The Effect of Dietary Mulberry Leaves (*Morus sp.*) And Feeding Frequency on Growth Performance in The Growing Rabbit (*Orytolagus Cunniculus*)

By

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A report submitted in fulfilment of the requirements for the degree of Bachelor of Applied Science (ANIMAL HUSBANDRY SCIENCE) with Honours

Faculty of Agro Based Industry

UNIVERSITY MALAYSIA KELANTAN

2018

DECLARATION

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

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I certify that the Report of this final year project entitle **"The Effect Of Dietary Mulberry *(Morus sp)* Leaves And Feeding Frequency On Growth Performance In The Growing Rabbit (*Orytolagus Cunniculus*)"** by **Lou Chan Hui**, matrix number F14A0123 has been examined and all the correction recommended by examiners have been done for the degree of Bachelor of Applied Science (Animal Husbandry Science), Faculty of Agro Based Industry, University Malaysia Kelantan.

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ACKNOWLEDGEMENT

I would like to express my deepest gratitude to my supervisor, Madam Nor Dini binti Rusli, for her excellent guidance, caring, patience, and providing me with an excellent atmosphere for doing research. Her timely and efficient contribution helped me shape this into its final form and I express my appreciation for her assistance in any way that I may have asked. I also need to give a deepest to the staff of Agro-Techno Park who allowed me to use the place and help me in the experiment period.

I also would like to thank Faculty of Veterinary Medicine, University Malaysia Kelantan and their staffs for the wonderful experience and their assistance along the effort in finishing my work. Thanks also given to Prof Madya Dr. Connie Fay Komilus, who allow me to use her nutrition lab in Unisza for proximate analysis to finish up my research.

I am indebted to many people for advice and help in one way or another to help me accomplish this study. I would never have been able to finish my dissertation without the guidance of my members and support from my family. I am also indebted to my friends for their help, knowledge and time. My research would not have been possible without their helps. Special thanks, tribute and appreciation to all those their names do not appear here who have contributed to the successful completion of this study.

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ABSTRAK

Pellet komersial telah digunakan secara meluas sebagai makanan utama arnab dan merangkumi kos operasi utama. Untuk menurunkan kos makanan, daun mulberi dikaji dalam ramuan makanan haiwan dalam tumbesaran arnab. Kajian ini dijalankan untuk menentukan komposisi kiia daun mulberi (*morus sp.)*dan menyiasat kesan kekerapan makan daun mulberi (*morus sp.*) pada prestasi pertumbuhan dan kecernaan arnab. Dua belas ekor arnab New Zealand berumur 4 hingga 5 minggu dipilih secara rawak dari populasi dan diedarkan kepada empat kumpulan rawatan. Setiap kumpulan ada tiga ekor arnab. Eksperimen ini berlangsung selama tempoh 84 hari. Terdapat empat kumpulan rawatan iaitu Kawalan, Rawatan 1, Rawatan 2, dan Rawatan 3, yang diberi makan sekali sehari; diberi makan sekali sehari dengan daun mulberi; diberi makan dua kali sehari; dan diberi makan dua kali sehari dengan daun mulberi. Arnab-arnab ditimbang pada hari pertama, dan setiap tujuh hari memerhatikan perubahan berat badan. Daun mulberi (10%) diberikan tambahan kepada kumpulan sasaran setiap hari dan air segar dibekalkan ad libitum. Tahi arnab dikumpulkan untuk penyasiatan pencernaan pada 10 hari terakhir. Hasilnya menunjukkan bahawa kekerapan makna dan daun mulberi tidak memunyai perbezaan yang signifikan terhadap prestasi pertumbuhan arnab dan pencernaan. Tetapi ia menunjukkan perbezaan yang ketara kepada nisbah penukaran makanan arnab (FCR). Arnab makan dua kali sehari tanpa daun mulberi memberikan indeks FCR yang terbaik iaitu 6.45$\pm$0.402 berbanding dengan 8.32$\pm$0.402, 8.05$\pm$0.402 dan 8.26$\pm$0.402 dalam Kawalan, Rawatan 1 dan Rawatan 3 masing- masing. Umpan selalunya melalui saluran pencernaan meningkatkan penyerapan nutrient dan meningkatkan berat badan. Daun mulberi mempunyai peratusan CF dan CP lebih tinggi berbanding dengan pellet komersil dalam diet harian. Kajian lanjut diperlukan pada kekerapan makan yang lebih tinggi dan paras mulberi yang lebih tinggi.

Kata kunci : *Morus sp.*, arnab, prestasi pertubuhan, kebolehtelapan, nisbah penukaran makanan.

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ABSTRACT

Commercial pellet has been widely used as the main feed for rabbit and covers main farm operational cost. In order to lower the feeding cost, mulberry leave was investigated in this study as the feed ingredient in the growing rabbit. This study was conducted to determine chemical composition of mulberry (*morus sp*.) leaves and investigate the effect of feeding frequency of mulberry (*morus sp.*) leaves on growth performance and digestibility of the rabbits. Twelve 4 to 5 weeks old New Zealand White rabbits were picked randomly from the population and were distributed into four treatment groups. Each group had 3 rabbits. This experiment last for a period of 84 days. There were four groups of treatment which were Control, Treatment 1, Treatment 2, and Treatment 3, which fed once per day; fed once per day with mulberry leaves; fed twice per day; and feed twice per day with mulberry leaves respectively. The rabbits were weighed on day 1 of feed trial and every seven day to observe body weight change. Mulberry leaves (10%) were given additionally to the targeted group every day and fresh water was supplied *ad libitum*. Rabbit droppings were collected for digestibility investigation on the last 10 days of experiment. The result showed that feeding frequency and mulberry leaves do not have significant difference on the rabbit growth performance and digestibility. But it shows significant difference to the rabbit feed conversion ratio (FCR). Rabbit fed twice per day without mulberry leaves give the best FCR index which is 6.45$\pm$0.4 compared to 8.32$\pm$0.4, 8.05$\pm$0.4 and 8.26$\pm$0.4 in Control, Treatment 1 and Treatment 3 respectively. Feed frequently gone through digestive tract increase nutrients absorption and improve body weight gain. Mulberry leaves have the higher CF and CP percentage compared to the commercial pellet which is suitable to replace commercial pellet in daily diet. Further research is necessary at higher feeding frequency and higher mulberry leaves amount.

Keyword: *Morus sp.*, rabbit, growth performance, digestibility, feed conversion ration.

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LIST OF ABBREVIATIONS

ADF	Acid detergent fibre
ANOVA	Analysis of variance
CF	Crude fibre
CP	Crude protein
DE	Digestible energy
DM	Dry matter
EE	Ether extract
GE	Gross energy
H_2SO_4	Sulphuric acid
H_3BO_3	Boric acid
ME	Metabolize energy
MP	Metabolize protein
NaOH	Sodium hydroxide
NDF	Natural detergent fibre
NE	Net energy
NFE	Nitrogen-free extract
NPN	Non-protein nitrogen

LIST OF SYMBOLS

^{o}C	Non-protein nitrogen
Cal	Calorie
Cal/g	Calorie per gram
d	Day
g	Gram
h	Hour
J	Joule
Kcal	Kilocalorie
Kg	Kilogram
kJ	KiloJoule
mL	Millilitre

CHAPTER 1

INTRODCUTION

1.1 BACKGROUND OF STUDY

In 2016, Malaysia Productivity Corporation, 23rd Productivity Report 2015/2016 stated that Malaysia's agriculture import has increased from RM78billon to RM84billon which include 7.7% increment of livestock in 2014 to 2015 (Sectoral Productivity Performance, 2016). According to the statistic in 2013-2014 that released by the Department Of Statistic Malaysia (2015), it was reported that Malaysia has imported much livestock from foreign country to fulfil the local requirement in Malaysia. The statistic showed that the import dependency ratio of beef, mutton, pork and chicken meat increased from 2014 to 2015, except chicken and duck egg (Department Of Statistic Malayisia, 2015). The per capita consumption rate for mutton and chicken meat also increase from 2014 to 2015. In 2014 the population in Malaysia increased from 30.7 million to 31.2 million people and it is increasing every year (Department Of Statistic Malaysia, 2016). The population in Malaysia and the consumption of the livestock is directly proportional increase.

In Malaysia, chicken is the main protein source for the community. The chicken meat per capita consumption increased from 2000 to 2011 (Jayaraman *et al*, 2013). The consumption of chicken meat has increased because there is no religion restriction to the meat and accepted to all religion in Malaysia. The market price of chicken meat is affordable to buy compared beef, pork and mutton. The chicken is healthier compared to beef, mutton and pork (Jayaraman *et al*., 2013). The chicken meat production rising every year but to ensure the production can sustain the demand, the industry used a lot of medicine and vaccine to ensure the chickens are healthy and away from diseases. This meat is lack of it quality when it affected by the outbreak diseases such as Influenza A H1N1, H1N2 and H5N1. This outbreak will affect to the wide area of the infected area and it can bring bad effect to the human included death because it is a zoonotic disease. The influenza H1N5 was detected recently in Kelantan, Malaysia in early 2017 and more than 1000 of chickens were culled around 2km of the infected area (New Straits Times, 2017). This outbreak is causing concern to public on the chicken meat consumption and consequently the demand will be reduced.

High demand of white meat in Malaysia market is an important issue that need to overcome in coming years. Rabbit meat is the alternative white meat sources to the community in Malaysia. Rabbit farming is a very potential livestock industry in Malaysia. Rabbit has high reproduction and high meat production. Rabbit rearing also contributes not only meat production but also fur skin, wool production and also as domestic pet.

1.2 Problem statement

Normally in rabbit production farm, farmers use commercial pellet as the main diet to the rabbits. Feed is the main expense to the animal farming. In daily feeding with the same amount of feed but increase the feeding frequency may improve the body weight gain of the rabbit growth, feed utilization and more uniform size (Dwyer *et al.*, 2002; Wang *et al.*, 1998; Xia *et al.*, 2017) of the rabbits. So farmers might be able to raise the rabbits better with the same amount of feed expenses. However, to lower the feeding cost, we can give alternative plant to the rabbit as the daily diet. But not all plants are suitable to the rabbit and providing the required nutrient to the rabbits. Bamikole *et al*. (2005) reported that the mulberry leaves can replace 50% of the commercial pellet in diet of rabbit. Mulberry leaves has a good potential to replace the concentrate in the rabbit feed. By adding in mulberry leaves as supplement might be able to improve rabbit body weight gain.

1.3 Hypothesis

Ho : The higher feeding frequency with supplement of mulberry leaves cannot improve the growth performance of the rabbits.

H1 : The higher feeding frequency with supplement of mulberry leaves can improve the growth performance of the rabbits.

1.4 Objectives of study

i. To evaluate the nutrient contents of the mulberry leaves.
ii. To evaluate whether the feeding frequency and mulberry leaves affect the growth performance and digestibility of the rabbits.
iii. To determine the feed conversion ration of the rabbit with the feed apply.

1.5 Scope of study

Twelve 4 to 5 weeks old New Zealand white rabbit from rabbit farm in Agropark Techno Park of University Malaysia Kelantan, Jeli Campus and the use of mulberry (*Morus sp*) leaves in rabbit diet.

