 3.4: The complete feed formulation ratio for mulberry pellet.

RAW INGREDIENTS	AMOUNT %	AMOUNT % (30kg)
Mulberry	89%	
Leaves (70%)		18.69kg
Stems (30%)		8.01kg
Molasses	5%	1.50kg
Starch	5%	1.50kg
Sodium Bicarbonate, Na	1%	0.3kg
Total	100%	30.00kg

3.5 Feeding management

The feed trial was carried out at Rabbit Barn of Universiti Malaysia Kelantan, Kampus Jeli for 5 weeks after a period of 7 days of adaptation. Rabbits were fed pellets once times a day at 5p.m every day. Water was always made available.

3.6 Data Collection

All animals were weighed individually at the start of the experiment and then once a week before the feeding routine. During the experiment, the average body weight gain, total feed intake, and FCR were measured. During the experiment, the given feeds were weighed before each meal, and the refusals (leftover feed) were collected and weighed every day before the first meal. Total feed intake and average body weight gain of each rabbit were collected during a 7-day period throughout the experiment.

3.7 Evaluation of rabbit performance between groups

3.7.1 Body weight gain

The weight of rabbits has been weighed weekly before morning feeding. Each of the rabbit was weighed using weighing scale. All the records based on

the weight, groups and cage were recorded in one book act as record keeping book.

3.7.2 Feed intake

The feeds were weighed and fed to the rabbits every morning. Each rabbit was served with different amount of feed that it followed their body weight and calculated with dry matter (DM). For the treatment 1 groups, the commercial pellet of goat was giving to the rabbits, while treatment 2 groups will be fed with the commercial premium pellet of rabbit. The leftover of the next meal has been weighed using digital balance. To know the feed intake of the rabbit, the leftover of the feed has been subtracted with the total amount of feed.

3.7.3 Feed conversion ratio

Feed conversion ratio (FCR) was the conventional measure of livestock production efficiency as the weight of feed intake divided by weight gained by the animal. The amount of feed ingested by an animal that can be converted into one kilo of live weight.

$$FCR = \frac{\text{The weight of feed intake}}{\text{The animal weight gain}} \quad (3.7.3)$$

3.8 Evaluation of rabbit performance between groups

3.8.1 Dry matter analysis

Dry matter was determined by weighing 2g of both different type of pellet sample and placed on aluminum foil that have been shaped like a bowl. W1 as the weight of empty aluminum foil bowl-shaped and W2 as weight of sample in DM. The sample was dried at 110oC in an oven for 12 to 24 hours. After dried, let the sample cool down in the desiccator. W3 as final weight after drying process. Lastly, the DM was calculated by following the formula below:

$$DM\% = W3 - W2W3 \times 100\% \quad (3.8.1)$$

W1= Weight of empty aluminum foil bowl-shaped (g)

W2= Weight of sample (g) in DM

W3= Final weight of dried sample (g)

3.8.2 Nutrient Analysis

a) Moisture content

Moisture content represents the amount of water in feed samples. A moisture content that exceeds the defined limit increases the probability of mould formation, lowering pellet quality during storage.

$$\text{Moisture content (\%)} = \frac{W2 - W3 \times 100}{W2 - W1} \qquad (3.8.2.1)$$

were,

W1 = weight of container with lid;

W2 = weight of container with lid and sample before drying; and

W3 = weight of container with lid and sample after drying.

a) Crude protein (CP)

Crude protein was determined by using Kjeldahl method which involved digestion, distillation, and titration process.

i. Digestion:

1g of dry pellet sample into the digestion tube has been weighed and fell roughly. To the digestion tube, 10 ml filtered water and 1 Kjeltab tablet were attached. After filling the digestion tube with 12 ml of concentrated H2SO4 solution, was inserted into the digestion rack in the fume chamber. Prior to inserting the digestion rack, the Gerhardt Kjeldatherm digestion block was turned on and preheated to 400oC. The rack then be removed from the rack holder and permitted to cool.

ii. Distillation:

Approximately 40% of NaOH was added to the alkali tank of the Foss Kjeltech distillation machine. Following that, digested samples will be mixed with 80ml purified water and 50ml 45 percent sodium hydroxide (NaOH). A total of approximately 30 ml of receiver solvent was applied to the receiver flask. Around 250 ml of Erlenmeyer titration flask was

mounted on the receiving platform and filled with 4% boric acid (H3BO3) and indicator. The flask then be placed into the receiver solution tank. For five minutes, the samples were distilled. The transition of color was noticed.

iii. Titration:

Boric acid receiving solution was titrated with standard 0.1 M HCl until it turned pink in color. The volume of HCl used will be recorded and CP will be calculated by using formula below:

$$N\% = [V - V(blank)] \times n \times 14.007W \qquad (3.8.2.2)$$

V = Volume of acid neutralized sample (ml)

N = concentration of HCl

W = Weight of sample (g) in DM

CP % = N% x 6.25

b) Crude fat (ether extract) analysis

The crude fat content was measured using the Soxtec method. Prior to starting, the aluminum cups were heated to 103°C for 30 minutes and then dried for 20 minutes in desiccators. Weights will be applied to the cups, and measurements were registered to four decimal points (W1). 2g of sample was weighted into the thimble, and the sample's weight was noted (W2). The thimbles were transferred to the thimble table, and the sample was covered with a sheet of de-fatted cotton. The thimbles were then transferred to the thimble support. The thimbles were attached to the magnets and placed into the extraction device. Each cup was loaded with 80ml petroleum ether and placed in the extraction device using the cup holder. The machine was initiated by pressing the RUN switch. After the extraction was complete, the cups were extracted and heated to 103°C for 30 minutes. The cups were permitted to cool for 20 minutes in the desiccators. Weighing the cups yielded the final weight, which was been noted as W3. The EE % has been measured using the following formula:

$$EE\ \% = W3 - W1W2 \times 100\% \qquad (3.8.2.3)$$

W1= Weight of empty cup (g)

