Effect of Pineapple By-Product Silage on Growth Performance of Goat

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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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EFFECT OF PINEAPPLE SILAGE ON GROWTH PERFORMANCE OF GOAT

ABSTRACT

Feed with adequate nutrients will produce high quality livestock production. Commercial feed and concentrates can give a significant impact on the growth performance of the goats, however they are quite expensive. One of the reasons that cause environmental pollution is the spoilage of agriculture waste. Pineapple residue is one of the agricultural wastes that can be converted and used as animal feedstuff. Pineapple by-products consist of the residual pulp, skins, stem and leaves. This study was aimed to investigate the utilization of pineapple residue as silage, and to determine the body weight gain, feed intake and body condition score of goats fed with pineapple silage. A total of 8 young male crossbreed goats were used for 60 days of feeding trial. The goats were divided into two groups of 4 goats each; control and treatment 1 group. Commercial pellet was assigned for both groups. Napier grass was offered for control group while pineapple silage mix with Napier grass was for treatment 1. Based on the results, treatment 1 group did not showed significantly difference on average feed intake (86.25 vs 119.11 kg/group), average body weight change (15.37 vs 14.88 kg/group), average body condition score (2.40 vs 2.31) and average daily gain (0.08 vs 0.06 kg/d/group) than control group, respectively. In addition, feed conversion ratio of Napier grass mixed with pineapple by-product silage was lower than Napier grass (18.92 vs 33.75) but still higher compared to common FCR of goat. The utilization of pineapple residue as silage would become an alternative way to produce a low cost feedstuff and reduce the environmental pollution.

Keywords: pineapple residue, silage, feed intake, body weight gain

KESAN SILAJ NANAS TERHADAP PRESTASI PERTUMBUHAN KAMBING

ABSTRAK

Makanan dengan nutrien yang mencukupi akan menghasilkan pengeluaran ternakan berkualiti tinggi. Makanan komersial dan pelet dapat memberi impak yang signifikan terhadap prestasi pembesaran kambing, namun makanan tersebut agak mahal. Salah satu sebab yang menyebabkan pencemaran alam sekitar adalah merosakkan sisa pertanian. Sisa nenas adalah salah satu sisa pertanian yang boleh ditukar dan digunakan sebagai bahan makanan haiwan. Produk lebihan nenas terdiri daripada pulpa, kulit, batang dan daun. Kajian ini bertujuan untuk mengkaji penggunaan sisa nenas sebagai silaj, dan untuk menentukan perubahan berat badan, pengambilan makanan dan skor keadaan kambing yang diberi makan dengan silaj nanas. Sebanyak 8 ekor kambing jantan muda digunakan selama 60 hari percubaan pemakanan. Kambing terbahagi kepada dua kumpulan, 4 kambing masing-masing; kumpulan kawalan dan kumpulan rawatan 1. Pelet komersil telah diberikan untuk kedua-dua kumpulan. Rumput Napier diberikan untuk kumpulan kawalan manakala campuran silaj nenas dengan rumput Napier adalah untuk kumpulan rawatan 1. Berdasarkan keputusan, kumpulan rawatan 1 tidak menunjukkan perbezaan yang signifikan dalam purata pengambilan makanan (86.25 vs 119.11 kg/kumpulan), purata perubahan berat badan (15.37 vs 14.88 kg/kumpulan), purata skor keadaan badan (2.40 vs 2.31) dan purata kenaikan harian (0.08 vs 0.06 kg/d/kumpulan) masing-masing daripada kumpulan kawalan. Di samping itu, nisbah penukaran makanan rumput Napier yang dicampur dengan silaj oleh produk lebihan nenas adalah lebih rendah daripada rumput Napier (18.92 vs 33.75) tetapi masih lebih tinggi berbanding FCR biasa. Penggunaan sisa nenas sebagai silaj menjadi cara alternatif untuk menghasilkan bahan makanan kos rendah dan mengurangkan pencemaran alam sekitar.

Kata kunci: sisa nanas, silaj, pengambilan makanan, perubahan berat badan

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LIST OF SYMBOLS

Kg	Kilogram
G	Gram
Cm	Centimeter
M	Meter
Mt	Metric ton
%	Percent

LIST OF ABBREVIATION

PFR	Pineapple fruit residue
GDP	Gross domestic product
SSL	Self sufficiency level
FAO	Food and Agriculture Organization
DM	Dry matter
CP	Crude protein
DMI	Dry matter intake
TDN	Total digestible nutrient
BW	Body weight
DMI	Dry matter intake
BWC	Body weight change
ADG	Average daily gain
FCR	Feed conversion ratio
BCS	Body condition score
NPN	Non-protein nitrogen
ME	Metabolisable energy
DCP	Digestible crude protein

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CHAPTER 1

1. Introduction

1.1. Research Background

Crops grown in temperate countries which absolutely provide residues give potential value for ruminants such as goat, sheep and cow. According to Schieber, Stintzing and Carle (2001), tropical and subtropical fruit processing produce high ratios of by-products than temperate fruits. The pineapple (*Ananas cosmosus* (L) Merr.) belongs to the family Bromeliaceae is known as one of the most important fruit crops in the world. In Malaysia, pineapples are mostly cultivated in Johor, Sarawak, Sabah, Kedah, Selangor, Penang and Kelantan (Halim, 2016).

Pineapple fruit residue (PFR) mainly consists of pulp, skin, stem, and leaves which are non-edible to the human. Upadhyay, Lamba, and Tawata (2010) has reported that, 65% out of the whole fruit is non-edible for human consumption which includes spent pulp, crown with leaves, pomace and peels. On top of that, the increasing production of pineapple processed products has highly leads to massive waste production in many countries. A study by Nisarani *et al*. (2015) reported that, pineapple fruit residue can lead to major problem due to high moisture and sugar content which can contribute to spoilage and fungal growth. Therefore, some effective techniques are developed to improve the digestibility of crude fibre from low-quality feed ingredients which is by converting PFR into silage. In this present study, PFR will be used in feeding trial of goat. Silage making of pineapple residue is one of the techniques where the pineapple residue is fermented by adding some other additives to increase its palatability and nutritive value. In addition, the conversion of waste materials that contain high moisture become a difficulty due to the lack of proper alternatives and high cost of drying equipment (Makinde & Sonaiya, 2010).

Ruminant livestock industry which consists of cow, goat and sheep are increase in demand for their meat and milk production throughout the year. Ruminants have the ability to transform the nutrients in the feed into high quality animal protein. Therefore, alternative feeds from the conversion of agricultural waste are often considered to overcome feed problems in ruminants (Rahman, Abdullah, Wan Khadijah, Nakagawa & Akashi, 2015). Besides, large crop residues which do not have direct value for human can be convert into the form that can be used directly by ruminants such as goat (Gillespie & Flanders, 2010). In addition, goats are able to digest a large variety of feed contain of fiber and roughages. The rumen bacteria break down the plant food into volatile fatty acids along with the minerals and vitamins (Rashid, 2008).

1.2. Problem statement

Demand for high quality animal proteins in Malaysia has been increasing day by day. However, high quality livestock production such as goat can be produced through the use of good feeds. Feed with adequate nutrients consumption will increase growth performance of goats. Although commercial feedstuff and concentrates can give a significant impact of the growth performance of the goats, they are quite expensive. Therefore, pineapple by-product is one of the agricultural wastes that can be used as animal feedstuff which also known as roughages. Moreover, agricultural waste have becomes one of the reasons causing serious problem of environmental pollution due to their high moisture content. Therefore, the alternatives way have to be developed to overcome this problem which is by conversion of pineapple by-product into silage as ruminant feed and also in order to improve their growth performance.

1.3. Aim

This research is aimed to determine the effect of converting pineapple by-product as ruminant feed silage. The objectives are:

Main objective:

- To evaluate the effectiveness of pineapple residue silage on growth performance of goats.