1.6 Significance of study

Feed is the main expense in the production farm. Commercial pellet is high quality feed but it is costly. Increase the daily feeding frequency can improve the rabbit body weight gain with the same amount of feeding intake, therefore the production of meat can maximised to increase farmers' profit. Mulberry leaves has a great potential as feed supplement of rabbit. The contents of crude protein and fibre in mulberry leave are sufficient to the rabbit diet. In addition to that, the mulberry leaves also contain variable of vitamins such as ascorbic acid, and β-carotene, and mineral such as iron, zinc, and calcium (Srivastava *et al.*, 2006) that cannot get naturally from commercial pellet. The mulberry tree is the fast growing tree, which is also being easily cultured and planted. Additional of mulberry leaves in daily diet can improve the growth of the rabbits and give sufficient vitamins and minerals to rabbits.

CHAPTER 2

LITERATURE REVIEW

2.1 New Zealand Rabbit

Rabbit is the animal that under *Animalia* kingdom, family of *Leporidae*, is the species *Orytolagus cunniculus.* Rabbit in human life was used for meat, fur, research and pet purpose. Rabbit meat be the meal of human is because it is fine in texture, high protein, low fat content, cholesterol, salt, fibre (easy to digest) and taste good (Lee & Wee, 2010). Rabbit can be the future protein source because has the ability to utilize high roughage and low grain diet (Irlbeck, 2001).

New Zealand rabbit is considering large size rabbit. It is originated from United State of America (U.S.A.). New Zealand rabbit is the cross breed rabbit of Belgian Hare and white rabbit, Flemish (Lee & Wee, 2010). New Zealand rabbits were historically true meat providing breeds (Verhoef-Verhallen, 2006) but it also keep as pet. This breed of rabbit growth rapidly and can attend to the slaughter mass quickly, the doe are fertile and produce kids without difficulty (Verhoef-Verhallen, 2006). The mass of the buck can up to 4.5 to 5kg and the doe mass can up to 5 to 6kg (Lee & Wee, 2010).

2.2 Digestive System of the Rabbit

Rabbit is herbivorous non-ruminant (Irlbeck, 2001; Johnson, 2006) or pseudo-ruminant (Chiou, Yu, & Kuo, 2000). Rabbit is monogastric digestive system function same as other animal (Halls, 2008) with simple stomach without chamber but along with the microbial inhabited cecum and colon (Irlbeck, 2001). The rabbit digestive system included oesophagus, stomach, small intestine, duodenum, jejunum, ileum, large intestine, cecum, colon and rectum (Nath *et al.*, 2016). The main microflora occurs in rabbit Gastrointestinal (GI) tract is *Bacteroides sp*. (Johnson, 2006). The rabbit has the functional cecum and it's the largest compartment and it take pard 40% to the GI tract (Halls, 2008). Cecum is the most important organ for microbial fermentation (Abdel-Khalek *et al.*, 2011).

2.2.1 Stomach

Rabbit is the simple monogastric herbivore. The entire GI tract, stomach occupies 15% of the whole GI tract (Harcourt-Brown, 2002; Johnson, 2006). The matured rabbit has the stomach pH 1-2 as human being. Rabbit eat frequently up to 30 times per day. Even after 24 hours of fasting, the rabbit stomach still consists of the mixture of feed, hair and fluid (Johnson, 2006; O'Malley, 2005). Young rabbit with age of 2 weeks, it consume mother's cecotrophs from doe. The content of feed in stomach may affect the digest passage, gastric transit it takes around 3-6 hours (Harcourt-Brown, 2002; Johnson, 2006). Rabbit has the high voluntary feed intake (VFI) than a deer and it also has low gut retention compared to bovine (Johnson, 2006; Lowe, DeBlas *et al.*, 2010).

2.2.2 Small Intestine

This part of organ occupied 12% of the GI tract (Johnson, 2006; O'Malley, 2005). The function of small intestine and stomach of rabbit similar to the monogastric animal. Mainly nutrient absorption is occurring here. Motilin hormone stimulates the GI tract smooth muscle to contract but it responds to fat and inhibit by carbohydrate (Harcourt-Brown, 2002; Johnson, 2006). Lysozyme helps in degradation of the microbial protein in colon for the absorption of small intestine. The bacteria in cecotrophs convert carbohydrate into glucose and carbon dioxide and absorb primarily along with the amino acid and vitamins in the small intestine (Johnson, 2006).

2.2.3 Hindgut

Cecum and colon in the hindgut of rabbit (Johnson, 2006). Motilin is not present in cecum but present in colon and rectum. Caecum is the largest compartment in the digestive system of rabbit (Abdel-Khalek et al., 2011; Halls, 2008). It has 10 times of the size of stomach and take place around 40% of the intestinal content (Fisher, 2013; Halls, 2008; Johnson, 2006). Cecum has a thin wall and blind-end tube called vermiform appendix (Johnson, 2006; Nath et al., 2016).

The digestible materials will move into caecum and the cecal epithelium will absorb the volatile fatty acid (VFA) that generate from the bacteria when fermentation (Halls, 2008; Johnson, 2006). In morning, the cecal content is alkaline but it's acidic in the mid afternoon, this due to the fluctuation of the microbes called "transfaunation" (Johnson, 2006). Rabbit colon has 3 major part which are ascending part, transverse part and descending part (Johnson, 2006; Nath et al., 2016). In colon, there is a 3 longitudinal flat bands muscular tissue that increases the surface area for absorption. The haustral and segmental mechanism separate the ingesta to liquid content and indigestible particles. The large particle move to the middle of lumen, water absorption will occur and excrete out the particle from the body in hard dry droppings (Johnson, 2006).

2.2.4 Caecotrophy In Rabbit

Cecotrophs is consumable material that produces by the rabbit itself in the colon and cecum. It is small dark (Halls, 2008), soft and shiny surface. Caecotrophy begins when the rabbit start to intake solid feed in addition sucking doe's milk, it normally start at age of three weeks (Halls, 2008). It is one of the protein source to the rabbit. At the age of 2 weeks, kids start to consume cecotrophs from doe (Johnson, 2006). The cecotrophs in the stomach for 6 to 8 hours, fermentation will occur. Cecotrophs contain microorganism and the fermentation product from the microbes such as VFA, essential amino acids and vitamins B and K (Halls, 2008; Johnson, 2006), it can absorb to the body of the rabbit in small intestine. The fibre materials that larger than 0.5mm does not enter the cecum, it will transit to the form rabbit droppings. The smaller particles ad liquid will flow in to cecum by antiperistalsis and form high nutrient particles that coated with mucus (Halls, 2008; Johnson, 2006) which can protect the caecotrophs from the stomach acid when it store for several hours (Halls, 2008). This usually happened after 8 hours after feeding, caecotrophs will ingest normally at night. Rabbit normally will consume 50 to 80% of the daily faecal materials but it depending to the quantity and quality of the daily diet and the age of the rabbit.

A natural respond, the rabbit will recognize the caecotrophs with the strong smell of VFA, it can stimulate the caecotrophs consumption. The caecotrophs will ingest more when the diet of the rabbit lack of protein in diet. The caecotrophs consumption is affected by the protein and energy content in the feed. Consumption of caecotrophs is less if the diet is less than 15% crude fibre (Johnson, 2006). The less protein diet will increase the caecotrophs consumption but it decrease when the protein content is high (Halls, 2008; Johnson, 2006). Caecotrphs improve the digestibility of the protein in rabbit forage (Halls, 2008).

2.3 Diet Nutrition of Rabbit

Rabbit feed intake depends on the feed nutrient content and/or the palatability of the feed given. The dry matter intake is dependent to the actual energy need of the rabbit and protein and fibre level in the feed ration (Abdel-Khalek et al., 2011; Fekete & Bokori, 1985). The feed conversion to meat declines with the age increasing. The best feed conversion of rabbit efficient at 3 weeks old and least expensive gains is 4 to 6 weeks old, so it is an opportunity to use this full growth advantage during the interval (Abdel-Khalek et al., 2011; Blas & Wiseman, 2002).

2.3.1 Carbohydrate

Carbohydrate is one of the energy source for the animal. Plant carbohydrate can be classified into two groups incorporate with animal feed, which are: carbohydrate that hydrolysed by the gastrointestinal enzyme and carbohydrate that hydrolysed by the microbial enzyme (Blas & Wiseman, 2002). Further grouping, it can be separated into simple sugar & oligosaccharide and polysaccharide. α-galactosides (oligosaccharide) digested by the microbial enzyme while the simple sugar easy to digest in the endogenous enzyme of the host and adsorbed by the small intestine. Glucose and fructose id readily to absorb in the small intestine compared to starch (Blas & Wiseman, 2002) because glucose and fructose is monosaccharide which are the simplest for sugar that can absorb easily. Starch is the polysaccharides that store in the green plant which is the abundant carbohydrate which next to cellulose.

In the rabbit digestive system, starch is almost digested, mostly it digested in the small intestine but also in other part of the digestive system, for example large intestine and stomach (Blas & Wiseman, 2002). In 30 days old weaned rabbit is has the higher pancreatic amylase activity compared to 25 days old rabbit that still in suckling doe's milk. The undigested starch in small intestine will quickly utilize by the microbes for fermentation in cecum to produce volatile fatty acid and absorb directly in cecum (Blas & Wiseman, 2002; Cheeke, 1987). Starch digestibility can be affected by the origin of the starch, age of the rabbit and dietary level. The 42 days old rabbit, it mortality rate is increasing, so it need more starch in diet as energy. As the starch and fibre in the diet decrease, mortality of the rabbits will decrease. But high carbohydrate can bring problems to the rabbit digestive system (Blas & Wiseman, 2002).The high glucose content in diet allow colonization of *Clostridium spiroforme* and *E coli* (Johnson, 2006; O'Malley, 2005).

2.3.2 Crude protein (CP)

Protein made up from the long chain of amino acid and it is the important substance to build up body tissues. Isoleucine, leucine, lysine, ethionine, phenylalainine, threonine, tryptophan and valine are the eight essential to the rabbit because the bone cannot synthesize higher content. The plant protein can come from the plant seed or plant leaves. The forage plant concentrate the protein in the leaves (Blas & Wiseman, 2002). Crude protein and amino acid is the common units to calculate the requirements and the nutrient content of the feed stuff. Rabbit cannot utilize the crude protein as good as the large herbivores (Chiou et al., 2000). Non protein nitrogen (N) could not help the rabbit and low quality protein dietary could not meet the growth requirement (Carabano et al., 2009).

According to Carabano et al. (2009), in order to get the optimum growth and mortality of rabbits, the recommended ratio needed is 23.5 kcal DE/g DP or 10g DP/J DE. The rabbit cannot absorb all the crude protein in the plant but it can only utilize the digestible protein. The digestible protein cannot be determined easily in the laboratory or in vitro (Blas & Wiseman, 2002). To make a calculation, Villamide and Fraga (1998) have made and design some equation to determine the digestible protein in the plant. To calculate the digestible protein in dry forage, equation DP=-38.4+0.831CP have to be used (Villamide & Fraga, 1998). In general, the plant in high CP content has less resistant to digestion. The growing rabbit should have 2.9g DP day^{-1} kg^{-1} $LW^{0.75}$ (Blas & Wiseman, 2002) in diet to gain weight normally.