W2= Weight of sample (g) in DM

W3= Weight of cup after extraction process (g)

c) Crude Fibre analysis

In fiber analysis test, every batch of samples were running along with a blank through entire procedure. Firstly, the pre-dried crucibles were placed on a balance and tared. Each sample was weighed with a precision of 1000 ± 2 mg. If sample homogeneity permitted, a smaller sample was used to further improved the filtration speed. If fat or carbonate content was high, Fibertec Cold Extraction Unit were used to remove prior the analysis. Next, the crucibles were placed in hot filtration unit using the holder and were locked into position in front of the heater in the Fibertec 8000 which the safety handle engaged were ensured first. Then, the reflector was placed in front of the crucibles. After that, Acid tank and Alkali tank were refilled with 1.25% sulphuric acid and 1.25% KOH respectively and were placed in the drawer (left for acid tank and right for alkali tank) and all connections were fixed. The amber bottle with antifoaming agent n-Octanol inside side door was refilled. Water tap was opened (about 2 ½ minutes) for reflux system. Next, the instrument was turned on and the default CF program was started by pressed the "START" button twice for double confirmations. At the end of extraction, the reflector was removed, and the safety handle also was lifted. After that, the crucibles were moved to the cold extraction unit for acetone soaks by used the crucible holder and then, the crucibles were refilled with 20-25 ml of Acetone and soaked within 3-5minutes, and this procedure were repeated three times. Let it evaporate. Next, the crucibles were dried off in an oven at 105 ± 2

°C for at least 5 hours or at 130 ± 2 °C for 2 hours. The crucibles then were cooled to room temperature in a desiccator and were weighed accurately to 0.1 mg. Then, the sample in the crucibles were ashed at least 3 hours at 525 ± 15 °C. The crucibles were heated and cooled with caution. Finally, the crucibles were cooled down slowly to room temperature in a desiccator and weighed accurately to 0.1 mg.

$$\text{Crude Fiber} = \frac{100 \times W2 - W3 - C}{W1} \qquad (3.8.2.4)$$

W1 = Sample weight

W2 = Crucible + Residue

W3 = Crucible + ash residue

C = Blank

d) Ash analysis

The ash content of feedstuff samples was measured by burning the organic matter at 6000C for 8 hours in a muffle furnace. W1 was the weight of the empty crucible, and W2 was the weight of 2 grams of sample. For eight hours, the sample was incinerated at 600°C in a furnace. The sample was allowed to cool in the desiccator for a few minutes. W3 was assigned to the final residue within the crucible after it was weighted. The following method was used to measure the amount of ash:

$$\text{Ash } \% = W3 - W1W2 \times 100\% \qquad (3.8.2.5)$$

W1 = Weight of empty crucible (g)

W2 = Weight of sample (g) in DM

W3 = Weight of crucible and ash (g)

3.8.2 Statistical analysis

Data was presented in mean ± standard deviation (SD). All the experiment's data have been analyzed using One-Way ANOVA and Student T-Test with Microsoft Excel and SPSS applications to compare the differences and its significance, with $p<0.05$ deemed important. Duncan, informative, and homogeneity of variance tests, as well as a mean map, was used to calculate the mean and standard deviation. Body weight shift, average weight gain, overall feed intake, average dry matter, feed conversion ratio, and cost benefit ratio were among the data that were been analyzed.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Proximate Analysis

Table 4.1: Chemical composition of different pellets treatments.

Parameters	Treatments (mean ± standard deviation)			p-value
	T1	T2	T3	
Dry Matter (%)	93.95 ± 1.43^{b}	70.86 ± 3.33^{a}	85.76 ± 2.11^{b}	0.001
Crude Protein (%)	5.45 ± 0.40^{a}	8.79 ± 0.32^{b}	11.79 ± 0.29^{c}	0.000
Ether extract (%)	1.42 ± 0.13^{a}	5.85 ± 0.19^{c}	3.87 ± 0.10^{b}	0.000
Crude Fiber (%)	17.87 ± 0.16^{b}	14.26 ± 0.42^{a}	17.97 ± 0.80^{b}	0.004
Ash (%)	12.35 ± 0.16^{b}	11.52 ± 0.07^{a}	12.30 ± 0.31^{b}	0.051

^{abc} mean with different superscript in a row differ significantly ($p<0.05$)

T1 = TMR loose form of mulberry mixture; T2 = Commercial pellet of rabbit; T3 = Mulberry pellet.

According to Table 4.1, there were significant differences in dry matter content ($p<0.05$) between the treatments. T1 has the highest dry matter content (93.95%), followed by T3 (85.76%) and T2 (70.86%). However, no significant differences in dry matter content were seen between T1 and T3. The dry matter content of rabbit pellets is critical in determining the pellets' quality (Prayoga et al, 2020). The dry matter content of pellets from various treatment ranges in T1 and T3 was shown to be adequate for storage without risk of fungal development. Molds develop when the dry matter content of pellet feed is less than 85 %, as seen in T2 (70.86%). Molds degrade the quality of pellets by absorbing nutrients

from the feed and producing harmful compounds (mycotoxins), which may result in decreased animal productivity (Prayoga et al, 2020).