Specific objectives:

- To determine the body weight change (BWC), body condition score (BCS) and average daily gain (ADG) of goats fed with pineapple by-product silage.
- To determine the feed intake in goats following the feeding of pineapple by-product silage mixed with Napier grass.
- To evaluate the feed coversion ratio (FCR) of goats following the pineapple by-product silage feeding.

1.4. Hypothesis

H_o = Pineapple by-product silage cannot improve the feed intake, BWC, BCS, ADG and FCR in goats.

H_1 = Pineapple by-product silage can improve the feed intake, BWS, BCS, ADG and FCR in goats.

1.5. Scope of the study

This study is conducted to evaluate the effect of pineapple by-product silage on goat performance. The parameters that were observed are the body weight change, feed intake and body condition score of goats. Eight goats from Agro Techno Park, UMK Jeli Campus were used as animal feed trial. The goats were divided into two groups; control and treatment 1 group, for 60 days of feeding trial.

1.6. Significance of the study

This study will benefit to the small farmers as they can cut cost of feeding materials. Imported feedstuffs are known to be expensive and will increase the feeding cost. Therefore, an alternative way to produce a low cost feedstuff is being introduced by converting the agriculture waste such as pineapple residue into animal feed silage. It also can reduce the environmental pollution caused by the massive production of the pineapple residue.

1.7. Limitation of the study

This study did not perform the digestibility of the pineapple silage, nutrient intake of goats, and the meat quality of goats due to time and budget constraints.

CHAPTER 2

2. Literature Review

2.1. Current Issues on Livestock Industry in Malaysia

Malaysia livestock industry becomes one of the important industries in agricultural sector which provide good and useful animal protein for the population in Malaysia. The rising of the development in livestock industry will make sure the food security of the country is stable and also will reduce the dependency from other countries. Shanmuganvelu (2014) has reported, livestock sector contributed about 12.4% of the total agricultural gross domestic product (GDP) in 2013. Poultry sub-sector contributed 62.9% to livestock GDP and 12.1% to the ruminant sub-sector (Shanmuganvelu, 2014).

Livestock industry can be classified into ruminants and non-ruminants. The ruminant sector then divided into large ruminant which consists of dairy and beef cattle, dairy buffaloes while small ruminant consists of sheep and goats. Recently, in Malaysia, the increasing demand of livestock products has been rising due to the rapid economic and human population growth (Nor Amna and Mohamad, 2015). According to Department of Veterinary Services (2017), estimation of the ruminant population in 2018, which consists of buffalo, cattle, goat and sheep has the total of 1,353,841 compared to ruminant population in 2017 which is 1,333,807 (Table 2.1). In 2018, as for ruminants sector, cattle are leading the population with the estimation of 710,481. The estimation population of goat in 2018 is 399,045. However, from 2014 – 2018, the population of goat production drop from 429,398 to 399,045 (Table 2.1). The production of ruminant products is still unable to meet the local demand. Thus, Malaysia imports beef, mutton and milk from other countries especially from New Zealand, India and Australia to control the insufficiency of the ruminant products (Nor Amna and Mohamad, 2015). Besides, the estimation levels of self-sufficiency (SSL) in 2018 for beef, mutton and milk were 21.97%, 10.41% and 61.44% respectively (Table 2.2). Recently, demand for mutton has been increasing day by day due to the increasing of population in Malaysia. However, Malaysia still cannot provide sufficient source of mutton and need to import the products from other developing countries. The retardation of this ruminant sector is normally due to some factors such as expensive feed, the lack of land resources, poor private-sector involvement and cheaper import substitutes (Shanmuganvelu, 2014).

Apart from that, non-ruminant sector which consists of poultry and swine are developing very well in terms of production capacity and technology (Nor Amna and Mohamad, 2015). In Malaysia, poultry, eggs and pork sub-sectors has shown a steady growth over the years which mainly attributed to the active participation of the private sector (Loh, 2002). According to Department of Veterinary Services (2017), the production of poultry population in 2018 is estimated for about 311,978,594 which is increase by 6.4% from 2017. As for swine population in 2018 is estimated for about 1,842,428 and was drop by 0.4% from 2017. For poultry meat and pork, the estimation of SSL is the highest compare to the other livestock population which are 103.40% and 90.53% (Table 2.2). The possibility of non-ruminants to develop rapidly is due to the technology transfer and adoption (Nor Amna and Mohamad, 2015). Thus, the local livestock and international competitive for export are dominating by poultry and swine industries.

In addition, according to the Department of Veterinary Services (2017), the output of livestock products from 2014 until 2018 was dominated by poultry meat following by pork, beef and mutton (Table 2.3). Thus, it indicates the rate of products production from goat and sheep are still in the low production level.

Table 2.1: Malaysia: Livestock Population, 2014 – 2018^{E}

Livestock Type	2014	2015	2016	2017	2018^{E}
Buffalo					
P.Malaysia	61,687	60,198	59,740	54,632	54,205
Sabah	52,450	52,975	53,872	53,850	54,680
Sarawak	7,122	5,396	5,521	5,531	5,436
Total	**121,259**	**118,569**	**119,133**	**114,013**	**114,321**
Cattle					
P.Malaysia	662,818	661,005	654,602	620,521	624,263
Sabah	68,105	70,493	73,215	73,200	75,766
Sarawak	15,860	10,840	10,010	10,111	10,452
Total	**746,783**	**742,338**	**737,827**	**703,832**	**710,481**
Goat					
P.Malaysia	363,768	364,946	350,370	318,032	329,735
Sabah	50,650	52,342	54,541	54,525	56,346
Sarawak	14,980	14,363	11,618	12,747	12,964
Total	**429,398**	**431,651**	**416,529**	**385,304**	**399,045**
Sheep					
P.Malaysia	138,127	142,153	134,057	126,161	125,576
Sabah	2,050	2,069	2,645	2,565	2,597
Sarawak	2,258	2,811	1,777	1,932	1,821
Total	**142,435**	**147,033**	**138,479**	**130,658**	**129,994**

P : Provisional E : Estimate

Source: Department of Veterinary Services, Malaysia (2017).

Table 2.2: Malaysia: Self-Sufficiency Level in Livestock Products (%), 2012 – 2018^{E}

Commodity	Region	2014	2015	2016	2017	2018^{E}
Beef	Malaysia	25.29	23.06	23.04	22.17	21.97
	P.Malaysia	26.68	24.14	23.93	23.19	22.33
Mutton	Malaysia	12.73	11.45	13.00	10.23	10.41
	P.Malaysia	13.57	12.18	13.69	10.90	11.24
Pork	Malaysia	95.66	93.57	90.96	92.12	90.53
	P.Malaysia	94.73	91.38	89.29	90.52	87.62
Poultry meat	Malaysia	104.27	104.16	103.24	103.68	103.40
	P.Malaysia	105.09	104.78	103.72	104.22	109.65

P : Provisional E : Estimate

Source: Department of Veterinary Services, Malaysia (2017)

Table 2.3: Malaysia: Output of Livestock Products, 2014 – 2018^{E}

Commodity	Region	2014	2015	2016	2017	2018 ^{E}
Beef (M. Tonne)	S. Malaysia	51,219	48,977	46,469	44,892	46,169
Total	**Malaysia**	**52,857**	**50,493**	**47,956**	**46,333**	**47,597**
Mutton (M. Tonne)	S. Malaysia	4,425	4,283	4,853	4,275	4,444
Total	**Malaysia**	**4,543**	**4,407**	**4,992**	**4,400**	**4,572**
Pork (M. Tonne)	S. Malaysia	168,158	166,769	161,716	166,668	161,318
Total	**Malaysia**	**217,558**	**222,598**	**195,176**	**218,177**	**217,360**
Poultry Meat ('000 M.Tonne)	S. Malaysia	1,449.6	1,495.4	1,611.5	1,522.5	1,567.7
Total	**Malaysia**	**1,584.1**	**1,633.4**	**1,755.2**	**1,664.9**	**1,707.6**

P : Provisional E : Estimate

Source: Department of Veterinary Services, Malaysia (2017)

2.2. Agricultural by-products as Animal Feed

Feed is known as the large proportion of the cost of livestock production industry. In Malaysia, ruminant industry is not well developed and is mainly being operated by smallholder farmers. Ruminants mostly depend on the locally available feedstuff and only some supplementation ingredients were imported from other countries. The major source of local materials used as ruminants feedstuff are crop residues and other agro-industrial by-products such as rice bran, oil palm frond, copra cake, palm kernel cake, tapioca, sago, and broken rice (Loh, 2002).