2.3.3 Crude fibre (CF)

Fibre is the main dietary of the rabbit; it occupied 40-50% in the total diet (Blas & Wiseman, 2002). Plant cell wall consists of series of polysaccharides that associate or substitute with glycoprotein, phenolic compound such as phenolic polyer lignin and acetic acid (Blas & Wiseman, 2002; Smith et al., 2009). Growing plant has less cellulosic microfibrils and non-cellulosic components like pectic substances. When the plant getting older, cells are developing a thick secondary cell wall which consist cellulose embedded in polysaccharide and lignin matrix (Blas & Wiseman, 2002; Cheeke, 1987; Halls, 2010). In mammalian digestive system, the dietary fibre is resistance to the mammalian endogenous enzyme and absorption, and it can only fermented in the gut. Cellulose is the main component of the plant cell wall. Lignin is the non carbohydrate (Blas & Wiseman, 2002; Halls, 2008) component in plant cell wall that indigestible by the animal although in ruminant chambers.

Fibre in diet is important to maintain the rabbit gut health. Fibre improves gut motility and caecotrophy, stimulate appetite, reducing fur chewing and preventing typhlitis. The CP content less than 15% in diet affect the rabbit digestive system upset while the diet more than 20% CF can increase the chances of caecal impaction and typhlitis (Johnson, 2006). The CF in diet should be 20-25% to main gut health (Halls, 2008). The higher CF content fasten the food particles pass through in the digestive tract (Halls, 2008). Fasten feed ingestion will promote incomplete digestion material in the GI tract such as starch. Starch allows microbes fermentation but excessive starch promotes the microbes' growth rapidly. It is giving chances to the unpleasant microorganism, such as *Clostridium spiroforme* growing in the GI tract which will bring diseases such as typhlitis, diarrhea and death (Halls, 2008). The caecal pH value is depending to the dietary fibre level and the sources (Abdel-Khalek et al., 2011)

Volatile fatty acid is the main product from the microbial fermentation (Blas & Wiseman, 2002). It produced in the cecum and absorb directly in hindgut act as the source of energy to the rabbit and the volatile fatty acid concentration is affected by the level of fibre consume (Blas & Wiseman, 2002).

2.3.4 Crude Fat

Lipid can be divided into simple lipid which do not fatty acid and complex lipid which contain fatty acid. Triglycerides consider the true fat which is the energy storage in the animal and vegetable organisms. Triglycerides has 2.25 times more energy compared to others component (Blas & Wiseman, 2002). Triglycerides usually present in rabbit feed, pure vegetables and animal fat VFA is the major energy source for rabbits and the production is depending to the microflora concentration and the availability and type of feed in diet (Halls, 2008).

Excess of VFA may reduce the cecal pH, this will inhibit normal flora and allows pathogen to grow and colonize (Johnson, 2006). Pure fat or oil is not adding into the rabbit feed because traditionally rabbit diet is low or moderate energy (Blas & Wiseman, 2002; Szendrő, Matics, & Gerencsér, 2011). The crude fat in rabbit diet should not exceed 30-35g/kg of feed (Blas & Wiseman, 2002; Fisher, 2013). The lactating doe need more energy and it can consume higher amount energy concentrate. Higher level of fat in the diet will reduce the dry matter intake, it can reduce the digesta transit in gastrointestinal tract (Blas & Wiseman, 2002; Chiou et al., 2000). High fat content can negatively inhibit the microflora activity in the digestive system, especially in cecum.

2.3.5 Energy

The energy in feed can be categories into gross energy, digestible energy, metabolize energy and net energy. Growing rabbit can consume the sufficient feed to fulfil the daily energy requirement but doe rabbit in pregnancy and lactating required higher energy in diet. The growing rabbit should have900–1000 kJ DE day^{-1} kg^{-1} $LW^{0.75}$ while pregnant lactating female rabbit can consume 1100–1300 kJ DE day^{-1} kg^{-1} $LW^{0.75}$ (Blas & Wiseman, 2002). The average daily growth achieved to the maximum when the digestible energy at 10–10.5 MJ kg^{-1}. The excessive energy consume by the rabbit will affect the rabbit gain weight the energy retained as protein and fat (Blas & Wiseman, 2002).

2.3.6 Vitamins and mineral

The rabbit meat is high in protein and low in energy it also poor in sodium and iron but rich in potassium and phosphorus compared to the domestic animal (Blas & Wiseman, 2002; Fisher, 2013). The macro mineral needed by the rabbits are potassium, calcium, phosphorus, magnesium, calcium, chloride and sulphur but only calcium, phosphorus and sodium consider in rabbit feed formulation (Blas & Wiseman, 2002; Irlbeck, 2001).

Calcium is the main component of the skeleton system it take 98% to build bones and teeth (Blas & Wiseman, 2002; Smith et al., 2009). Compared to other domestic animal, rabbit metabolise calcium differently, it absorb calcium in the diet directly therefore the blood calcium level increase while intake and excessive calcium consume, it will be excreted out through urine with white, thick, creamy precipitate. Excessive calcium (more than 15g kg^{-1}) in diet increases the risk of urolithiasia and may result in calcification of the soft tissues. 5g kg^{-1} of calcium in diet can cover the nutritional requirement of rabbit in 35 to 90 days growing rabbit. Phosphorus plays many important role in reaction related to energy metabolism. The calcium to phosphorus ratio is widely accepted with 2:1 or 1.5:1 in the diet formulation. Lack of calcium and phosphorus in diet will lead to bad behaviour, rickets, osteomalacia and lack of fertility to the rabbits. Excessive phosphorus (9g kg^{-1}) will decrease feed intake and impair prolificacy in doe (Blas & Wiseman, 2002; Irlbeck, 2001). The recommended calcium and phosphorus in diet as shown in Table 2.1 below:

Table 2.1: Requirement of calcium and phosphorus for rabbit (g kg^{-1}) (Blas & Wiseman, 2002)

	Calcium	**Phosphorus**
Breeding does		
Recommendation	10.5	6.0
Acceptable commercial range	10.0–12.5	5.5–7.0
Growing rabbit (1-2 months of age)		
Recommendation	6.0	4.0
Acceptable commercial range	4.5-7.6	3.3-4.6
Growing rabbit (>2 months of age)		

Recommendation	4.0	3.0
Acceptable commercial range	3.0-6.0	3.0-4.5

There are fat soluble and water soluble vitamins need to be included in the rabbit diet. Fat soluble vitamins which are vitamin A, D, E and K while water soluble vitamin are vitamin C and B vitamins which needed in diet for the rabbits (Blas & Wiseman, 2002; Gidenne *et al*., 2010). Fat soluble vitamin absorbs and store in the liver in appreciable amount, while water soluble vitamin absorb and excrete rapidly but except vitamin B12. The rabbit has the functional cecum, therefore it need more fat soluble vitamins compared to water soluble vitamins (Blas & Wiseman, 2002; Irlbeck, 2001).

For growing rabbit, it fed with 6000IU and 10000IU vitamin A is sufficient to the growing-fattening rabbit and breeder rabbit respectively. Excessive intake of vitamin A, overload and toxicity symptoms will occur (Irlbeck, 2001). Vitamin D can synthesis naturally under the skin when exposed to sunlight. It can help in calcium absorption and lacking of vitamin D can cause rickets in growing rabbit and osteomalacia in adult rabbit. The recommended level of vitamin D in diet is not more than 1000-1300IU(Bamikole *et al*, 2005). Lack of vitamin E will cause muscular dystrophy and poor reproduction. The recommended amount of 15 and 50mg vitamin E kg^{-1} for fattener and doe respectively in their diet is sufficient (Blas & Wiseman, 2002).

Vitamin C can help to deposit of vitamin E in muscle and organ of the rabbits, which the vitamin C can protect vitamin E from oxidation. The vitamin C can reduce the stress of the rabbit. In diet supply 50-100mg vitamin C kg^{-1} to the rabbit is recommend by Blas and Wiseman (2002).

2.4 Mulberry leaves

Mulberry tree name *Morus sp.* in scientific. This plant is origin from China and the leaves is the main food of the silk worm. Mulberry tree is the fast growing plant (Lumis, n.d.) and it can culture easily just by using the cut twigs. The cut twig sticks into the soil and it can grow. The height of the plant can grow up to 40 to 70 feet and spread up to 10 to 20 feet wide (Lumis, n.d.).

The mulberry tree leave is very nutritive. From Yao *et al*. (2000), stated that the dry matter in the leaves have around 24.4 to 33.8% from different season in China. The crude protein can up to 18.9 to 21.9% while the 84.4 to 90.4% of true protein present in the crude protein (Yao *et al*, 2000). Neutral detergent fibre present in the dry matter of the mulberry leave is 36.7 to 46.2% (Yao *et al*., 2000). The mulberry leaves can replace 50% the concentrate in the rabbit diet (Bamikole *et al.*, 2005; Safwat *et al.*, 2014), it can reduce the production cost of the rabbit farming. The mulberry leaves contain minerals such as iron, calcium and zinc and it contain antioxidant such as ascorbic acid and beta carotene which can inhibit cellular damage caused by free radical (Mccarthy, 2015). The leaves also reduce the bad cholesterol in the body and the leaves have anti-inflammation to the body that has been used in tradition to treat inflammation caused by chronic diseases (Mccarthy, 2015). It might be able to reduce the skin inflammation of the rabbits in the farming industry.

2.5 Feeding Frequency

Feeding management always concern in animal husbandry because it affects directly to the animal growth. Higher feeding frequency could be evenly spread the feed through-out the day (Robles *et al.*, 2014) and it could moderating the gastrointestinal pH fluctuation and modifying feeding behaviour (Macleod *et al.*, 1994; Macmillan *et al.*, 2017; Mowat & Ruiz, 1987; Robles et al., 2014).

The increase of daily feeding frequency can increase average daily gain (ADG) of young dairy heifers (Hill et al., 2015; Schutz *et al.*, 2011). Higher feeding frequency can improve fibre digestion more uniformly, especially fermentable carbohydrate are fed combine with forage (Mowat & Ruiz, 1987). Wang *et al.* (1998) stated that more frequent in daily feeding can produce more uniform sizes fish in farm. This matter can use to improve uniformity of the rabbits in every batch. The inter-individual variation can minimized in the food consumption and growth of cultured fish to maximize production, reduce feed wastage and reduce environment bad impact (Jobling & Baardvik, 1994; Mccarthy *et al.*, 1992; Wang et al., 1998). Improve of feeding frequency may help and improve the rabbits growth and meat production and this can maintain the cost of production but increase the profit of the farmers.

CHAPTER 3

METHODOLOGY

3.1 Experimental site and animals

In the experiment, twelve 4 to 5 weeks old New Zealand white rabbit were used to test for the feed intake. The animal were randomly picked from the population and randomly put into the 12 cages that prepared. Every cage was allocated with one rabbits which randomly picked from the population.

The experiment was run in the rabbit house which allocated in the Agro Techno Park of University Malaysia Kelantan, Jeli Campus. The duration of this experiment was 84 days. It was estimated that the highest temperature in in the experimental area was 36ºC and lowest with 22ºC (AccuWeather, 2017).