Akande & Kemi Eunice (2015) in their research stated that the dietary protein levels for fattening rabbits should consequently be high, with a minimum need of 16.11-18.00% for. However, none of the treatments in this study pellet were adequate as they were only T1 (5.45%), T2 (879%) and T3 (11.79%) respectively. According to Ali et al. (2011), Obinne & Okorie (2008), and Obinne & Mmereole (2010), rabbits grew at the fastest rate when given diets containing 16% of crude protein. Additionally, this research demonstrates a significant difference in crude protein concentration ($p<0.05$) between all the treatments. Nevertheless, rabbits may adapt to low and inadequate protein environments since they exercise caecotrophy, although their output will be less than optimal (Akande & Kemi Eunice, 2015).

The presence of significant errors during the Kjedahl Test or from the machine used could explain why most of the the crude protein levels in this study were low, including the commercial pellet. There is no error-free test for protein content, and mistakes in protein testing are unavoidable (Williams, 2000). To begin with, the grinding process was a major source of error. According to a previous study by Williams (2000), grinding the sample influences the error of reference testing (Kjeldahl test), as single tests performed on separately ground

samples resulted much higher errors than duplicate tests performed on ground samples. (Williams, 2000) also concluded that when an instrument is only calibrated once to provide accurate results, the precision influences the instrument's performance every time it is used. That is why accuracy and precision should be checked daily, with accuracy determined by comparing the results to those of certified reference values and precision determined by determining the instrument's variability in testing the same samples over a period of at least a few days.

Apart from protein, the rabbit's monogastric nature necessitates the consumption of fibre. Fibre content was around 17.87 % in T1, 14.26 % in T2, and 17.97 % in T3, which was also within the recommended range of fibre for rabbit, which is between 12 and 20% (Gidenne et al, 2003). The crude fibre content varied significantly ($p<0.05$) across treatment groups. However, no significant difference between group in dry matter content was seen between T1 and T3. The slightly elevated crude fibre content was most likely caused by the fibre remnant from the mulberry stems included in the ingredient. According to Leng (2008) and De Blas & Wiseman (2010), fibre is critical for regulating the activity of microorganisms in the rabbit digestive system, sustaining intestine peristalsis, and so promoting digestive health. If a diet is deficient in fibre, it results in a reduction in intestine peristalsis and a longer time for feed to move throughout the digestive tract (Irlbeck, 2001). In contrast, when the fibre level is too low, rabbits are more susceptible to digestive disease, even if growth and FCR

are maintained. Below 13% ADF (Acid Detergent Fibre), the risk of diarrhoea rises, healthy rabbit growth is often lowered by 10% to 20%, but the FCR is maintained or enhanced 5% to 10%, (Gidenne et al., 2000; Bennegadi et al., 2001).

The data on ether extract digestibility (EE) of diets evaluated reveal a wide range, ranging from 1.42% to 5.85% (Table 4.1). This study also reveals a significant difference ($p<0.05$) in ether extract content across all treatments. The extract ether content, on the other hand, was suitable for developing rabbits in all treatment groups. Most foods contain 2% to 5% DM fat, which rabbits may get from a vegetable diet, but rabbits do not need essential fat in their diet. Fat may improve palatability, but too much can raise the risk of obesity, hepatic lipidosis, and aortic atherosclerosis. The variable treatment results may be attributable to the digestibility of fatty acids, which varies depending on the fat source in the meal (Fiorentini et al,2015). According to (Table 3.4), mulberry pellet and TMR loose form of mulberry did not contain any necessary fat sources in the formulation of the raw material or during the pelleting process. According to Fernandez-carmona et al. (2000), most commercial pellets may include raw ingredients such as sunflower oils and soyabean as constituents in diets that enable the integration of a significant quantity of cellular fat. Furthermore, some feed producers have used a mixture of expansion and extrusion before pelleting, which allows for increased fat inclusion in the mix (up to 10% in rabbit diets)

without compromising pellet durability. This might be the single reason T2 has a greater fat content (5.8%) than other treatments.

The crude fibre content in T1 was 17.87 %, T2 was 14.26 %, and T3 was 17.97%, respectively. Following that, significant variations in crude fibre were observed ($p<0.05$) across the three treatment groups. However, there were no discernible difference in crude fibre content between T1 and T3. The crude fibre level of all treatments was relatively high, in comparison to the 15% to 16% crude fibre need for fattening rabbits. The slightly elevated crude fibre content in T1 and T3 was most likely attributable to mulberry stem fibres. A fibre content of 18% to 25% DM is ideal for rabbits (Carpenter,2010).

The ash content showed significant differences ($p<0.05$) for the treatments of T1, T2 and T3, those were 12.35%, 11.52%, and 12.30%, respectively. However, no difference between groups was showed on ash content between T1 and T3. The difference of ash in this research probably due to the different of pellet ingredients between commercial and mulberry pellet. The extract ether content in feed was appropriate for growing rabbits.

4.2 Body Weight and Average Weight in Rabbit per Group

The body weight of rabbits was increased from week 1 to week 5, and there was no significant difference in body weight between the control, treatment 1, and treatment 2 groups, as the p-values were more than 0.05.