According to Department of Agriculture (2017), main fruit crops production in Malaysia in 2017 includes banana, pineapple, durian, watermelon, guava, papaya, rambutan, jackfruit, mangosteen and starfruit. The highest percentage of fruit crop production was dominated by banana with 26.4% followed by pineapple with 25.6% of total production. Department of Agriculture (2017), also has reported that, there has been decreasing in the amount of pineapple production from 2015 – 2017; 452,021.00 mt, 391,714.00 mt and 340,722.00 of pineapple has been produced throughout the year.

Crops such as sorghum, corn, or other forages and residue of sugarcane, pineapple, juice extraction citrus, pumpkin, cassava, and others are highly available during short period of time of harvest season (Jaime, 2016). Due to their high moisture content, preservation is required in order to maintain for a longer period and used as animal feed (Jaime, 2016). According to Farda, Laconi, and Mulatsih (2015), provision of land is increasingly difficult due to land limitation for forage fodder cultivation. The availability of land also has higher priority for human food than for forage crop as ruminant feed. Oladosu *et al*. (2016) has reported, improvement of valuable fodder crops is important in order to create environment-friendly rather than eliminates them by burning practices. Therefore, an alternative way to produce animal feed can be obtained from agriculture wastes that are widely produces throughout the year.

2.3. Pineapple by-products as Animal Feed

Pineapple (*Ananas cosmosus* (L) Merr.) which belongs to the Bromeliaceae is also called as pina (Spanish), abacaxi (Portuguese), annachi pazham (Tamil) or nanas (Malaysia) (Paull and Duarte, 2011). This species is the only one that is grown commercially for its fruit (Paull and Duarte, 2011). Pineapple is one of the important tropical plants which usually consumed fresh or as a juice, fruit pulp and canned (Suksathit, Wachirapakorn, & Opatpatanakit, 2011). According to FAO (2009), 90 – 95% of the tropical fruits are consumed locally and not exported from the producing country. Pineapple by-products are known as household waste or also known as a by-product of pineapple industry which consists of pulp, peels or skin, leaves and contain high moisture content. From the pineapple processing which only used the fruits and juice, a lot of pineapple residue is produced and dumped. However, pineapple residue is high in moisture and sugar content which can fastens the microbial spoilage of the residue. From that, it can lead to the problem which can give serious impact to the environmental pollution. Nisarani *et al*. (2015), has reported in their research about the quality of keeping pineapple residue is low can contribute in putrefaction due to high moisture and sugar content. The residues from the processed pineapple can be converted into an animal feed or other by-product. Pineapple residue from pressed fruit shells and pulp are sold to the farmers either in wet or dried condition (Paull & Duarte, 2011) to be used as animal feed.

2.4. Ensiling pineapple residue

According to Woolford and Pahlow (1998), silage is the process of ensiling the grass or other green fodder with sufficient moisture contents by storing them anaerobically to prevent from spoilage by aerobic microorganisms. Forage can be preserved as silage by acidification or sterilization or hay by drying process (Oladosu *et al.*, 2016). Pineapple residue can be preserved for a longer period of times by ensiling them with or without additives to utilize as fodder sources of livestock feeding. Ensiling of fresh pineapple residue without additives can be done by inserting the sample into the polyethylene bag and compressed by foot to expel the air out of the bag. The polyethlene bag should be tightened using rubber band and stored to allow fermentation process (Nguyen, Nguyen & Preston, 2009). Fresh pineapple residue also can be preserved by dehydration or drying to conserve them from any microbial spoilage. Oladosu *et al*. (2016) mentioned in their study, conserving forage crops as hay works well in dry climates which it can be dried quickly. They also stated, the key principle of drying method is rapid drying to <15% moisture of the forage crops in order to prevent from heat formation from aerobic bacteria and mould growth.

Other than that, different silage additives used in silage fermentation are to reduce fermentation losses, increase energy recovery and nutrient, improve the animal performance and promote rapid fermentation (Oladosu *et al*., 2016). Many attempts have been made towards increasing the utilization and digestibility of agriculture wastes such as physical, chemical and biological pre-treatment in order to improve their efficiencies (Oladosu *et al*., 2016). From research study that has been done by Nguyen *et al*. (2009), they used poultry litter, ground maize cobs and rice polishing as an additives to ensile the pineapple residue. According to Yitbarek and Tamir (2014), silage additives should be safe to handle, increase nutritive value, improve hygienic quality, reduce dry matter (DM) losses, limit secondary fermentation, give high returns to farmers, increase animal production, reduce aerobic deterioration during feed out, and also can be cost effectives.

2.5. Goat

Goat (*Capra hircus*) that belongs to the Bovidae family is known as a ruminant animal that have four-compartment stomach which categorized in the small ruminants groups other than sheep. Goats are a domesticated animal species and are highly valued for their meat, milk, skin, fur and hides. According to Mahgoub, Kadim and Webb (2012), they reported that goat sector is important in the tropics and subtropics where they contributed in the major source of meat, milk, fibre, skin and manure. Besides, goats also can be divided into two categories which are for single-purpose and dual-purposes. However, there are two major productions that are highly concentrated on which are meat production goat and milk production goat. In addition, a study by Lu (1987), reported that goats are able to utilize low-quality rangelands to produce high-quality animal protein.

2.6. General Nutrients Requirement for Goats

Generally, nutrient requirements for goat are depend on the age, sex, breed, production purposes either meat or dairy and physiological stage. Goats commonly consumed feedstuff mostly from plant origin. Forages mainly consist of water (moisture) and dry matter (DM) content. According to Mahgoub *et al*. (2012), DM can be classified into organic matter that includes nutrients such as carbohydrates, proteins, fats, vitamins whereas inorganic matter is consists of minerals. Therefore, it is important for the goats to consume good feedstuff in order to provide sufficient nutrients for growth, body maintenance, reproduction, lactation and pregnancy (Mahgoub *et al*., 2012).

2.6.1. Water

Firstly, one of the most essential nutrients with high consumption is known as water and it may be the most critical nutrients. This is because, life depends more on the availability of water compared to other nutrients. Insufficient of water can lead to the lower feed intake and feed efficiency of the goats which can affects growth, reproduction and milk production (Mahgoub *et al*., 2012).

2.6.2. Energy

According to Pond, Church, Pond and Schoknecht (2005), pasture such as forages, range and browse, hays, silage, by-product feeds and grains are the major sources that contribute into energy. The affects resulting from energy deficiencies are weight loss, reduced growth, reduced reproductive efficiency, reduced milk and fibre production and increase death loss. Therefore, pasture, silage, hay or by-product feeds can be used as the major energy contributor to meet energy requirement for goats.

2.6.3. Protein

Pond *et al.* (2005) stated that small ruminants like goats and sheep, they rely on microbial population in their rumen which functioned to produce many amino acids and vitamins required based on certain production. Moreover, the quantity of the protein is much more important compare to the quality of the protein itself in the diet. However, as for young animals, they are not yet develop a true rumen or microbial population where this will lead them to require and consume a high-quality protein in their diet. Besides, nitrogen from proteins that come from feed origin and nitrogen from non-protein nitrogen (NPN) sources will be utilized by rumen microbial to produce amino acids. Usually, feeds that are high in protein are very costly and therefore, diets often contain urea, a cheap source of nitrogen from NPN. However, urea should not be used in diets for young animals due to their undeveloped rumen.