3.2 Experimental diets

The 12 randomly picked rabbits in the experiment were fed according to the treatment feed. Four different treatment diets, consisting of different treatment which Group 1; fed only once per day with commercial pellet only, Group 2; fed only once per day with commercial pellet and mulberry leaves, Group 3; fed two times per day with commercial pellet only, Group 4; fed two times per day with commercial pellet and mulberry leaves. Every treatment feed was given to 3 rabbits which separate each cage allocate with one rabbit. The commercial pellet given was 100g/day for the first 16 days, 110g/day for the next 16 days and 120g/day for the last 16 days for every rabbits. Fresh mulberry leaves were given to the particular treatment rabbits every morning with the amount of 10% from weight of commercial pellet. Water was given *ad libitum* to the rabbits.

3.2.1 Feed preparation

Commercial rabbit feed used in this study was bought from Perternakan Hong Lee Sdn. Bhd., Bukit Mertajam, Malaysia. The mulberry leaves were collected every day at 8.00am at the Agro Techno-Park of University Malaysia Kelantan, Jeli Campus. The mulberry leaves were obtained from 2 months old mulberry trees.

3.4 Proximate analysis of the feed samples

The nutrition contents of the feed samples that were analysed are gross energy (GE), crude fibre (CF), crude protein (CP), ether extract (EE), ash and nitrogen free extract (NFE) content. Several different methods and equipment were used for analyses as refer from AOAC (1995). All this analyses were conducted at Veterinary Faculty of University Malaysia Kelantan.

3.4.1 Dry matter analysis

The feed samples were weighed freshly using electronic balancer at the laboratory right after the sampling was done. These processes were done quickly to prevent any leakage of moisture from the feed samples. After weighing, the samples were oven dried at 105^{o}C for 16 hours (AOAC International, 1995). In the next day, the dry weight were measured to determine the DM content and loss of moisture in the both the roughage in the pasture and feed pellet. This formula (3.1) was used to determine the DM and moisture content in the samples,

$$\%DM = \frac{W_f}{W_i} \times 100 \quad (3.1)$$

Where,

%DM = Percentage of DM

W_i = Initial weight of sample

W_f = Final weight of sample

3.4.2 Determination of gross energy (GE) content

IKA calorimeter system C 200 is used for the determination of gross energy. Approximately 1g of samples will weight to 4 decimal points using electronic balance and pelletize using IKA pelleting press C 21. A jug of water is prepared to be in the range of 18ºC to 25ºC using ice pack and thermometer. The bomb calorimeter and the control system is turned on. The CalWin 2.25 software will start in the control centre. At the vessel cover, the 50 J cotton thread is tied to the ignition wire. Incineration crucible is placed at the crucible holder under the ignition wire and the tied thread will then insert into the crucible in a way that is touched the base of the crucible. The pelleted sample will put on the top of the thread.

The vessel cover will then place into the decomposition vessel properly. The union nut will screwed on the vessel. The decomposition vessel will place on the oxygen station and 30 bar of oxygen will insert. The ignition adapter is attached on the top of the vessel before inserting the vessel into the loading bay inside the calorimeter system and the cell cover is closed. Two litre of water prepared before is inserted into the tank fillers. New measurement is set in the CalWin 2.25 software and the weight of the pelleted sample is inserted into the software. The calorimeter is started and the result of the combustion process will appear in the control centre after 16 to 20 minutes. The following formula (3.2) is used to calculate the value of GE in the feed samples,

$$Ho = \frac{(C \times DT) - (QE \times t1) - (QE \times t2)}{m} \quad (3.2)$$

Where,

Ho = Gross energy (GE)

C = Heat capacity (C-value) of calorimeter

DT = Calculated temperature increase in inner vessel of measuring cell

QE x t1= Correction value for the heat energy generated by the cotton thread as ignition aid

QE x t1= Correction value for the heat energy from other burning aids

M = Weight of pelleted sample.

3.4.3 Determination of crude protein (CP) content

The Kjeldahl method was used to analyse the CP content in the samples, and the equipment used were Gerhardt Kjeldatherm and Gerhardt Vapodest. The Kjeldahl method is divided into three parts which are (1) Digestion, (2) Distillation and (3) Titration.

3.4.3.1 Digestion

About 1g of sample was weighed and inserted into each digestion tubes. Each tube was also filled with 10mL of distilled water and 1 piece of Kjeltab tablet. Next, 12 mL of concentrated H_2SO_4 solution was added into each tube inside the fume chamber and placed inside the digestion rack. The digestion block of Gerhardt Kjeldatherm was then turn on and heat to reach 400ºC for pre-heating, before inserting the digestion rack. The fume manifold was attached tightly on the top of the digestion tube before turning the H_2SO_4 aspirator completely to prevent the vaporised H_2SO_4 from escaping. The pre-heated digestion block was reset from 400ºC for another 30 minutes. After the total time 60 minutes of digestion, the digestion rack was removed into the rack holder inside the fume chamber and let to cool.

3.4.3.2 Distillation

The distillation unit was run for 3 times to clean the system. 40% of NaOH wasplaced in the alkali tank of Gerhardt Vapodest distillation unit. Then, the digested samples were diluted with 80mL of distilled water and 50 mL of 45% NaOH. 30mL of receiver solution is added to the receiver flask. The reaction is then allow to settle.

250mL Erienmeyer titration flask was placed on receiving platform and filled in with 4% boric acid (H_3BO_3) along with indicator and the added into receiver solution tank. The digestion tube containing diluted digest was attached to distillation unit and the samples were then distilled for 5 minutes. Steam distillates which are green in colour are collected. Receiving flask was removed from the unit for titration process.

3.4.3.3 Titration

H_3BO_3 receiving solution was then titrated with standard 0.1M HCl to reach pink colorization end point. The volume of HCl used for the titration was recorded. The following formula (3.3) is used for determination of CP content in the sample,

$$\%N = \frac{(T-B) \text{ x N x } 1.4007 \text{ x } 100}{\text{Weight of sample (mg)}} \quad (3.3)$$

%CP = %N x F

Where,

%N = Percentage of nitrogen in the sample

T = Volume of titrant used for feed sample.

B = Volume of titrant used for blank sample

N = Normality of titrant

%CP = Percentage of CP

F = Conversion factor for nitrogen to protein

3.4.4 Determination of crude fibre (CF) content

Gerhardt Fibretherm was used to determine the CF content inside the samples. Initially, the FibreBags are dried in Memmert oven for 1 hour and cool in the desiccators for 30 minutes. Then, the FibreBags with glass spacers were inserted into the carousel. About 1g of sample was weighed into the FibreBags along with the glass spacers to obtain the m_2 value. Next, the samples were defatted by washing them along with the glass spacers and carousel three times with 40mL of petroleum ether. Then, the FibreBags were dried for about 2 minutes before the two phases washing.

In the first phase, the FibreBags and the samples were boiled in 260mL of 0.13M sulphuric acid (H_2SO_4) for 30 minutes right after the solution start to boil. Then, the acid was removed by rinsing three times with hot water. For second phase of washing, the samples were then boiled with 330mL of 0.11M sodium hydroxide (NaOH) solution for 30 minutes after the solution started to boil. Again, the alkali was removed by rinsing three times with hot water. The FibreBags were removed from the carousel. The glass spacers were removed out carefully from the FibreBags without bringing out any samples.

The FibreBags were then dried with Memmert oven for 105ºC at 4 hours and put into desiccators for 30 minutes to cool off. To prepare for the incineration process, the crucibles were incinerated for 600ºC inside the Carbolite furnace for 30 minutes. The crucibles were then cooled off inside the desiccators for 30 minutes. The FibreBags were then put into each crucibles and weighed to get m_3 values. The crucible for blank FibreBag was weighed to get the value m_6 values. Next, all of the crucibles along with the FibreBags are incinerated inside the Carbolite furnace for 4 hours at 600ºC.

After that, the crucible were left inside the furnace overnight to cool off. The crucibles along with the ash were weighed to get m_4 values. The blank FibreBags ash and the crucible used for the blank were weighed to get the value m_7. The value of ash from the blank FibreBag (m_5) was determined from the value of m_6 and m_7. The following formula (3.5) is used to determine the %CF of the samples,

$$m_6 = m_7 - m_6 \tag{3.4}$$

$$\%CF = (m_3 - m_1 - m_4 - m_5) \times \frac{100}{m_2} \tag{3.5}$$

Where,

%CF = Percentage of CF

m_1 = Weight of FibreBag (g)

m_2 = Initial sample weight (g)

m_3 = Incinerating crucible and dried FibreBag after digestion (g)

m_4 = Incinerating crucible and ash (g)

m_5 = Blank value of the empty FibreBag (g)

m_6 = Incinerating crucible (g)

m_7 = Incinerating crucible and ash of the empty FibreBag (g)

3.4.5 Determination of ether extract (EE)/ crude fat content

The Soxtec method was used to determine the fat content in the feed samples. The equipment use for this method was FOSS Soxtec 2055 Fat Extraction System. In preparing the extraction unit, the temperature was set according to the suitability of the solvent use to achieve 3 to 5 drops per second. Proper program and time setting for boiling, rinsing and pre-drying are selected on the control unit of the extraction unit. The water tap was opened as the reflux condenser each time running the machine to prevent the solvent (petroleum ether) evaporation from condensers. The samples were then weighed inside the thimbles using electronic balance. The thimbles were cleaned and attached to the thimble support before weighing the sample.

As the fat content in both the forage and feed pellet samples were predicted to be lower than 10%, 2 to 3g of both samples were weighed into each of the thimble with a precision of ± 0.0001g. After the samples were weighed into the thimbles, a layer of defatted cotton is inserted into each thimbles. The thimbles were then attached into the thimble support and inserted to attach to the magnetic holder inside the extraction system. Next, the aluminium cups which were used to hold the petroleum ether were heated at 103ºC for 30 minutes in the Memmert oven and dried in the desiccators for 20 minutes until cool. The cups were then weighed up to 4 decimal points. 70 to 90 mL of petroleum ether was measured and put into the aluminium cups, and then were inserted into the extraction machine with a cup holder. This aluminium cup which initially holds the petroleum ether was finally hold the fat extracted from the samples.