4.2.1 Body weight (g) between groups (Mean ± SD)

Total Body Weight	Treatments (mean ± standard deviation)			p-value
	Control	Treatment 1	Treatment 2	
W1(Initial)	1188.67 ± 224.47[a]	1692.00 ± 98.03[c]	1508.67 ± 254.62[b]	0.285
W2	1480.00 ± 203.14[a]	1824.67 ± 125.73[c]	1525.33 ± 266.89[b]	0.484
W3	1784.00 ± 226.71[b]	1993.33 ± 119.36[c]	1598.67 ± 204.07[a]	0.395
W4	1730.67 ± 263.46[b]	2018.67 ± 117.03[c]	1667.33 ± 206.01[a]	0.478
W5	1908.67 ± 207.02[b]	2098.00 ± 117.89[c]	1569.33 ± 120.78[a]	0.206

[abc] mean with different superscript in a row differ significantly ($p<0.05$)

Control = Commercial pellet of rabbit; T1 = Mulberry pellet; T2 = 50% mulberry pellet and 50% commercial pellet.

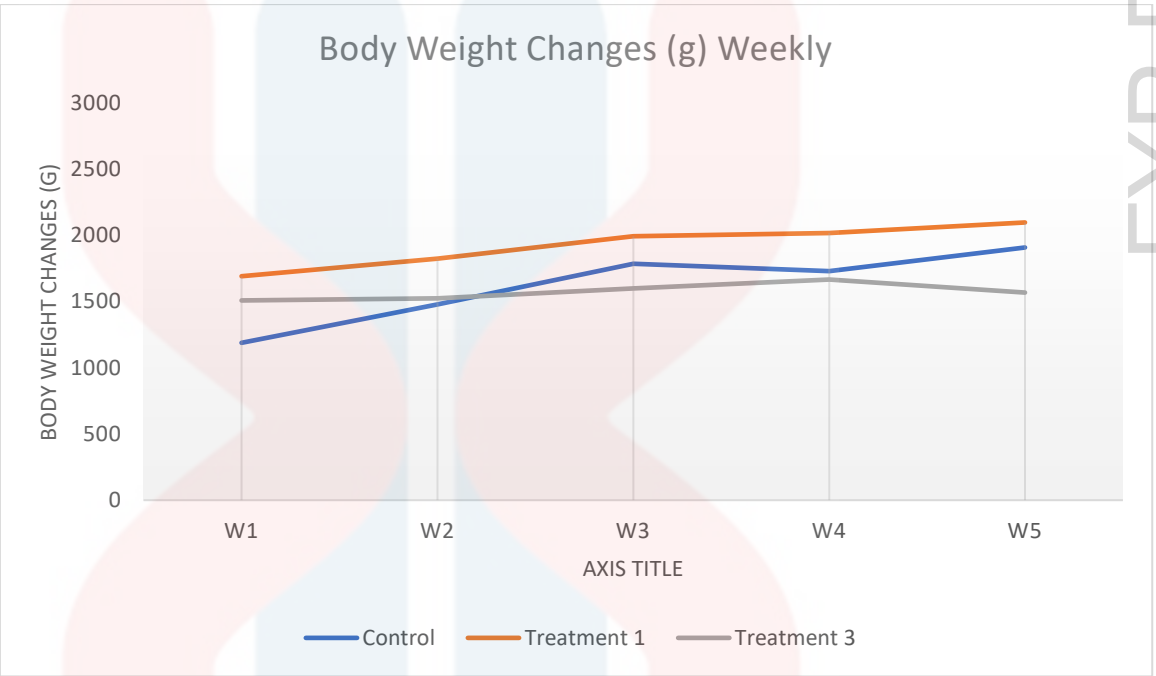

Figure 4.2.1 Body weight changes (g) between groups.

The body weight change of rabbits given a diet of 100% commercial pellet serves as the control, while treatment 1 fed a diet of 100% mulberry pellet and treatment 2 fed a diet of 50% commercial pellet and 50% mulberry pellet are reported on (Table 4.1.1). Overall, the outcomes of body weight changes for all feed groups were significantly different (Table 4.1.1). The diet control group performed well at first, but by week four, the value had begun to decline. While treatment 1 demonstrated consistent rising performance of body weight throughout the duration of the five-week feed trial. Treatment 2 had a modest rate of change in body weight and finished with a decrease in value during week 5. We explain the findings of the comparison between control, treatment 1,

and treatment 2, which reveal that treatment 1 outperforms the other treatments during the duration of the five-week feed trial.

4.2.2 Average weekly body weight (g/d) between groups (Mean±SD)

Parameters	Treatments (mean ± standard deviation)			p-value
	Control	Treatment 1	Treatment 2	
Total Body Weight	1466.67 ± 74.46[a]	1923.33 ± 113.48[c]	1573.33 ± 225.78[b]	0.165

[abc] mean with different superscript in a row differ significantly ($p<0.05$)

Control = Commercial pellet of rabbit; T1 = Mulberry pellet ; T2 = 50% mulberry pellet and 50% commercial pellet.

The findings of table 4.2.2 indicate two points. To begin, the average weekly changes in body weight between treatments reveal that treatment 1 is the highest group (1923.33g). Second, the control group received the least treatment (1466.67g). According to these findings, treatment 1 outperforms all other treatments. However, the average weekly weight change of rabbits revealed no statistically significant difference between the control, treatment 1, and treatment 2 groups, since the p-value was more than 0.05. The studies' findings established a strong case for the potential value of Mulberry pellets (treatment 1) as an alternative for commercial pellets on the market.