2.6.4. Vitamins

Vitamins are classified as water-soluble vitamins and fat-soluble vitamins. According to Pond *et al*. (2005), they reported that fat-soluble vitamins (A, D, E, and K) are required in the dietary sources for goats and sheep, meanwhile sufficient quantities of water-soluble vitamins can be produced by microbes in the rumen. Young animals required high amount of vitamins in their diets to meet requirements as well as animals of desired production (meat, milk, and fibre). Moreover, young animals still can obtain and receive adequate amount of vitamins from the milk. However, whether young or matured animals should not receive deficiency or excessive amount of vitamins where it can lead the animals to get disease infection.

2.6.5. Minerals

Minerals can be classified as macrominerals and microminerals. According to Sheep Industry Development (1992), several factors that can affect the mineral requirements for sheep and goats including age, sex, breed, growth rate, physiological state, level and chemical form of ingested minerals, and also interaction with other minerals in the diet. Macromineral requirements for sheep and goat are including Na and Cl, K, Ca, P, S, and Mg while for micromineral requirements for sheep and goats are including I, Cu, Co, Fe, Mn, Mo, Se, and Zn. For example, deficiency in Ca:P ratio or either one of them may reduce the growth and other possible metabolic problems. However, minerals also should be given in right amount, not more or less which are required by goats and sheep to prevent from any health problems occur in the animals.

Table 2.4: Nutrient requirements for selected groups of growing kids

Production Stage	Nutrient Requirements, dry matter basis		
	DMI, % of BW	%CP	%TDN
25 kg dairy doelings and castrates, gaining 100 - 150 g/hd.day	3.3 – 3.8	12	67
25 kg boer doelings and castrates, gaining 100 – 150 g/hd/day	3.0 – 3.4	15 – 17	67
25 kg intact dairy males, gaining			
-100 g/hd/day	3.2 – 3.7	10	67
-150 g/hd/day		15	86
25 kg intact boer males, gaining 100 – 150 g/hd/day	3.3 -3.7	15	67

DMI - dry matter intake, BW - body weight, CP – crude protein, TDN - total digestible nutrient.

Source: Nutrient Requirements of Small Ruminants, National Research Council, (2007); Rashid, (2008).

2.7. Feed intake of goat

Rashid (2008) reported that, goats are able to digest large variety of fibre and roughages. They prefer to eat brushy plants together with some other woody and weedy plants that are found on the ranges and goats are known as efficient browsers. Nutrient requirements of goats are determined by the sex, breed, age, production purposes either dairy or meats, body size, physiological stage and also climate. Based on the condition of the goats, feeding strategies should meet the protein, energy, vitamin and mineral needed for the goats. Rashid (2008), also stated in the article, the daily feed intake of goats ranging from 3 – 4% of its body weight as expressed in pounds (dry matter/head/day). Body weight, % of dry matter in the feeds eaten (12-35% in forages, 86-92% in hays and concentrates), the physiological stage of goats such as growth, pregnancy and lactation and palatability will influenced daily feed intake of the goats.

Energy requirements of the goats also vary for different physiological stage. Except for dairy kids, the maintenance requirements for energy are same for most goats. Dairy kids require 21% energy higher than the average of energy require for most goats. During breeding, lactation and late gestation, goats are recommended to consume high-energy rations of feed and lactating does require the highest energy demand in order to produce the milk (Rashid, 2008). Despite from high quality or good feeding, water intake also important for goats. Inadequate amount of water supplied to the goats can lead to the bad performance. Thus, goats should consume more water with along with good feedstuff in order to produce healthy and good performance of goats.

2.8. Body Condition Score of Goat

Body condition scoring (BCS) is a useful management tool that is designed to evaluate body reserves or fat accumulation of an animal such as cattle, sheep and goats. This is a great method for examining the nutritional status of the herd. BCS is a hands-on assessment using a numerical rating system based on the touching the body of the animal. Thus, for all animal species, the lower the number of the body condition score, the thinner the animal. Every farmers owned animals that either extremely thin or extremely fat. The decreasing of fertility, increased disease or internal parasite incidence, decreased milk production and increased operating cost are caused due to the failure to recognize the animals and take corrective action of the body scoring of these animals (Villaquiran, Gipson, Merkel, Goetsch, & Sahlu, 2004). Besides, during assigning the BCS, the evaluations need to be focused at the amount of the muscle, fat cover and skeletal features in eight important anatomical points by feeling it with the hand. These eight anatomical points are the brisket (sternum), shoulder, ribs, loin (lumbar vertebra), hooks, stifle, tail head, and pins. The scoring that is performed on the goats is ranging from 1.0 to 5.0.

According to Villaquiran *et al*. (2004), animal with BCS 1.0 is classified as emaciated and weak which have a highly visible backbone and continuous forms of ridge. Other than that, they have a hollow flank, a very visible ribs, no fat cover and penetration intercostal spaces (between ribs) by fingers are easier. BCS 1.0 have the spinous process of the lumbar vertebrae that can be grasped easily by thumb and forefinger. The visual aspects of the spinous process are rough, prominent and distinct which is giving a saw-tooth appearance. It also has an extremely little muscle and fat cannot be felt between the skin and bone. In this condition, the sternal fat can be easily grasped between thumb and fingers and can be moved from side to side.

Secondly, BCS 2.0 has slightly raw-boned, visible backbone with a continuous ridge. Some of the goat ribs can be seen and some of them are covered by a small amount of fat. However, the ribs still can be felt and the intercostal spaces still can be penetrated but has a smooth feature. Goats with a BCS 2.0 have an evident spinous process of the lumbar vertebrae and it still can be grasped by thumb and forefinger. Although, a muscle mass can be felt between the skin and bone. The transverse process which is about one-third to one-half of the length is discernible and can be grasped by the hand but the transverse process is difficult to see. In this condition, the sternal fat still can be grasped and lifted by the thumb and forefinger even though it is wider and thicker. Joints are less evident and the layer of the fat still can be moved side to side (Villaquiran *et al*., 2004).

Thirdly, Villaquiran *et* al. (2004) also reported that, BCS 3.0 have the features of non-prominent backbone, barely discernible ribs which contain of even layers of fat cover them. By applying some pressure, the intercostal spaces can be felt. The spinous process of the lumbar vertebrae of BCS 3.0 goats cannot be easily grasped due to the thickness of the tissue layer which covered the vertebrae. A slight hollow can be felt from the touched using a finger over the spinous process. The transverse process which is less than one-quarter of the length is discernible. In this condition, the sternal fat is wide and thick but it still can be grasped and has very little movement. The joints that are joining the ribs and cartilage are barely felt.

Next, BCS 4.0 have an unseen backbone, unseen ribs and side of the animal is sleek in appearance. The spinous process of the lumbar vertebrae is difficult to grasp due to it is wrapped in a thick layer of fat and muscle. The spinous process start to form a continuous line and from the spinous to the transverse process, round transition is exists. In this condition, the outline of the transverse process of the lumbar vertebrae is no longer discernible and it forms a rounded and smooth edge with no individual vertebrae discernible. The sternal fat cannot be grasped due to its width and depth and cannot be moved from side to side (Villaquiran *et al*., 2004).

Lastly, BCS 5.0 has a backbone which is buried in fat, non-visible ribs and rib cage covered with excessive fat. The spinous process is difficult to be found due to the thickness and excessive muscle and fat. In this condition, the spinous process forms a depression along the backbone and produces a bulging transition from the spinous to transverse process. The marks of the transverse process also difficult to be found due to the thickness of the muscle and fat and impossible to grasp the transverse process. Goats with BCS 5.0 also has extends sternal fat and covers the sternum, joining fat covering cartilage and ribs and cannot be grasped (Villaquiran *et al*., 2004).