The extraction unit was then run and the temperature will increase until it is ready for boiling, which is notified by the buzzer from the control unit. The thimbles were then lowered and immersed into the petroleum ether inside the aluminium cups. During this period, the condenser valves must be opened and the control unit was timed for the boiling. After the boiling period ended, the thimbles were moved to rinsing position and timed again. After the rinsing period ended, set the extraction unit to recovery position and timed for the last time. The aluminium cups were removed and heated at 103 °C for 30 minutes in the Memmert oven and dried in the desiccators for 20 minutes until cool. All aluminium cups were weighed and the weight of the fat content was calculated for each samples. The percentage of the fat was calculated using the following formula (3.6),

$$\%EE = \frac{Wf - Wi}{W_s} \times 100 \quad (3.6)$$

Where,

%EE = Percentage of EE/crude fat

Wi = Initial weight of the aluminium cup

Wf = Final weight of the aluminium cup

Ws = Weight of the sample

3.4.6 Determination of ash content

In the analysis of ash content, clean empty crucibles were placed in the Carbolite furnace at 600 °C for an hour. The crucibles were then let to cool in the desiccator before being weighed. Approximately 1 g of samples was weighed into the crucibles. Next, the samples along with the crucibles were incinerated at 550 °C for 4 hours. After 4 hours, the furnace door was opened and the crucibles were let to cool overnight. The samples turned to gray white ash at the end of the incineration process which indicated the complete oxidation of all organic matters in the samples. Total weights of the crucibles with along the ash were weighed. The following formula (3.7) was used to determine the total ash content in the samples,

$$\%Ash = \frac{Wf - Wi}{W_s} \times 100 \quad (3.7)$$

Where,

%Ash = Percentage of ash

Wi = Weight of the crucible with sample

Wf = Weight of the crucible with ash

Ws = Weight of the sample

3.4.7 Determination of nitrogen free extract (NFE)

The value of NFE is determined using the following formula (3.8). The total 100 value is taken from the total value of DM.

$$\%NFE = 100 - (\%CF + \%CP + \%EE + \%Ash) \quad (3.8)$$

Where,

%NFE = Percentage of NFE

3.5 Growth trial and feeding performance

3.5.1 Body weight and Average Daily Gain of rabbits

Experimental rabbits were weighed individually at the beginning and every week until 12 weeks. Weight data was recorded and average daily gain was done for the rabbits.

3.5.2 Feed intake and feed conversion ratio

Throughout the 12 weeks (84 days) feeding trial, daily feed offered and refused were weighed and recorded for individual rabbit. Daily feed were measured as the difference of the amount of feed offered and feed refused. The sample of feed offered and refused were collected every day from each goat for dry matter analysis to determine daily DMI

3.6 Digestibility trial

Digestibility study was conducted at Agro Techno Park for 10 days. Faecal samples were collected daily from experimental rabbits and stored at – 20^{o}C in deep freezer immediately after collection. At the end of each collection period, the faecal samples were bulked for each animal for proximate analysis according to AOAC procedures. The digestibility (%) determined using the formula (3.9)

$$\text{Digestibility (\%)} = \frac{\text{Total DM intake} - \text{Droppings excrete}}{\text{Total DM intake}} \quad (3.9)$$

DM = Dry matter

3.7 Data analysis

All the data recorded from the experiment were recorded in Microsoft Excel. Two way Anova was used to calculate the data to determine the treatment which apply to the rabbits. IBM software package for statistical analysis (SPSS) was used to find the reliability.

CHAPTER 4

RESULT

4.1 Chemical compositions of commercial pellet and mulberry leaves.

According to proximate analysis, commercial pellet has higher dry matter content (%) compared to mulberry leaves which are 88.89%±0.10 and 21.89%±0.36 respectively. But crude fibre (CF) and crude protein (CP) of mulberry leaves are higher compared to commercial pellet. CF of mulberry leaves and commercial pellet are 41.55%+2.98 and 32.55%+0.10 respectively, while CP are 26.50%+0.08 and 11.22%+0.01 respectively. But ether extract (EE) and ash content of commercial pellet are higher compared to mulberry leave. EE of commercial pellet and mulberry are 4.56% ± 0.05 and 2.67% ± 0.18 respectively and ash content are 10.75% ± 0.75 and 10.46% ± 0.49 respectively. There is no significant difference between groups ($p>0.05$).

Table 4.1.1: Chemical composition (%) of mulberry leave and commercial pellet (Mean±SE)

Constituents	Mulberry leaves	Commercial pellet
Dry matter (DM) %	21.89 ± 0.36	88.89 ± 0.10
Moisture (%)	78.10 ± 0.36	11.11 ± 0.10
Crude fibre (%)	41.55 ± 2.98	32.55 ± 0.10
Crude protein (%)	26.50 ± 0.08	11.22 ± 0.01

Ether extract (%)	2.67 ± 0.18	4.56 ± 0.05
Ash (%)	10.46 ± 0.49	10.75 ± 0.75

4.2 Body weight change and Average Daily Gain of rabbits

The body weights of the experimental rabbits were increased from day 1 to day 84. Initially, the body weights of the rabbits were almost the same but to the end there are significant difference between the treatments. At final, T2 and T3 rabbits have the highest body weight compared to Control and T1, which are 2118.66g±15.03, 2111.00g±25.39, 1912.00g±69.42 and 2010.33g±13.53 respectively. From Figure 4.2.1, control group has the lowest body weight, while the T2 group has the highest body weight on day 84. There is no significant difference between the groups which p>0.05.

Table 4.2.1: Body weight changes (g) between treatments (Mean±SE)

Experimental	Body weight changes (g)			
period (days)	Control	T1	T2	T3
1	812.33±40.43	780.66±10.93	720.00±18.66	877.33±20.41
7	875.66±43.97	900.00±11.51	850.00±31.38	994.33±10.66
14	980.33±38.48	1026.66±12.81	998.00±22.37	1126.33±18.38
21	1042.33±39.41	1104.66±14.43	1089.33±22.66	1197.33±14.50
28	1134.33±50.49	1210.00±16.11	1176.00±24.88	1337.00±19.22
35	1289.33±58.60	1323.33±21.31	1378.00±21.25	1481.00±20.94
42	1400.33±65.52	1496.66±18.89	1551.00±16.27	1626.00±9.85

49	1484.33±65.30	1576.33±17.65	1645.00±13.37	1706.33±8.46
56	1507.66±62.16	1658.00±16.53	1748.33±14.40	1808.00±2.47
63	1633.66±56.58	1781.00±11.00	1879.66±6.11	1839.33±9.55
70	1716.66±57.62	1846.33±13.77	1983.00±7.73	1940.33±18.22
77	1824.33±64.39	1939.00±9.41	2026.00±10.01	2039.00±24.79
84	1912.00±69.42	2010.33±13.53	2118.66±15.03	2111.00±25.39

From table 4.2.2, Treatment 2 has the highest average daily weight gain, which is 16.65g±0.81 but Control has the lowest average daily weight gain, which is 13.09g±0.81. While in Treatment 1 and Treatment 3, the average daily weight gains are 14.64g±0.81 and 14.69g±0.81 respectively. There is no significant difference between the groups which the $p>0.05$.

Table 4.2.2: Average daily body weight changes (g/d) between treatments(Mean±SE)

Parameters	Control	Treatment 1	Treatment 2	Treatment 3
Average daily weight gain(g)	13.09±0.81	14.64±0.81	16.65±0.81	14.69±0.81

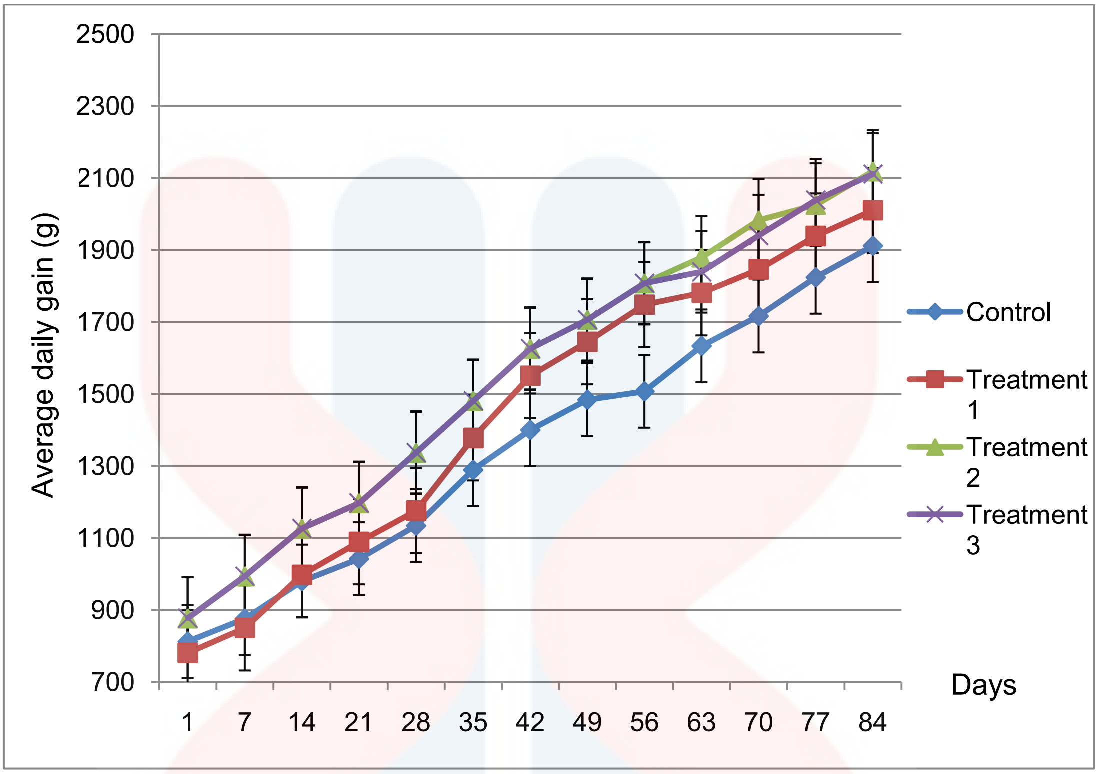

Figure 4.2.1: Average daily gain (ADG)

4.3 Feed intake and Feed Conversion Ratio

In the 84 days experiment period, the total dry matter intake (DMI) of the control, treatment 1, treatment 2 and treatment 3 are 79.98±163.68, 72.82±163.08, 80.81±130.70 and 83.39±29.22 respectively. Treatment 3 has the highest total DMI which is 83.39±29.22, while Treatment 1 has the lowest DMI which is 72.82±163.08. There is no significant different between groups which p>0.05.

Table 4.3.1: Dry matter intake (DMI) of feeds (Mean±SE)

Parameters	Control	Treatment 1	Treatment 2	Treatment 3
Commercial pellet DMI (g/d)	95.05±1.95	83.69±1.94	95.50±1.50	97.40±0.34

Mulberry DMI (g/d)	0.00	2.41±0.00	0.00	2.41±0.00
Total DMI (g/d)	95.05±1.95	86.10±1.94	95.50±1.50	99.81±0.34

According to Table 4.3.1, Treatment 3 has the highest feed conversion ratio (FCR), which is 8.26±0.402 and while Treatment 2 has the lowest FCR, which is 6.45±0.402. Control and Treatment 1 has the FCR 8.23±0.402 and 8.05±0.402 respectively. There is significant different the groups which p<0.05.

Table 4.3.1: Feed conversion ratio (Mean±SE)

Parameters	Control	Treatment 1	Treatment 2	Treatment 3
FCR	8.23±0.402	8.05±0.402	6.45±0.402*	8.26±0.402

4.4 Digestibility of rabbits

In Table 4.4.1, it shows that Control has the highest DM percentage but Treatment 2 has the lowest DM percentage which is 69.00%±1.80 and 66.58%±1.74 respectively. Organic matter (OM) in the faecal, Treatment 1 has the highest percentage while Control has the lowest, which are 84.11%±0.23 and 83.32%±0.25 respectively. While in CP and EE, Treatment 1 has the highest percentage which is 10.86%±0.24 and 2.24%±0.07 respectively, but Treatment 2 has the lowest percentage, which are 10.32%±0.28 and 1.86%±0.08 respectively. Treatment 2 has the highest CF percentage but Treatment 1 has the lowest percentage which is 38.18%±0.13 and 36.20%±0.42 respectively. There is no significant difference between the groups which p>0.05.