This study discovered evidence that the Mulberry pellet has the concentration required to achieve possible weight increases in rabbits. Supplementing diets with mulberry leaves has also been shown to promote body weight growth in growing animals (Benavides, 2000).

Additionally, Sánchez (2000) revealed that feed digestibility was a factor affecting rabbit growth rate. Mulberry leaves may be given to herbivorous and monogastric animals such as rabbits due to their great palatability and digestibility (70-90%).

Following that, these studies' feed diets may influence rabbit body weight increase. The quantity of mulberry supplied increased total intake and weight changes, indicating that it has a better nutritional content than the commercial feed diet. These studies demonstrate the nutritional composition of the mulberry pellet, including its dry matter (DM), crude fiber (CF), moisture content, ether extract (EE), crude protein (CP), and ash. Dry matter (table 4.1) values for treatment 1 (93.95 %) and treatment 3 (70.86 %) including mulberry leaves are substantially greater than those for treatment 1 (85.76 %), commercial pellet group.

Mulberry treatments promoted increased growth rates. This was most likely owing to the greater protein level of the mulberry pellet treatments (11.79% CP) compared to the commercial pellets (8.79% CP). Mulberry pellets may

provide a high-quality protein source that is far less expensive than most other protein feeds and can be used in place of corn or soybean meal.

As shown in Table 4.1, mulberry pellet (T1) also has a greater fibre content (17.97%) than the other treatments. This conclusion is consistent with prior research in which (Lebas, 2013) said that for rabbits to have adequate digestion, the quantity of fibre in their meal should be (>14%). However, having an excessive amount of fibre results in a drop in the digestion rate and activity of the microbes, which results in a decrease in feed intake, ME, and other nutrients available in the diet. This would result in a decrease in rabbit production (Tao & Li, 2006).

Although the fat-added diet cannot logically raise growth rate, it should improve feed efficiency since it includes more energy per gram of dry matter (Fernandez et al, 2000). T2 from commercial pellets had a greater fat content, which is not ideal for rabbit diets. As in result, T1 and T2 from mulberry pellets fulfil the fat range need for rabbits.

4.3 Feed Intake and Feed Conversion Ratio

4.3.1 Feed Intake

Table 4.3.1: Total feed intake weekly of rabbits in different pellets treatments.

Parameters (g)	Treatments (mean ± standard deviation)			p-value
	Control	Treatment 1	Treatment 2	
Total Feed Intake	94.60 ± 5.32	97.31 ± 1.35	97.54 ± 2.30	0.804

Control = Commercial pellet of rabbit; T1 = Mulberry pellet; T2 = 50% mulberry pellet and 50% commercial pellet.

As indicated in Table 4.3.1, total feed intake of rabbits in various pellet treatments was not significantly different between groups since it was greater in all three (p 0.05). While total feed intake in treatments T1 (97.31%) and T2 (97.54 %) was significantly greater than the control treatment (94.60 %).

As with other monogastric animals, the developing rabbit's total feed intake increases as the dietary energy concentration increases. When fed ad libitum, rabbits attempt to limit their feed intake to maintain a constant intake of digestible energy (DE), as was shown 40 years ago (Thierry Gidenne and L Maertens,2016). Daily feed intake and weight increase, regardless of the regime, tend to drop after the tenth week of age, when the ideal growing phase has passed.

Our findings confirm Hedhly et al. (2010) as well as de Blas and Wiseman (2010). As a result, rabbits given the mixture like T2 (50% mulberry pellet and 50% commercial pellet) probably consumed more feed to meet their energy requirements.

4.3.2 Feed Conversion ratio

Table 4.3.2: Total feed conversion ratio of rabbits in different pellets treatments.

Parameters	Treatments (mean ± standard deviation)			p-value
	Control	Treatment 1	Treatment 2	
FCR	6.06 ± 0.77	5.18 ± 0.27	6.49 ± 0.98	0.483

Control = Commercial pellet of rabbit; T1 = Mulberry pellet; T2 = 50% mulberry pellet and 50% commercial pellet.

The results of Table 4.3.2 suggest that the total feed conversion ratio of rabbits in various pellet treatments is greatest in treatment 2 (6.49%). The control group, on the other hand, got the least treatment values (5.18%). Additionally, since the p-value was greater than 0.05, the total feed conversion ratio of rabbits

in various pellet treatments indicated no statistically significant difference between the control, treatment 1, and treatment 2 groups.

The FCR is the most often used parameter to indicate the efficiency with which feed is converted to live weight gain. Based on the Table 4.3.2, we noticed that treatment 2 which is mulberry pellet show the highest FCR value. It is correlated with the result of average weekly gain of the treatment 2 groups in the Table 4.22.

However, due to the close relationship between dietary fibre and DE content, FCR is more connected with less digestible fibre than with DE concentration (Gidenne and Lebas, 2010). (Garcia-Palomares et al., 2006) also said that if the various fibre needs are satisfied, increasing the dietary energy level, particularly in the concluding stage, lowers the FCR by around 0.15 points. We already know that mulberry pellet treatments include more fibre than the commercial treatment used in this research. However, the results of FCR in the mulberry group in Table 4.3.2 do not support the previous study's findings.