CHAPTER 3

3. Methodology

3.1. Experimental Design and Site

In this study, a total of 8 young male goats were randomly selected and used for feeding trial. The goats were divided into two 2 groups of 4 animals each: control and treatment 1, and were placed in two different pens with individual feeding supplied with water. This experiment was conducted at Agro Techno Park, UMK Jeli Campus. Prior to the beginning of the experiment, treatment 1 goats were assigned with one week adaptation period with pineapple by-product silage and commercial pellet as the feed, (Table 3.1).

Table 3.1: Experimental design of feeding trial for goats

Group / Feed	Napier grass	Commercial pellet	Pineapple by-product silage
Control group	√ (70%)	√ (30%)	-
Treatment 1	√ (30%)	√ (30%)	√ (40%)

3.2. Sample Preparation

In this experiment, the Napier grass, commercial pellet and pineapple by-product silage were offered to the goats. Napier grasses were collected directly at Agro Techno Park, UMK Jeli Campus. The grasses were chopped manually and offered to the control group as fresh basis. The formula of pineapple by-product silages were obtained from another researcher from the same research team and were offered to the treatment 1 goats mixed together with Napier grass.

3.3. Feeding trial

This animal feed trial of goats was conducted for 60 days. Feed intake, BWC and BCS were measured during this experiment. The goats were fed twice per day. In this experiment, the control group were offered with commercial pellet (30%) in the morning and chopped Napier grass (70%) in the afternoon. As for treatment 1, the goats were offered with commercial pellet (30%) in the morning and pineapple by-product silage (40%) mixed with chopped Napier grass (30%) in the afternoon.

3.4. Evaluation of growth performance of goats

3.4.1. Body weight change

Initial BW of all goats were weighed individually on the first day before the feeding trial and followed for every two weeks interval before feeding in the morning by using hanging scale. The average of daily gain was calculated using this formula:

$$ADG = \frac{\text{Final live weight (kg) - Initial live weight (kg)}}{\text{Total experimental days (d)}}$$

3.4.2. Body condition score

Body condition score (BCS) is the evaluation of fat accumulation using a numerical rating system range from 1 - 5. BCS 1 is known as extremely thin and BCS 5 is known as extremely fat. BCS of all goats were measured for every two weeks interval by touching some parts of the body of the animal to evaluate the fat accumulation using numerical rating system. The ideal BCS is range between 2 - 4. In this feeding trial experiment, BCS 2 - 4 were targeted on all goats.

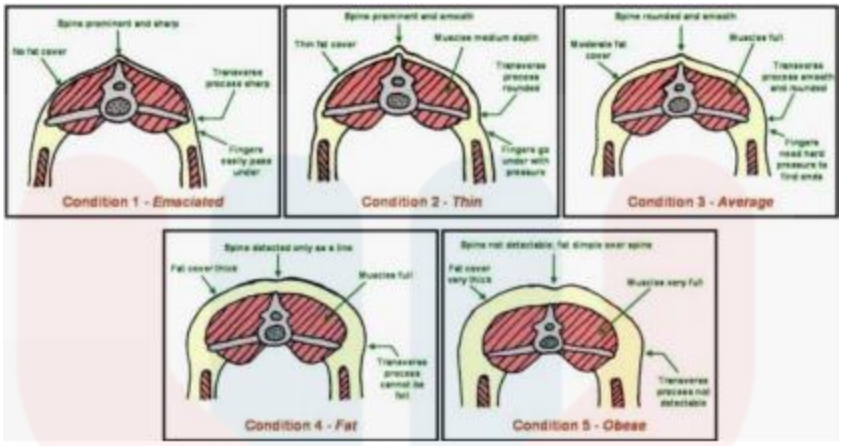

Figure 3.1: Body condition score of goat

3.4.3. Feed Intake

Throughout 60 days feeding trial, the amount of feeds that were offered and refusals of feed of individual goats were collected, weighed and recorded every day in the morning to estimate the feed intake. Daily feed intake was calculated using this formula:

$$\text{Feed intake (g)} = \text{Feed offered (g)} - \text{feed refused (g)}$$

Feed conversion ratio (FCR) is the measure of how efficient the animals convert the feed mass to increase the body weight gain. FCR was measured using this formula:

$$\text{FCR} = \frac{\text{Total daily feed intake (kg)}}{\text{ADG (kg)}}$$

3.5. Statistical analysis

All the data were subjected to analyse using SPSS statistical analysis by using an independent sample t-test. The data that were evaluated are feed intake, BWC, ADG, BCS, and FCR.

CHAPTER 4

RESULTS AND DISCUSSION

4.1. Feed Intake

Based on Figure 4.1, during the 60 days feeding trial, the control group had numerically higher (119.11 vs 86.25 kg/group) of total feed intake compared to treatment 1 group, respectively. However, there was no statistically significant difference between the groups ($p > 0.05$).

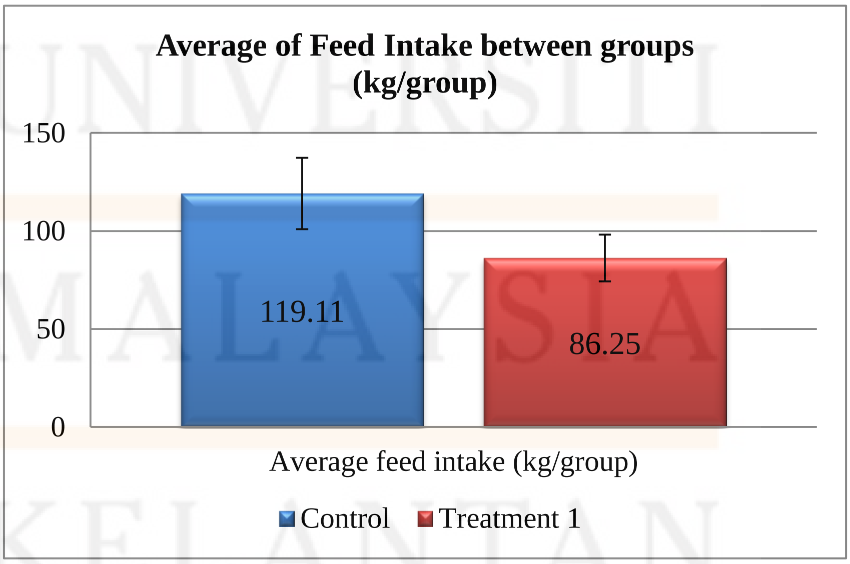

Figure 4.1: Average feed intake (kg/group) between groups for total experimental periods (60 days) (Mean±SE), p-value = 0.18

In this current study, the total of feed intake of goats during the 60 days feeding trial in control group was higher than treatment 1 group ($p < 0.05$). This can be supported with the finding by Maneerat *et al*. (2015) who reported that the total dry matter intake (DMI) of fattening steers in control diet (T1) was higher (9.77 kg/day) compared to those in bagasse-vinasse mixture with pineapple silage and bagasse-vinasse mixture with sweet corn husk and cob silage diets (8.12 kg/day) and (7.00 kg/day) respectively ($p < 0.05$). In this current study, DMI was not performed. Maneerat *et al.* (2015) stated one of the reasons for the high DMI of the control group is due to the fast digestion rate of molasses included in the diet. As for this current study, the high of feed intake in control group is due to the goats tend to eat leafy feed, brushy plants and more nutritious feed. This is proved by Mamoon (2008) who stated that goats are efficient browsers and more preferable to eat brushy plants with some woody and weedy plants found on the ranges. Moreover, Pitman (2011) noted that in the tropics, small ruminants often depends on low-quality grasses which are low in CP and high in neutral detergent fibre, which is usually aggravated by their scarce availability during the dry season. McDonald *et al.* (2011) demonstrated that ruminant intake is more related to the rate of digestion of diets than to digestibility per se.