Table 4.4.1: Chemical composition (%) ± SE of rabbits faecal (last 10 days).

Parameters	Control	Treatment 1	Treatment 2	Treatment 3
DM	69.00±1.80	67.02±3.30	66.58±1.74	68.23±1.75
Moisture	30.48±2.49	31.91±2.73	33.41±1.73	31.80±1.72
Ash	16.68±0.25	15.89±0.22	16.41±0.46	16.63±0.34
OM	83.32±0.25	84.11±0.23	83.59±0.46	83.37±0.34
CP	10.37±0.42	10.86±0.24	10.32±0.28	10.36±0.40
EE	2.37±0.13	2.24±0.07	1.86±0.08	1.91±0.10
CF	37.07±1.85	36.20±0.42	38.18±0.13	36.53±1.94

According to table 4.4.2, Control has the highest digestibility percentage, which is 50.90%±1.60, while Treatment 2 has the lowest percentage, which is 47.30%±1.60. Treatment 1 and Treatment 3 has the digestibility percentage 48.10%±1.60 and 48.30%±1.60 respectively. There is no significant different between the groups which $p>0.05$

Table 4.4.2: Digestibility (%) in different treatment groups (Mean±SE).

Parameters	Control	Treatment 1	Treatment 2	Treatment 3
Digestibility %	50.90±1.60	48.10±1.60	47.30±1.60	48.30±1.60

4.5 Meat costing

From Table 4.5.1, Treatment 2 show the lowest production cost between others which is RM0.0047±0.0106 per gram. Control group has the highest production cost which is RM0.0050+0.0029 per gram. Treatment 1 and treatment 3 has the production cost RM0.0047+0.0148 and RM0.0046+0.0016 respectively. Treatment 2 is the lowest and it is cost effective to reduce operating cost.

Table 4.5.1: Production cost (RM) per gram (Mean±SE).

Parameters	Control	Treatment 1	Treatment 2	Treatment 3
Total pellet intake (g)	7985.98 ±163.68	7930.03 ±163.08	8021.81 ±130.73	8182.69 ±29.22
Total feed cost (RM0.0012/g)	9.58±0.20	9.52±0.20	9.63±0.16	9.82±0.04
Total weight gain (g)	1912.00 ±69.42	2010.33 ±13.53	2118.66 ±15.03	2111.00 ±25.39
Production cost (RM/g)	0.0050 ±0.0029	0.0047 ±0.0148	0.0045 ±0.0106	0.0046 ±0.0016

CHAPTER 5

DISCUSSION

From the proximate analysis, the commercial pellet has higher dry matter content compared to mulberry leaves. Commercial pellet is a manufactured concentrate in which its water content must lower than 13% and suitable for long term storage. While mulberry leaves is fresh forage, therefore the water content in mulberry leaves is much higher compared to commercial pellet. In mulberry leaves, it has higher CP and CF content in DM compared to commercial pellet. In this study, CF is 41.55%±2.98 seemed to be higher than Yao *et al.* (2000) who reported 36.7% to 46.2% of CF. While the CP content in this study is 26.50%±0.08 which exceed the range that in Yao *et al.* (2000) research which is 18.9% to 21.9%.

CP and CF is the main component for the animal to growth. Mulberry leaves with the high content of CP and CF, can replace 50% of the rabbit daily diet (Bamikole et al., 2005; Safwat et al., 2014). Mulberry can help to reduce the farm production cost because 50% replacement can reduce 50% commercial pellet in daily feeding. Mulberry tree is fast growing plant which can grow easily at any tropical area (Lumis, n.d.). The mulberry leaves also contain minerals such as iron, calcium and zinc and it contain antioxidant such as ascorbic acid and beta carotene which can inhibit cellular damage caused by free radical (Mccarthy, 2015) and these are essential to the rabbits. The leaves also reduce the bad cholesterol in the body and the leaves have anti-inflammation to the body that has been used in tradition to treat inflammation caused by chronic diseases (Mccarthy, 2015).

According to the study, there is no significant difference between feeding frequency and mulberry leaves to the growth performance and digestibility on the rabbits. Feeding management always concern in animal husbandry because it affects directly to the animal growth. Higher feeding frequency could be evenly spread the feed through-out the day (Robles et al., 2014) and it could moderating the gastrointestinal pH fluctuation and modifying feeding behaviour (Macleod et al., 1994; Macmillan et al., 2017; Mowat & Ruiz, 1987; Robles et al., 2014). In the present study, feeding twice per day is the maximum feeding frequency to the rabbits. No significant difference occur might because the frequency is not enough to the rabbit to obtain the best result. Feeding frequency of more than 2 times per day could possibly improve the body weight gain. Research previously done on young dairy heifers, the increase of daily feeding frequency can increase average daily gain (ADG) of young dairy heifers (Hill et al., 2015; Schutz et al., 2011).

From the result, rabbit fed 2 times per day have better average daily weight gain compared to rabbits fed once per day but the different is not significant. Higher feeding frequency can improve fibre digestion more uniformly, especially fermentable carbohydrate are fed combine with forage (Mowat & Ruiz, 1987). Wang *et al.* (1998) stated that more frequent in daily feeding can produce more uniform sizes fish in farm. This method can use to improve uniformity of the rabbits in every batch. From the figure 4.2.1, the rabbits with higher feeding frequency have the higher gradient compared to feeding once per day. The inter-individual variation can minimized in the food consumption and growth of cultured fish to maximize production, reduce feed wastage and reduce environment bad impact (Jobling & Baardvik, 1994; I. D. Mccarthy et al., 1992; Wang et al., 1998). But no obvious result obtain on rabbit study.

Maybe increase higher feeding frequency can show an obvious result on rabbits study because research have done and shown good result in higher feeding frequency in other livestock such as sea cucumber (Xia *et al*., 2017), catfish (Nanninga & Engle, 2010), and dairy calves (Devries & Miller, 2017; Hill *et al*., 2015).

Increase feeding frequency reducing the feed wastage. From this research, with the same amount of feed, the rabbit fed once per day have higher feed wastage compared to feeding twice per day. Rabbits are playful and like to scratch on their feed when they do not eat it. Female rabbit and especially the pregnant rabbit, there will scratch on everywhere to make her own nest and feed bowl is one of their favourite targets to scratch on. Therefore, higher feeding frequency reduces the chances for the rabbits to scratch on the feed and they can consume more in everyday, it reduces the cost of operation and also improves the rabbit weight gain.

From the result, feeding frequency and mulberry leaves feeding show significant different on feed conversion ratio (FCR). From table 4.3.1, it shows that Treatment 2 give the lowest FCR. It is very important to the farm because it can maximise the farm production with the same amount of feed. Good FCR also indicated good feed or method on feeding the animals. Increase feeding frequency is to maximise the animal body weight gain with the same amount of feed(Devries & Miller, 2017; Hill *et al*., 2015; Nanninga & Engle, 2010; Xia *et al.*, 2017). The rabbits eat more frequent, feed go through the digestive tract more frequent and the absorption always happen. This can help to fasten the weight gain and help the rabbits reach to the require body weight in a shorter time. The modern chicken broiler farm, farmers shorten the time for broiler to reach the require sizes by switching on the lights for 24 hours (Bayram & Özkan, 2010; Chicken-Whisperer, 2017) and feed provide *ad libitum*. This method is to increase the broiler eating frequency and keep the digestive tract full with feed and 24 hours the broiler can absorb the nutrients to gain weight. 60 days of chicken farming, it reduced to 30 days farming. This help to reduce farming time and increase batch cycles in a year. Mulberry leaves is the nutritive forage for animals. This leaves act as a very good supplement to improve the rabbits body weights (Das *et al.*, n.d.). The various nutrients in the mulberry leave improve the palatability of the rabbits, help them to have appetite to eat more and improve the absorption. But commercial pellet and mulberry leaves need to make a balance in the diet to ensure the feed given is not exceed the nutrient requirement.

Commercial pellet was formulated by the producer and suit for the rabbit daily diet requirement. Adding in mulberry leaves it exceeds the nutrient requirement of the rabbits. For example the fibre content, the commercial pellet already consists of the balance fibre to the rabbit. Mulberry leave has high fibre content, addition amount to the diet it exceed the rabbit fibre diet requirement. High fibre diet it fasten the digestive tract movement and it reduce time of the feed in the digestive tract for absorption. Treatment 3 rabbits fed two times per day but the FCR is higher because the mulberry leaves was added to the daily diet. High fibre promotes the digestive tract movement and the feed cannot fully absorb by rabbits. Therefore, feed formulation is very important to reach the rabbit diet requirement to avoid feed wastage in farming.

According to the result shown above, Treatment 2 gives the lowest production in one gram of weight which is RM0.0045$\pm$0.0106 per gram. In the market, rabbit commercial pellet sell at RM30/25kg, which cost RM0.0012/gram. Feed is the main expenses to animal farming. The lowest meat production cost is the best to the farm because it can use the least feed and least expenses to produce the rabbit meat in the limited time. This can help the farm to lower the farm operational cost and increase the profit margin.

CHAPTER 6

CONCLUSION AND RECOMMENDATION

Based on the current finding, mulberry leaves have high CF and CP contents. The feeding frequency and mulberry leaves do not show significant difference in rabbits' body weight gain and digestibility but it shows significant difference on the FCR. Rabbits in Treatment 2 fed twice per day without mulberry leaves give the best FCR. Treatment 2 gives the lowest production cost compared to other treatments. Feeding frequency might need to increase more and the diet formulation using mulberry leaves percentage need to be improved in order to improve body weight gain and digestibility of rabbits. Therefore, this research can be further investigated to get more accurate and better results.

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APPENDIX A

Table A.1: Proximate analysis of mulberry leaves and commercial pellet.