The FCR of growing rabbits increases linearly with age. Clearly, young, and quickly growing animals have a substantially higher FCR during the early fattening stage than they do as they reach slaughter weight. Above a weight of 2 kg (9 weeks), the FCR increases rapidly due to adipose tissue's strong allometry (fat versus protein and water) and a high energy cost of synthesis (Gidenne &

Maertens, 2016). This explains why the weekly body weight fluctuations (g) across groups associated with FCR are significantly reduced, culminating in a dramatic fall between weeks 4 and 5 of feed trial duration (12 and 13 weeks of age).

Apart from that, heat stress has a negative effect on feed intake and, as a result, on the FCR (Marai et al., 2002). Environmental conditions (temperature, housing) have a significant effect on growth performance and hence on the FCR. Individual cage fattening improves the FCR by 5 to 10% as compared to cages holding 6 to 8 developing rabbits (Garcia-Palomares et al., 2006).

CHAPTER 5

CONCLUSION

5.1 Conclusion and Recommendation

Rabbit fed with mulberry leaf pellet had higher nutritional values in the chemical composition analysis compare with commercial pellet in term of dry matter, crude protein, ether extract, crude fibre and ash content of rabbits. But there was no significant difference on growth performance analysis based on feed intake, body weight gain and FCR values among the treatments. To summarise, treatment 3 (100 % of mulberry leaf pellet) was adequate in substituting commercial pellets in terms of nutritional value, but it requires further study and changes before being tested in a feed trial. As the development of efficient rabbit diets should be based on locally available forages of high nutritive value such as

Mulberry leaf pellet in helping developing countries. Because livestock are almost always raised with the hopes of generating a profit, it is usually desirable that the ration provide the most economical performance to produce the maximum economic return.

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APPENDIX A

Table A.1: Chemical composition of different pellets treatments.

Descriptive

Proximate analysis

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
						Lower Bound	Upper Bound		
DM	Treatment 1	3	93.9467	2.48269	1.43338	87.7793	100.1140	91.40	96.36
	Treatment 2	3	70.8567	5.76183	3.32659	56.5435	85.1698	66.68	77.43
	Treatment 3	3	85.7600	3.66305	2.11486	76.6605	94.8595	83.11	89.94
	Total	9	83.5211	10.76940	3.58980	75.2430	91.7992	66.68	96.36
CP	Treatment 1	3	5.4467	0.69010	0.39843	3.7324	7.1610	4.65	5.86
	Treatment 2	3	8.7867	0.54721	0.31593	7.4273	10.1460	8.27	9.36
	Treatment 3	3	11.7900	0.51000	0.29445	10.5231	13.0569	11.28	12.30
	Total	9	8.6744	2.79475	0.93158	6.5262	10.8227	4.65	12.30
Fat	Treatment 1	3	1.4167	0.21939	0.12667	0.8717	1.9617	1.17	1.59
	Treatment 2	3	5.8500	0.32419	0.18717	5.0447	6.6553	5.56	6.20
	Treatment 3	3	3.8733	0.17214	0.09939	3.4457	4.3010	3.68	4.01
	Total	9	3.7133	1.93528	0.64509	2.2257	5.2009	1.17	6.20
Fibre	Treatment 1	3	17.8683	0.28314	0.16347	17.1650	18.5717	17.60	18.17
	Treatment 2	3	14.2603	0.72548	0.41886	12.4581	16.0625	13.47	14.89
	Treatment 3	3	17.9740	1.38934	0.80214	14.5227	21.4253	16.96	19.56
	Total	9	16.7009	1.99667	0.66556	15.1661	18.2357	13.47	19.56
Ash	Treatment 1	3	12.3533	0.28501	0.16455	11.6453	13.0613	12.07	12.64
	Treatment 2	3	11.5233	0.12583	0.07265	11.2108	11.8359	11.39	11.64
	Treatment 3	3	12.3033	0.53519	0.30899	10.9738	13.6328	11.96	12.92
	Total	9	12.0600	0.50828	0.16943	11.6693	12.4507	11.39	12.92

ANOVA

Proximate analysis

		Sum of Squares	df	Mean Square	F	Sig.
DM	Between Groups	822.279	2	411.139	23.369	0.001
	Within Groups	105.561	6	17.593		
	Total	927.839	8			
CP	Between Groups	60.413	2	30.207	87.491	0.000
	Within Groups	2.072	6	0.345		
	Total	62.485	8			
Fat	Between Groups	29.597	2	14.798	242.774	0.000
	Within Groups	0.366	6	0.061		
	Total	29.963	8			
Fibre	Between Groups	26.820	2	13.410	15.859	0.004
	Within Groups	5.074	6	0.846		
	Total	31.894	8			
Ash	Between Groups	1.300	2	0.650	5.084	0.051
	Within Groups	0.767	6	0.128		
	Total	2.067	8			

POST HOC TESTS

Homogenous Subsets

DM

Duncan[a]

Parameter	N	Subset for alpha = 0.05	
		1	2
Treatment 2	3	70.8567	
Treatment 3	3		85.7600
Treatment 1	3		93.9467
Sig.		1.000	0.054

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

CP

Duncan[a]

Parameter	N	Subset for alpha = 0.05		
		1	2	3
Treatment 1	3	5.4467		
Treatment 2	3		8.7867	
Treatment 3	3			11.7900
Sig.		1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

Fat

Duncan[a]

Parameter	N	Subset for alpha = 0.05		
		1	2	3
Treatment 1	3	1.4167		
Treatment 3	3		3.8733	
Treatment 2	3			5.8500
Sig.		1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