Goat has its own specific of nutrient requirement that it needs for to live, grow, produce and reproduce. Goat needs adequate amount of protein, fibre, carbohydrates, fat, water and minerals to fulfil their requirements needed in their daily life. Salah *et al.* (2014) stated from their findings that the effect of protein level on energy requirement show that there was no significant difference between the three classes of protein which are (low protein for small ruminants and cattle, medium protein for small ruminants and cattle, high protein for small ruminants and cattle) for the three animal species which are sheep, goat and cattle. The authors also reported that frequently, the animals tend to produce more heat during digestion because of the increasing physical gut work and chewing when the animal diets have low energy density and/or high fibre content. Generally, fibrous diets increased visceral energy consumption, energy costs of intake and chewing, heat production, energy expenditure and consequently metabolisable energy (ME). Furthermore, Salah *et al.* (2014) stated that animals given with diets composed of poor quality roughages are tend to have low N retention and high protein requirement. However, from current study by another researcher in the same teammate found that CP (%) content in the pineapple by-products silage in day 21, 28 and 35 of ensiling were (4.92), (5.16) and (4.96) respectively. As for this current study, silages that were used for feeding trial of goat were from day 21 and above. Thus, silages that were ensiled up to 28 days showed slightly higher CP than 21 and 35 days.

Besides, daily feed intake is influenced by BW, % of DM in the feeds eaten, palatability and physiological stage of the goats (Mamoon, 2008). However, some studies by An *et al.* (1992) and Man *et al.* (1995) reported that feed intake of some roughages resources is low and this is probably due to the high content of anti-nutritional factors and high fibre content (Ben Salem *et al.*, 2005).

In the present study, before the beginning of feeding trial, the goats in the treatment group was assigned with pineapple by-product silage with the percentage of 20%, 40%, 50%, 70% and 100% to see if the goats show a good performance and behaviour during the experimental period. Initially, the goats showed a good behaviour when 20% and 40% of pineapple by-product silage was given as a feed. However, after the amount of pineapple by-product silage was increased up to 50% and 70%, the goat showed bad behaviour in which their feed intake was reduced and they prefer not to eat the feed. One of the goat in the treatment group with the ID 037 showed the most bad behaviour during the experimental period where it came out of the pen to search for another feed. The physical and body condition score of the goat also showed that the amount given of pineapple by-product silage to the goat is not too effective. Thus, a decision is made to only use only 40% of pineapple by-product silage mixed with 30% of Napier grass as daily feeding during the feeding trial.

In addition, the lacking of nutrient in the feed also can be one of the factors that the goat does not eat the given feed. According to Suzika *et al.* (2013) who found that the CP content in the pineapple by-product is low (< 60 g/kg DM). A good quality silage is when there is good microbial fermentation process. However, pineapple by-product contain high in moisture content where result in low DM content which presupposed difficulties in their preservation by anaerobic fermentation (Suzika *et al.*, 2013). Moreover, for silages, the pH value that is < 4.2 was well preserved, 4.3 – 4.5 was intermediate range (McDonald *et al.*, 2002). However, in the present study by another researcher from the same teammate found that pineapple by-product silage at day 14, 21, 28 and 35 were 3.97, 4.07, 4.33 and 4.67 respectively. Some previous study evaluating fruit by-products more often to present different results of chemicals composition (Tripodo *et al.*, 2004; Gutierrez *et al.*, 2003). This is because fruit by-products are not uniform residues in which they are characterized by different proportions of skin, crowns or seed and remnants of pulp. As in pineapple by-products, it contains a low crude protein content and high in moisture content. Therefore, pineapple by-product silage that used in this feeding trial was formulated by adding only molasses which the functions are for the energy and palatability.

Napier grass (*Pennisetum purpureum)* is most commonly known as common feed of ruminants. Finding by Aganga *et al.* (2005) who found that chemical composition of Napier grass are different according to the height of the cutting. The author also reported that CP (%) content of Napier grass cut at 50 cm height is higher compared to

75 cm, 1 m, 1.25 cm and 1.5 cm height which are 13.29%, 10.33%, 8.85%, 6.67% and 4.79% respectively. However, the DM (%) content of Napier grass cut at 75 cm height is significantly higher than 50 cm height which are 45.94% and 37.00% respectively. The CP (%) content in grasses also depends on their age and maturity. Young grasses contain higher CP (%) content compared to old grasses. However, lignin and fibre content is higher in old grasses than in young grasses. Usually, fat content should not represent more than 5% of a diet otherwise it could cause depresses in ruminal fermentation. Acid detergent lignin content of Napier grass is lowest in cut at 75 cm height compared to 50 cm, 1 m, 1.25 m and 1.5 m height which are 2.0%, 3.5%, 3.5%, 3.0% and 6.50% respectively (Aganga, 2005). As for this present study, the Napier grass was harvested randomly following the availability of the grass at Agro Techno Park, UMK Jeli during the 60 days of feeding trial. Therefore, the chemical composition of the Napier grass was not observed due to the limited sources of the Napier grass.

4.2. Average Body Weight Change (BWC) between groups

Figure 4.2 shows the mean of BWC between treatments for each sampling in two weeks interval for 60 days of feeding trial. According to the Figure 4.2, average of body weights change of both control and treatment 1 group were increased from day 1 until day 60. During day 1, the average of body weight between control and treatment groups were almost the same which are (13.00 vs 13.05 kg/group) respectively. However, there was no significant difference between the groups ($p > 0.05$). Moreover, during day 29 the body weight gain in both control and treatment group did not differed significantly which are (15.13 vs 15.38 kg/group) respectively and there was also no significant difference between groups ($p > 0.05$). However, at the final of feeding trial (day 60), BWC of treatment group was significantly higher compared to the control groups which are (17.73 vs 16.63 kg/group) respectively but there was no significant difference between groups. Thus, there were no statistically significant differences (p > 0.05) of BWC between control and treatment groups during the 60 days of feeding trial.

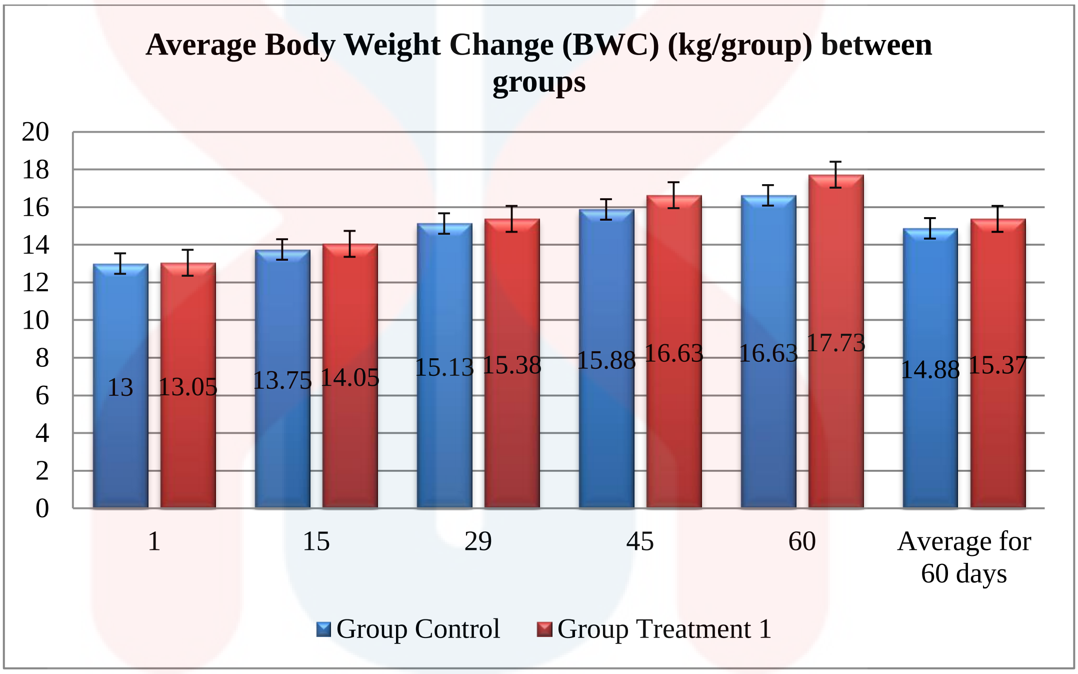

Figure 4.2: Comparison of Body Weight Change (kg/group) between groups (Mean±SE), p-value = 0.66