Feed	Mulberry leaves 1	Mulberry leaves 2	Mulberry leaves 3	Commercial pellet 1	Commercial pellet 2	Commercial pellet 3
Dry matter (%)	21.21	22.04	22.44	89.07	88.71	88.89
Moisture content (%)	78.79	77.96	77.56	10.93	11.29	11.11
Ash (%)	10.37	10.47	10.54	10.88	10.76	10.62
Protein (%)	26.61	26.55	26.34	11.25	11.19	11.22
Fat (%)	2.54	2.46	3.03	4.60	4.64	4.46
Crude Fibre (%)	47.47	37.57	39.96	32.42	32.49	32.75

Table A.2: Daily commercial pellet dry matter intake (g)

	Commercial pellet dry matter intake (g)											
Experimental period (day)	Control 1	Control 2	Control 3	T1A	T1B	T1C	T2A	T2B	T2C	T3A	T3B	T3C
1	88.89	88.89	59.57	79.70	67.96	65.44	88.89	67.12	88.89	79.70	72.99	88.89
2	74.67	88.89	61.24	73.83	78.02	72.15	88.89	10.91	88.89	88.89	74.67	88.89
3	88.89	88.89	26.85	75.51	70.47	73.83	88.89	57.05	88.89	88.89	88.89	88.89
4	88.89	88.89	34.40	76.35	75.51	68.79	88.89	58.73	82.22	88.89	88.89	88.89
5	88.89	88.89	57.79	76.35	78.86	72.15	88.89	53.69	88.89	88.89	88.89	88.89
6	88.89	88.89	68.79	73.83	78.86	70.47	88.89	41.95	88.89	88.89	88.89	88.89
7	88.89	88.89	35.24	72.15	72.99	88.89	88.89	67.12	88.89	88.89	88.89	88.89
8	88.89	88.89	73.83	76.35	88.89	81.38	88.89	69.63	88.89	88.89	88.89	76.35
9	88.89	88.89	67.96	88.89	88.89	88.89	88.89	75.51	88.89	88.89	88.89	70.47
10	88.89	88.89	57.08	79.70	88.89	78.86	88.89	70.47	88.89	88.89	88.89	88.89

11	88.89	88.89	69.63	88.89	88.89	88.89	88.89	67.12	88.89	88.89	88.89	88.89
12	88.89	88.89	88.89	88.89	88.89	88.89	88.89	80.54	88.89	88.89	88.89	88.89
13	88.89	88.89	78.86	88.89	88.89	88.89	88.89	83.06	88.89	88.89	88.89	88.89
14	88.89	88.89	75.51	88.89	88.89	66.24	88.89	81.38	88.89	88.89	88.89	88.89
15	88.89	88.89	79.70	88.89	88.89	72.99	88.89	73.83	88.89	88.89	88.89	88.89
16	88.89	88.89	77.18	88.89	88.89	75.51	88.89	88.89	74.67	88.89	88.89	88.89
17	88.89	88.89	88.89	88.89	88.89	88.89	88.89	88.89	88.89	88.89	88.89	88.89
18	88.89	88.89	88.89	88.89	88.89	88.89	88.89	78.86	88.89	88.89	88.89	88.89
19	88.89	88.89	88.89	88.89	88.89	88.89	88.89	76.35	88.89	88.89	88.89	88.89
20	88.89	88.89	88.89	88.89	88.89	88.89	88.89	78.86	88.89	88.89	88.89	88.89
21	88.89	88.89	88.89	88.89	88.89	88.89	88.89	77.18	88.89	88.89	88.89	88.89
22	88.89	88.89	88.89	88.89	88.89	88.89	88.89	75.51	88.89	88.89	88.89	88.89
23	88.89	88.89	88.89	88.89	88.89	88.89	88.89	77.18	88.89	88.89	88.89	88.89

24	88.89	88.89	88.89	88.89	88.89	88.89	88.89	75.51	88.89	88.89	88.89	88.89
25	88.89	88.89	78.86	88.89	88.89	88.89	88.89	80.54	88.89	88.89	88.89	88.89
26	88.89	88.89	69.63	88.89	88.89	88.89	88.89	88.89	88.89	88.89	88.89	88.89
27	88.89	88.89	88.89	88.89	88.89	88.89	88.89	88.89	88.89	88.89	88.89	88.89
28	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78
29	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78
30	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78
31	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78
32	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78
33	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78
34	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78
35	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78
36	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78

37	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78
38	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78
39	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78
40	97.78	97.78	49.33	97.78	97.78	97.78	97.78	97.78	97.78	97.78	37.35	97.78
41	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78
42	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78
43	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78
44	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78
45	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78
46	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78
47	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78
48	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78
49	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78

50	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78
51	97.78	55.21	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78
52	97.78	53.66	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78	82.65	97.78
53	97.78	78.80	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78
54	97.78	65.21	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78
55	97.78	76.16	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78	97.78
56	106.67	106.67	106.67	106.67	106.67	106.67	106.67	106.67	106.67	106.67	106.67	106.67
57	106.67	106.67	106.67	106.67	106.67	106.67	106.67	106.67	106.67	106.67	106.67	106.67
58	106.67	106.67	106.67	106.67	106.67	106.67	106.67	106.67	106.67	106.67	106.67	106.67
59	106.67	106.67	106.67	106.67	106.67	106.67	106.67	106.67	106.67	106.67	106.67	106.67
60	106.67	106.67	106.67	96.52	106.67	106.67	106.67	106.67	106.67	106.67	106.67	106.67
61	106.67	106.67	106.67	92.04	106.67	106.67	106.67	106.67	106.67	106.67	106.67	106.67
62	106.67	106.67	106.67	90.88	106.67	106.67	106.67	106.67	106.67	106.67	106.67	106.67

63	106.67	106.67	106.67	106.67	106.67	106.67	106.67	106.67	106.67	106.67	106.67	106.67
64	106.67	106.67	106.67	80.75	106.67	106.67	106.67	106.67	106.67	106.67	106.67	106.67
65	106.67	106.67	102.91	87.14	106.67	106.67	106.67	106.67	106.67	106.67	106.67	106.67
66	106.67	106.67	106.67	84.51	106.67	106.67	106.67	106.67	106.67	106.67	106.67	106.67
67	106.67	106.67	106.67	82.74	106.67	106.67	85.30	106.67	106.67	106.67	106.67	106.67
68	106.67	106.67	85.40	94.15	106.67	106.67	88.88	106.67	106.67	106.67	106.67	106.67
69	106.67	106.67	78.07	83.67	106.67	106.67	106.67	106.67	97.52	106.67	106.67	106.67
70	106.67	106.67	98.31	79.65	106.67	106.67	106.67	106.67	89.79	106.67	106.67	106.67
71	106.67	106.67	106.67	106.67	106.67	106.67	106.67	106.67	106.67	106.67	106.67	106.67
72	106.67	106.67	106.67	75.62	106.67	106.67	106.67	106.67	78.38	106.67	106.67	106.67
73	106.67	106.67	106.67	106.67	106.67	106.67	106.67	106.67	106.67	106.67	106.67	106.67
74	106.67	106.67	106.67	84.22	106.67	106.67	106.67	106.67	84.15	106.67	106.67	106.67
75	106.67	106.67	106.67	82.55	106.67	106.67	106.67	106.67	95.77	106.67	106.67	106.67

76	106.67	106.67	106.67	0.00	106.67	106.67	106.67	106.67	106.67	106.67	106.67	106.67
77	106.67	106.67	106.67	106.67	106.67	106.67	106.67	106.67	106.67	106.67	106.67	106.67
78	106.67	106.67	106.67	106.67	106.67	106.67	106.67	106.67	106.67	106.67	106.67	106.67
79	106.67	106.67	106.67	106.67	106.67	106.67	106.67	106.67	106.67	106.67	106.67	106.67
80	106.67	106.67	94.48	77.92	106.67	106.67	106.67	106.67	92.62	106.67	106.67	106.67
81	106.67	106.67	106.67	52.27	106.67	106.67	106.67	106.67	106.67	106.67	106.67	106.67
82	106.67	106.67	106.67	76.03	106.67	106.67	106.67	106.67	106.67	106.67	106.67	106.67
83	106.67	106.67	106.67	101.67	106.67	106.67	106.67	106.67	106.67	106.67	106.67	106.67
84	106.67	106.67	106.67	96.59	106.67	106.67	106.67	106.67	106.67	106.67	106.67	106.67
Total	8216.99	8071.36	7669.60	7607.18	8131.66	8051.24	8192.06	7764.83	8108.54	8222.03	8125.53	8200.25

Table A.3: Daily mulberry leaves dry matter intake (g)

Experimental period (day)	Mulberry leaves dry matter intake (g)											
	Control 1	Control 2	Control 3	T1A	T1B	T1C	T2A	T2B	T2C	T3A	T3B	T3C
1	0.00	0.00	0.00	2.19	2.19	2.19	0.00	0.00	0.00	2.19	2.19	2.19
2	0.00	0.00	0.00	2.19	2.19	2.19	0.00	0.00	0.00	2.19	2.19	2.19
3	0.00	0.00	0.00	2.19	2.19	2.19	0.00	0.00	0.00	2.19	2.19	2.19
4	0.00	0.00	0.00	2.19	2.19	2.19	0.00	0.00	0.00	2.19	2.19	2.19
5	0.00	0.00	0.00	2.19	2.19	2.19	0.00	0.00	0.00	2.19	2.19	2.19
6	0.00	0.00	0.00	2.19	2.19	2.19	0.00	0.00	0.00	2.19	2.19	2.19
7	0.00	0.00	0.00	2.19	2.19	2.19	0.00	0.00	0.00	2.19	2.19	2.19
8	0.00	0.00	0.00	2.19	2.19	2.19	0.00	0.00	0.00	2.19	2.19	2.19
9	0.00	0.00	0.00	2.19	2.19	2.19	0.00	0.00	0.00	2.19	2.19	2.19
10	0.00	0.00	0.00	2.19	2.19	2.19	0.00	0.00	0.00	2.19	2.19	2.19

11	0.00	0.00	0.00	2.19	2.19	2.19	0.00	0.00	0.00	2.19	2.19	2.19
12	0.00	0.00	0.00	2.19	2.19	2.19	0.00	0.00	0.00	2.19	2.19	2.19
13	0.00	0.00	0.00	2.19	2.19	2.19	0.00	0.00	0.00	2.19	2.19	2.19
14	0.00	0.00	0.00	2.19	2.19	2.19	0.00	0.00	0.00	2.19	2.19	2.19
15	0.00	0.00	0.00	2.19	2.19	2.19	0.00	0.00	0.00	2.19	2.19	2.19
16	0.00	0.00	0.00	2.19	2.19	2.19	0.00	0.00	0.00	2.19	2.19	2.19
17	0.00	0.00	0.00	2.19	2.19	2.19	0.00	0.00	0.00	2.19	2.19	2.19
18	0.00	0.00	0.00	2.19	2.19	2.19	0.00	0.00	0.00	2.19	2.19	2.19
19	0.00	0.00	0.00	2.19	2.19	2.19	0.00	0.00	0.00	2.19	2.19	2.19
20	0.00	0.00	0.00	2.19	2.19	2.19	0.00	0.00	0.00	2.19	2.19	2.19
21	0.00	0.00	0.00	2.19	2.19	2.19	0.00	0.00	0.00	2.19	2.19	2.19
22	0.00	0.00	0.00	2.19	2.19	2.19	0.00	0.00	0.00	2.19	2.19	2.19
23	0.00	0.00	0.00	2.19	2.19	2.19	0.00	0.00	0.00	2.19	2.19	2.19

24	0.00	0.00	0.00	2.19	2.19	2.19	0.00	0.00	0.00	2.19	2.19	2.19
25	0.00	0.00	0.00	2.19	2.19	2.19	0.00	0.00	0.00	2.19	2.19	2.19
26	0.00	0.00	0.00	2.19	2.19	2.19	0.00	0.00	0.00	2.19	2.19	2.19
27	0.00	0.00	0.00	2.19	2.19	2.19	0.00	0.00	0.00	2.19	2.19	2.19
28	0.00	0.00	0.00	2.41	2.41	2.41	0.00	0.00	0.00	2.41	2.41	2.41
29	0.00	0.00	0.00	2.41	2.41	2.41	0.00	0.00	0.00	2.41	2.41	2.41
30	0.00	0.00	0.00	2.41	2.41	2.41	0.00	0.00	0.00	2.41	2.41	2.41
31	0.00	0.00	0.00	2.41	2.41	2.41	0.00	0.00	0.00	2.41	2.41	2.41
32	0.00	0.00	0.00	2.41	2.41	2.41	0.00	0.00	0.00	2.41	2.41	2.41
33	0.00	0.00	0.00	2.41	2.41	2.41	0.00	0.00	0.00	2.41	2.41	2.41
34	0.00	0.00	0.00	2.41	2.41	2.41	0.00	0.00	0.00	2.41	2.41	2.41
35	0.00	0.00	0.00	2.41	2.41	2.41	0.00	0.00	0.00	2.41	2.41	2.41
36	0.00	0.00	0.00	2.41	2.41	2.41	0.00	0.00	0.00	2.41	2.41	2.41