Fibre

Duncan[a]

Parameter	N	Subset for alpha = 0.05	
		1	2
Treatment 2	3	14.2603	
Treatment 1	3		17.8683
Treatment 3	3		17.9740
Sig.		1.000	0.893

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

Ash

Duncan[a]

Parameter	N	Subset for alpha = 0.05	
		1	2
Treatment 2	3	11.5233	
Treatment 3	3		12.3033
Treatment 1	3		12.3533
Sig.		1.000	0.870

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

Table A.4: Body weight changes (g/d) between groups (Mean±SE)

Descriptive

Body weight changes

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
						Lower Bound	Upper Bound		
W1	Control	3	1188.6667	388.79472	224.47074	222.8470	2154.4863	876.00	1624.00
	Treatment 1	3	1692.0000	169.78810	98.02721	1270.2230	2113.7770	1590.00	1888.00
	Treatment 2	3	1508.6667	441.01852	254.62216	413.1159	2604.2174	1070.00	1952.00
	Total	9	1463.1111	377.21494	125.73831	1173.1580	1753.0642	876.00	1952.00
W2	Control	3	1480.0000	351.84656	203.13870	605.9647	2354.0353	1264.00	1886.00
	Treatment 1	3	1824.6667	217.77358	125.73164	1283.6871	2365.6462	1692.00	2076.00
	Treatment 2	3	1525.3333	462.26544	266.88907	377.0023	2673.6643	1098.00	2016.00
	Total	9	1610.0000	350.04857	116.68286	1340.9289	1879.0711	1098.00	2076.00
W3	Control	3	1784.6667	392.67968	226.71372	809.1963	2760.1371	1550.00	2238.00
	Treatment 1	3	1993.3333	206.73010	119.35568	1479.7873	2506.8794	1848.00	2230.00
	Treatment 2	3	1598.6667	353.46476	204.07297	720.6115	2476.7218	1282.00	1980.00
	Total	9	1792.2222	331.21812	110.40604	1537.6254	2046.8190	1282.00	2238.00
W4	Control	3	1730.6667	456.32591	263.45989	597.0903	2864.2431	1344.00	2234.00
	Treatment 1	3	2018.6667	202.70504	117.03181	1515.1194	2522.2139	1886.00	2252.00
	Treatment 2	3	1667.3333	356.81555	206.00755	780.9544	2553.7123	1262.00	1934.00
	Total	9	1805.5556	347.07172	115.69057	1538.7726	2072.3385	1262.00	2252.00
W5	Control	3	1908.6667	358.57682	207.02442	1017.9125	2799.4209	1600.00	2302.00
	Treatment 1	3	2098.0000	204.18619	117.88695	1590.7734	2605.2266	1932.00	2326.00
	Treatment 2	3	1569.3333	373.72361	215.76942	640.9524	2497.7142	1300.00	1996.00
	Total	9	1858.6667	362.34652	120.78217	1580.1425	2137.1909	1300.00	2326.00

ANOVA

Body weight changes

		Sum of Squares	df	Mean Square	F	Sig.
W1	Between Groups	389355.556	2	194677.778	1.560	0.285
	Within Groups	748973.333	6	124828.889		
	Total	1138328.889	8			
W2	Between Groups	210450.667	2	105225.333	0.820	0.484
	Within Groups	769821.333	6	128303.556		
	Total	980272.000	8			
W3	Between Groups	233899.556	2	116949.778	1.090	0.395
	Within Groups	643744.000	6	107290.667		
	Total	877643.556	8			
W4	Between Groups	210390.222	2	105195.111	0.838	0.478
	Within Groups	753280.000	6	125546.667		
	Total	963670.222	8			
W5	Between Groups	430482.667	2	215241.333	2.083	0.206
	Within Groups	619877.333	6	103312.889		
	Total	1050360.000	8			

POST HOC TESTS

Homogenous Subsets

Body Weight Changes

W1

Duncan[a]

Experimental Period	N	Subset for alpha = 0.05
		1
Control	3	1188.6667
Treatment 2	3	1508.6667
Treatment 1	3	1692.0000
Sig.		0.143

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

W2

Duncan[a]

Experimental Period	N	Subset for alpha = 0.05
		1
Control	3	1480.0000
Treatment 2	3	1525.3333
Treatment 1	3	1824.6667
Sig.		0.298

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

W3

Duncan[a]

Experimental Period	N	Subset for alpha = 0.05
		1
Treatment 2	3	1598.6667
Control	3	1784.6667
Treatment 1	3	1993.3333
Sig.		0.204

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

W4

Duncan[a]

Experimental Period	N	Subset for alpha = 0.05
		1
Treatment 2	3	1667.3333
Control	3	1730.6667
Treatment 1	3	2018.6667
Sig.		0.284

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

W5

Duncan[a]

Experimental Period	N	Subset for alpha = 0.05
		1
Treatment 2	3	1569.3333
Control	3	1908.6667
Treatment 1	3	2098.0000
Sig.		0.100

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

Table A.4: Average daily weight changes (g) between groups (Mean ± SE)

Descriptive

Average Daily Weight Changes

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
Control	3	1466.6667	128.97028	74.46103	1146.2867	1787.0466	1360.00	1610.00
Treatment 1	3	1923.3333	196.55364	113.48030	1435.0670	2411.5996	1800.00	2150.00
Treatment 2	3	1573.3333	391.06692	225.78259	601.8693	2544.7974	1200.00	1980.00
Total	9	1654.4444	307.98178	102.66059	1417.7087	1891.1802	1200.00	2150.00

ANOVA

Average Daily Weight Gain

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	342422.222	2	171211.111	2.467	0.165
Within Groups	416400.000	6	69400.000		
Total	758822.222	8			

POST HOC TESTS

Homogenous Subsets

Average Daily Weight Gain

Duncan[a]

Parameter	N	Subset for alpha = 0.05
		1
Control	3	1466.6667
Treatment 2	3	1573.3333
Treatment 1	3	1923.3333
Sig.		0.086

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

Table A.5: Total feed intake of rabbits in different pellets treatments.