*List of p-value is stated in appendix A14

The effects of including the pineapple by-product silage in the goat's feed on the growth performance of goats showed (Figure 4.2) that the initial and final body weights (kg) did not differed significantly between groups (p > 0.05). However, the treatment group fed with Napier grass mix with pineapple by-product silage displayed the significantly higher of ADG (kg/d) (Figure 4.4) compared to control group. Moreover, this can be supported with the finding by Maneerat *et al.* (2015) who reported that treatment 3 group which fed with bagasse-vinasse mixture with pineapple peel silage displayed the highest average of daily gain (ADG) ($p < 0.05$). Galvani *et al.* (2008) reported that for the same gain, protein and energy cost may be different depending on the body composition. Other than that, some previous studies like NRC (2000) and Luo *et al.* (2004) suggested greater requirements for intact males compared with females and castrated males. Moreover, in this present study, the effect of age in nutrient requirements is not well studied. But finding by Luo *et al.* (2004) stated that ruminants indicated decreasing requirements with age. Besides, high of energy losses as extra heat can be expected when diets are given to low-performing animals (Salah *et al.*, 2014). This can be due to the animals own genetic which have low rumen digestibility.

Moreover, this also can happened when the animals tend to eat more feed but they did not gaining so much body weight gain due to their genetic and physiological status. This can be supported with the finding from previous study by Mandal *et al* (2005) who stated that during feeding trials, the animal passes through several physiological stages, each of which consumes more or less dry matter and energy, therefore affecting the maintenance needs. Findings by Ngwa *et al.* (2000) and Lu *et al.* (2005) stated that goats are differ from sheep in terms of level of intake, feeding behaviour, taste discrimination, diet selection, and rate of eating due to the differences in anatomy and physiology of the animals. From the results above shows that BWC was increased but not too much and this could be from the nutrient absorbed by the goat maybe low due to the low nutrient in the pineapple by-product silage or also it can happen because of the genetic and physiological status of the goat itself. This can be supported with the finding by Kadzere et al. (2002) who reported that animals that experience heat-stressed can decrease their feed intake in order to create less metabolic heat because the heat increment of feeding is an important source of heat production. The goats may be only received enough crude protein source from the commercial pellet given. Based on the data recorded, the feed intake of goat in treatment 1 are high which indicates that the goats ate the feed given but they did not gain more weight from eating the Napier grass mixed with the pineapple by-product silage.

4.3. Body Condition Score (BCS)

From Figure 4.3, control and treatment both have a similar average body condition score for the 60 days feeding trial. However, during day 15 of feeding trial, treatment 1 group had significantly higher of BCS compared to control group which are (2.20 vs 2.09) respectively but there was no significant difference between groups ($p > 0.05$). However, during day 45 of feeding trial, treatment 1 group also had significantly higher of BCS compared to control group which are (2.56 vs 2.39) respectively but no significant difference between groups ($p > 0.05$). Thus, there was no statistically significant difference between the groups ($p > 0.05$) during the 60 days of feeding trial.

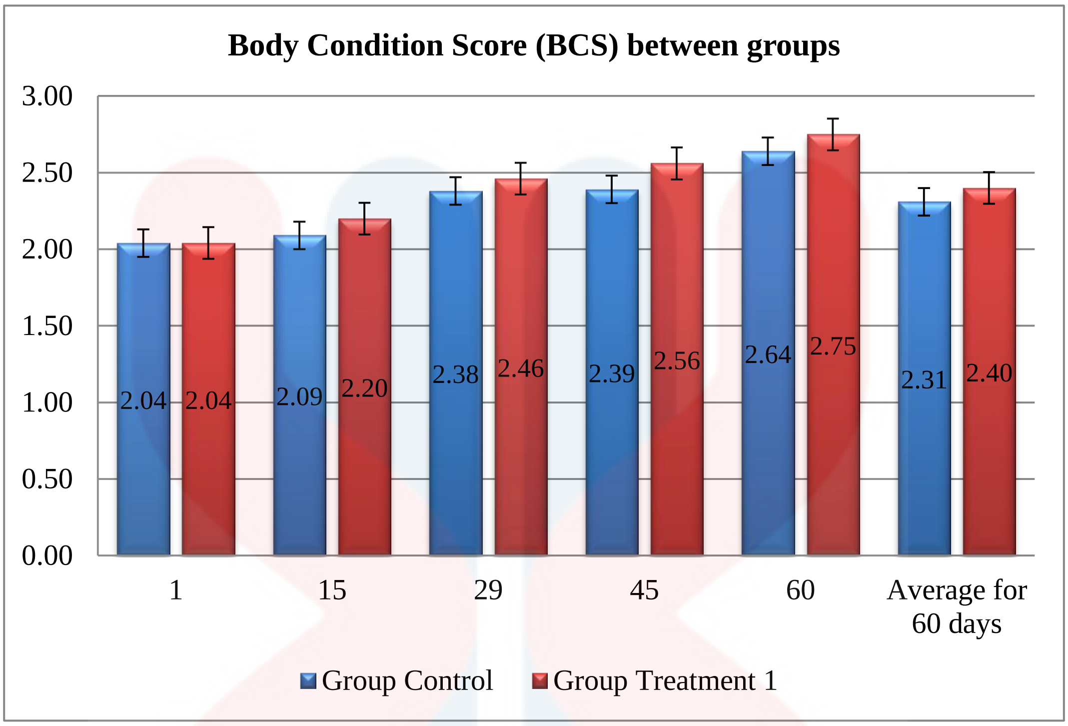

Figure 4.3: Comparison of Body Condition Score (BCS) between groups (Mean±SE), p-value = 0.59

*List of p-value is stated in appendix A21

The goats have low BCS and BW during the experimental period before starting the feeding trial due to stress and low feed quantity in which to make the goats adapt with the new environment. This can be supported with the finding by Gupta *et al.* (2013) who reported that heat stress redistributes the body resources including protein and energy which can cause decreased growth, production, reproduction and health of the animals. Besides, similar finding also stated that the general homeostatic responses to heat stress in goats include raised water consumption, body temperature and respiration rate, decreased of feed intake and DMI (Mortola *et al.*, 2000; Facanha *et al.*, 2012; Gupta *et al.*, 2013; Caulfield *et al.*, 2014). Therefore, after decided to add 40% of pineapple by-product silage and mixed with 30% Napier grass, the treatment 1 goats showed an improvement in feed intake, body weight gain and body condition score but there was no significant difference ($p > 0.05$) compared to control group which was fed with 70% of Napier grass and 30% commercial pellet.

4.4. Average Daily Gain (ADG)

Figure 4.4 shows that during 60 days of feeding trial, treatment 1 group has the highest ADG (kg/d) compared to control group which is (0.08 vs 0.06 kg/d/group) respectively. However, there was no statistically significant difference between the groups ($p > 0.05$).