37	0.00	0.00	0.00	2.41	2.41	2.41	0.00	0.00	0.00	2.41	2.41	2.41
38	0.00	0.00	0.00	2.41	2.41	2.41	0.00	0.00	0.00	2.41	2.41	2.41
39	0.00	0.00	0.00	2.41	2.41	2.41	0.00	0.00	0.00	2.41	2.41	2.41
40	0.00	0.00	0.00	2.41	2.41	2.41	0.00	0.00	0.00	2.41	2.41	2.41
41	0.00	0.00	0.00	2.41	2.41	2.41	0.00	0.00	0.00	2.41	2.41	2.41
42	0.00	0.00	0.00	2.41	2.41	2.41	0.00	0.00	0.00	2.41	2.41	2.41
43	0.00	0.00	0.00	2.41	2.41	2.41	0.00	0.00	0.00	2.41	2.41	2.41
44	0.00	0.00	0.00	2.41	2.41	2.41	0.00	0.00	0.00	2.41	2.41	2.41
45	0.00	0.00	0.00	2.41	2.41	2.41	0.00	0.00	0.00	2.41	2.41	2.41
46	0.00	0.00	0.00	2.41	2.41	2.41	0.00	0.00	0.00	2.41	2.41	2.41
47	0.00	0.00	0.00	2.41	2.41	2.41	0.00	0.00	0.00	2.41	2.41	2.41
48	0.00	0.00	0.00	2.41	2.41	2.41	0.00	0.00	0.00	2.41	2.41	2.41
49	0.00	0.00	0.00	2.41	2.41	2.41	0.00	0.00	0.00	2.41	2.41	2.41

50	0.00	0.00	0.00	2.41	2.41	2.41	0.00	0.00	0.00	2.41	2.41	2.41
51	0.00	0.00	0.00	2.41	2.41	2.41	0.00	0.00	0.00	2.41	2.41	2.41
52	0.00	0.00	0.00	2.41	2.41	2.41	0.00	0.00	0.00	2.41	2.41	2.41
53	0.00	0.00	0.00	2.41	2.41	2.41	0.00	0.00	0.00	2.41	2.41	2.41
54	0.00	0.00	0.00	2.41	2.41	2.41	0.00	0.00	0.00	2.41	2.41	2.41
55	0.00	0.00	0.00	2.41	2.41	2.41	0.00	0.00	0.00	2.41	2.41	2.41
56	0.00	0.00	0.00	2.63	2.63	2.63	0.00	0.00	0.00	2.63	2.63	2.63
57	0.00	0.00	0.00	2.63	2.63	2.63	0.00	0.00	0.00	2.63	2.63	2.63
58	0.00	0.00	0.00	2.63	2.63	2.63	0.00	0.00	0.00	2.63	2.63	2.63
59	0.00	0.00	0.00	2.63	2.63	2.63	0.00	0.00	0.00	2.63	2.63	2.63
60	0.00	0.00	0.00	2.63	2.63	2.63	0.00	0.00	0.00	2.63	2.63	2.63
61	0.00	0.00	0.00	2.63	2.63	2.63	0.00	0.00	0.00	2.63	2.63	2.63
62	0.00	0.00	0.00	2.63	2.63	2.63	0.00	0.00	0.00	2.63	2.63	2.63

63	0.00	0.00	0.00	2.63	2.63	2.63	0.00	0.00	0.00	2.63	2.63	2.63
64	0.00	0.00	0.00	2.63	2.63	2.63	0.00	0.00	0.00	2.63	2.63	2.63
65	0.00	0.00	0.00	2.63	2.63	2.63	0.00	0.00	0.00	2.63	2.63	2.63
66	0.00	0.00	0.00	2.63	2.63	2.63	0.00	0.00	0.00	2.63	2.63	2.63
67	0.00	0.00	0.00	2.63	2.63	2.63	0.00	0.00	0.00	2.63	2.63	2.63
68	0.00	0.00	0.00	2.63	2.63	2.63	0.00	0.00	0.00	2.63	2.63	2.63
69	0.00	0.00	0.00	2.63	2.63	2.63	0.00	0.00	0.00	2.63	2.63	2.63
70	0.00	0.00	0.00	2.63	2.63	2.63	0.00	0.00	0.00	2.63	2.63	2.63
71	0.00	0.00	0.00	2.63	2.63	2.63	0.00	0.00	0.00	2.63	2.63	2.63
72	0.00	0.00	0.00	2.63	2.63	2.63	0.00	0.00	0.00	2.63	2.63	2.63
73	0.00	0.00	0.00	2.63	2.63	2.63	0.00	0.00	0.00	2.63	2.63	2.63
74	0.00	0.00	0.00	2.63	2.63	2.63	0.00	0.00	0.00	2.63	2.63	2.63
75	0.00	0.00	0.00	2.63	2.63	2.63	0.00	0.00	0.00	2.63	2.63	2.63

76		0.00	0.00	0.00	2.63	2.63	2.63	0.00	0.00	0.00	2.63	2.63	2.63
77		0.00	0.00	0.00	2.63	2.63	2.63	0.00	0.00	0.00	2.63	2.63	2.63
78		0.00	0.00	0.00	2.63	2.63	2.63	0.00	0.00	0.00	2.63	2.63	2.63
79		0.00	0.00	0.00	2.63	2.63	2.63	0.00	0.00	0.00	2.63	2.63	2.63
80		0.00	0.00	0.00	2.63	2.63	2.63	0.00	0.00	0.00	2.63	2.63	2.63
81		0.00	0.00	0.00	2.63	2.63	2.63	0.00	0.00	0.00	2.63	2.63	2.63
82		0.00	0.00	0.00	2.63	2.63	2.63	0.00	0.00	0.00	2.63	2.63	2.63
83		0.00	0.00	0.00	2.63	2.63	2.63	0.00	0.00	0.00	2.63	2.63	2.63
84		0.00	0.00	0.00	2.63	2.63	2.63	0.00	0.00	0.00	2.63	2.63	2.63
	Total	0.00	0.00	0.00	202.79	202.79	202.79	0.00	0.00	0.00	202.79	202.79	202.79

Table A.4: Total dry matter intake (g)

Type of feed	Total dry matter intake (g)											
	Control 1	Control 2	Control 3	T1A	T1B	T1C	T2A	T2B	T2C	T3A	T3B	T3C
Pellet	8216.99	8071.36	7669.60	7607.18	8131.66	8051.24	8192.06	7764.83	8108.54	8222.03	8125.53	8200.25
Leaves	0.00	0.00	0.00	202.79	202.79	202.79	0.00	0.00	0.00	202.79	202.79	202.79
TOTAL	8216.99	8071.36	7669.60	7809.97	8334.45	8254.04	8192.06	7764.83	8108.54	8424.82	8328.33	8403.05

Table A.5: Proximate analysis of rabbit droppings.

Parameters	Control 1	Control 2	Control 3	T1A	T1B	T1C	T2A	T2B	T2C	T3A	T3B	T3C
Dropping produced (g)	713.70	726.26	836.00	634.99	896.51	809.73	826.84	813.63	853.96	928.30	824.04	745.12
Dry matter (%)	68.27	72.42	66.31	64.77	62.77	73.51	68.43	68.20	63.11	65.40	67.87	71.43
Moisture content (%)	32.16	25.58	33.69	35.23	34.02	26.49	31.57	31.80	36.87	34.60	32.13	28.67
Ash (%)	16.85	17.01	16.18	16.31	15.82	15.54	15.50	16.95	16.77	15.95	17.00	16.94
Protein (%)	10.63	9.55	10.93	11.21	10.96	10.40	10.05	10.04	10.87	10.73	10.79	9.55
Fat (%)	2.17	2.33	2.60	2.37	2.23	2.12	1.71	1.94	1.94	2.08	1.72	1.94
Crude Fibre (%)	37.58	39.99	33.65	35.37	36.71	36.51	37.92	38.25	38.36	37.83	39.05	32.72

Table A.6: Body weight changes (g) between treatments.

Experimental period (days)	Body weight changes (g)											
	Control 1	Control 2	Control 3	T1A	T1B	T1C	T2A	T2B	T2C	TC1	TC2	TC3
1	845	939	653	920	786	636	775	645	740	945	888	799
7	901	1020	706	1041	916	743	940	723	887	1015	1018	950
14	990	1114	837	1200	1012	868	1049	905	1040	1160	1169	1050
21	1037	1187	903	1289	1111	914	1137	995	1136	1226	1229	1137
28	1184	1286	933	1404	1238	988	1274	1098	1156	1377	1377	1257
35	1386	1435	1047	1554	1400	1016	1430	1290	1414	1471	1561	1411
42	1504	1567	1130	1705	1559	1226	1567	1486	1600	1625	1662	1591
49	1587	1651	1215	1753	1659	1317	1665	1590	1680	1706	1737	1676
56	1730	1504	1289	1823	1736	1415	1756	1693	1796	1805	1818	1801
63	1797	1699	1405	1880	1846	1617	1857	1881	1901	1812	1878	1828
70	1900	1759	1491	1938	1961	1640	1952	1991	2006	1872	2003	1946

77	1990	1924	1559	1982	2034	1801	2067	1999	2012	1942	2118	2057
84	2096	2013	1627	2053	2161	1817	2170	2124	2062	2048	2216	2069

Table A.7: Feed conversion ratio of rabbits

Parameters	Control 1	Control 2	Control 3	T1A	T1B	T1C	T2A	T2B	T2C	TC1	TC2	TC3
FCR	7.3892	8.4545	8.8585	8.3706	7.3265	8.4534	6.6064	5.9062	6.9001	9.2254	7.5806	7.9930

Table A.8: Digestibility of rabbits.

Parameters	Control 1	Control 2	Control 3	T1A	T1B	T1C	T2A	T2B	T2C	TC1	TC2	TC3
Digestibility	0.5445	0.5085	0.4743	0.5041	0.4837	0.4554	0.4693	0.4800	0.4706	0.4463	0.4891	0.5126

APPENDIX B

Appendix B.1: The rabbits set to the cages individually

Appendix B.2: The black net install at the bottom of the cages to collect rabbit droppings.

Appendix B.3: The rabbits fed once per day have feed waste, the arrow showing the wasted commercial pellet.

Appendix B.4: Rabbit dropping put in the oven for dry matter analysis and storage for proximate analysis.

A

B

C

Appendix B.5: Proximate analysis equipement; A: Machine for fibre analysis (automated); B: Machine for protein analysis; Machine for fibre analysis (manually)

Appendix B.6: Machine for ether extract analysis.

Appendix B.7: Machine for protein analysis.