Descriptive

Total feed intake

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
Control	3	94.6000	9.20624	5.31523	71.7304	117.4696	83.97	100.00
Treatment 1	3	97.3067	2.33258	1.34672	91.5122	103.1011	95.94	100.00
Treatment 2	3	97.5433	3.98663	2.30168	87.6400	107.4467	92.94	99.86
Total	9	96.4833	5.34115	1.78038	92.3778	100.5889	83.97	100.00

ANOVA

Total feed intake

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	16.045	2	8.023	0.227	0.804
Within Groups	212.178	6	35.363		
Total	228.223	8			

POST HOC TESTS

Homogenous Subsets

Total feed intake

Duncan[a]

Parameter	N	Subset for alpha = 0.05
		1
Control	3	94.6000
Treatment 1	3	97.3067
Treatment 2	3	97.5433
Sig.		0.578

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

Table A.5: Total feed conversion ratio of rabbits in different pellets treatments.

Descriptive

Feed conversion ratio

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
Control	3	6.0633	1.33515	0.77085	2.7466	9.3800	4.74	7.41
Treatment 1	3	5.1800	0.46808	0.27025	4.0172	6.3428	4.67	5.59
Treatment 2	3	6.4900	1.69638	0.97940	2.2760	10.7040	5.05	8.36
Total	9	5.9111	1.24686	0.41562	4.9527	6.8695	4.67	8.36

ANOVA

Feed conversion ratio

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	2.678	2	1.339	0.823	0.483
Within Groups	9.759	6	1.626		
Total	12.437	8			

POST HOC TESTS

Homogenous Subsets

Feed conversion ratio

Duncan[a]

Parameter	N	Subset for alpha = 0.05
		1
Treatment 1	3	5.1800
Control	3	6.0633
Treatment 2	3	6.4900
Sig.		0.269

Means for groups in homogeneous subsets are displayed.

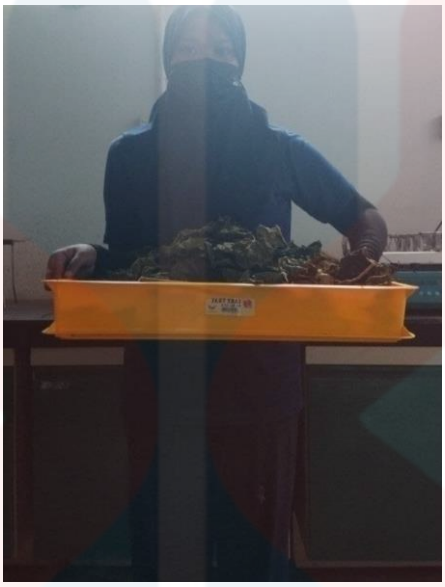
a. Uses Harmonic Mean Sample Size = 3.000.

APPENDIX B

Appendix B.1: The cutting of mulberry leaves using cutter.

Appendix B.2: The collected mulberry leaves with stems.

Appendix B.3: The drying of mulberry leaves and stems in the oven.



Appendix B.4: The drying of mulberry leaves and stems were separated.

Appendix B.5: The blending of mulberry leaves and stems into powder.

Appendix B.6: All the raw ingredients were weighed according to the formulated ratio.

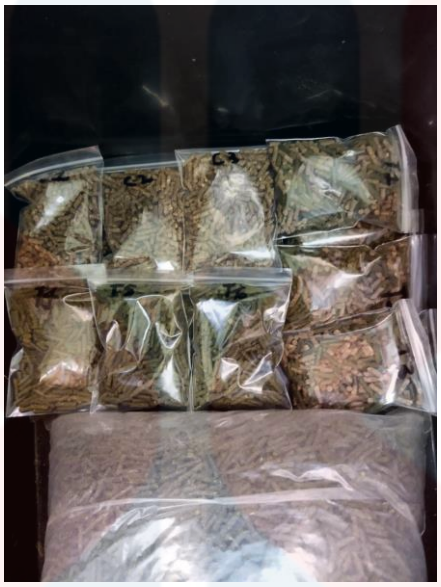
Appendix B.7: The mixing of all raw ingredients using mixer machine.

Appendix B.8: The packaging of complete formulated feed for pelletized (30kg).

Appendix B.9: The mulberry complete formulation feed were put into pelletizer machine.

Appendix B.10: The The mulberry leaf pellet was separated from dust and fines.

Appendix B.11: The pelletized mulberry pellet was done with packaging.



Appendix B.12: The preparation of samples for chemical analysis test in laboratory.

Appendix B.12: The run process of chemical analysis test in animal laboratory.

Appendix B.13: The feeding trial of the mulberry leaf pellet to the rabbits.

Appendix B.14: The measure of body weight of the rabbit per week.