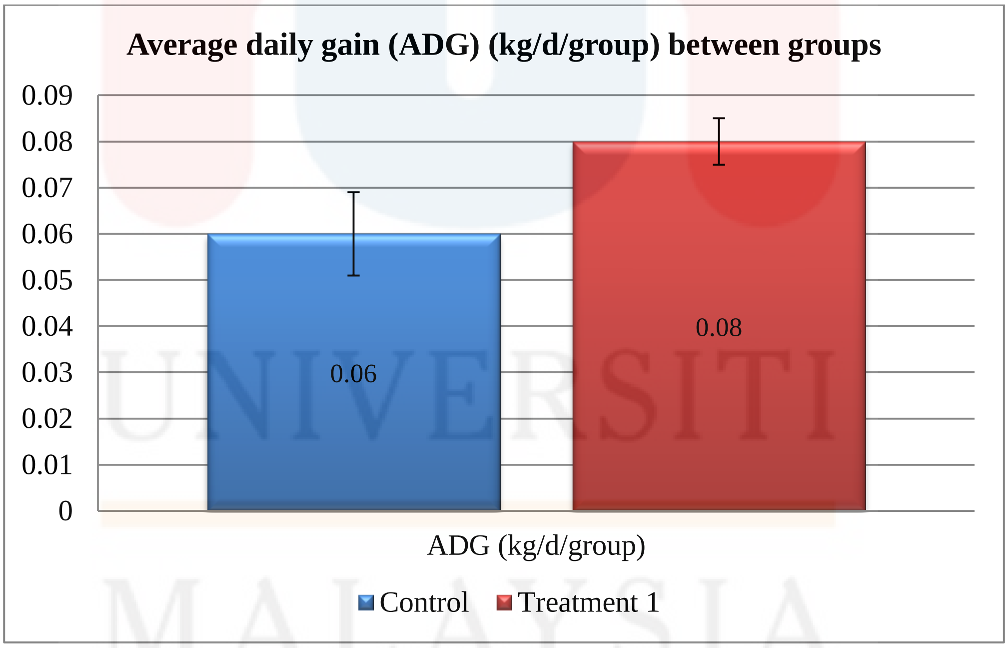

Figure 4.4: Comparison of Average Daily Gain (ADG) (kg/d/group) between groups (Mean±SE), p-value = 0.20

From Figure 4.2, the body weight change of treatment group is increased significantly during the 60 days of feeding trial compared to control group. Control group which was fed with 70% Napier grass and 30% commercial pellet showed and increasing of weight from day 1 (13.00 kg/group) until day 60 (16.63 kg/group) of feeding trial as well as for treatment group which was fed with 30% Napier grass mixed with 40% pineapple silage and 30% commercial pellet which are (13.05 kg/group) and (17.73 kg/group) respectively. However, there were no statistically significant differences in the BWC for goats fed with pineapple residue silage and no pineapple residue silage. Figure 4.2 and 4.4 shows that BWC and ADG of treatment group were significantly higher compared to control group but there was no significant difference between the groups ($p > 0.05$). Thus, this means that pineapple by-product silage feeding were not affected the BWC and ADG of the goats. This can be confirmed by previous study published by Cutrim *et al.* (2013) which stated that pineapple by-product silage were not affected the final BWG and daily weight gain. However, finding by Gowda *et al.* (2015) reported that the average daily weight gain (ADG) in lambs fed with pineapple by-product silage diet affect the desired growth rate and also did not have any adverse effects on general health and nutrient utilization.

From the previous findings by Salah *et al.* (2014), goat with ADG 3.53 g/kg $LW^{0.75}$ has the estimated digestible crude protein (DCP) maintenance requirement in the range of 2.12 to 3.90 and DCP for gain in range of 0.1 and 0.3 for tropical breeds. Other than that, finding by Goetsh *et al.* (1997) reported that fibre content in feed is positively corresponded to protein requirement for maintenance. And the author also stated that the protein requirements increased with the increasing of roughage to concentrate. Other study illustrated by Bunting *et al.* (1992) also reported that the increasing requirement of absorbed amino acids for growth in ruminants has been associated with the high temperature. The author also stated that curvilinear response of protein requirements with ADG probably reflects the biological phenomena tied to the body composition of growing animals such as water, fat, protein, etc. Study by Maneerat *et al.* (2015), crude protein content in bagasse-vinasse mix with pineapple peel was 9.10%. However, previous study by Maneerat *et al.* (2013) reported that crude protein in pineapple by-product silages was 3.80%. Apart from that, current finding by another researcher in the same teammate found that pineapple skin by-product silage that was ensiled up to 35 days has highest crude protein content followed by 28 and 21 days which are (6.21 %), (5.64 %) and (5.16 %) respectively. Thus, it showed that the longer the pineapple peel by-product is ensiled, crude protein content is increasing. However, future study must be carried out to find out if it is ensiled for a longer times, the crude protein still can be increased in value or decrease. Furthermore, Maneerat *et al.* (2015) reported that silages were well preserved with high in lactic acid content and low pH value. Finding by Zobell *et al.* (2004) stated that good quality silage is characterized by the considerable of lactic acid concentration. However, recent study that was done by another researcher in the same teammates did not observed on the lactic acid content in the pineapple by-product silage.

4.5. Feed Conversion Ratio (FCR)

Based on Figure 4.5, control group has significantly higher of FCR compared to treatment group which are (33.75 vs 18.92) respectively. However, there was statistically significant difference between the groups ($p < 0.05$).

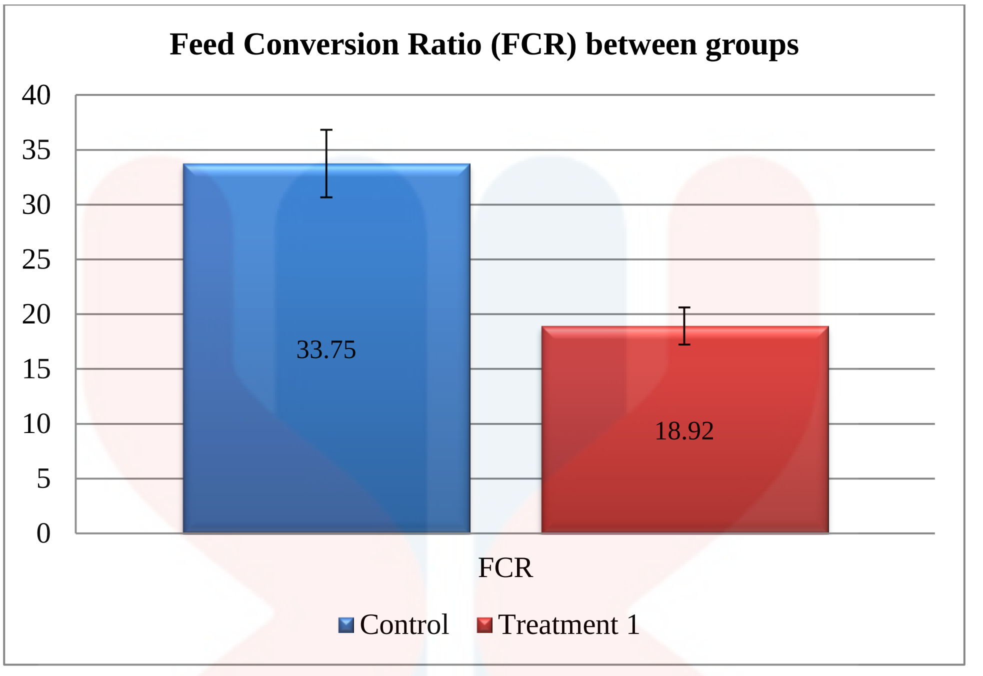

Figure 4.5: Comparison of Feed Conversion Ratio (FCR) between groups (Mean±SE), p-value = 0.01

Feed conversion ratio (FCR) can be defined as the amount of feed the animal takes to grow a kilogram of the animal. When the FCR is low, this means that it takes less feed to produce one kilogram of animal and also low FCR is a good indication of a high quality of feed. In this current study, from the result shows that feed conversion ratio (FCR) has significant difference between groups ($p < 0.05$). Moreover, treatment 1 group has significantly lower FCR than control group, which indicating that feeding Napier grass mix with pineapple by-product resulted in the best feed conversion efficiency. This can be supported with the finding from Maneerat *et al.* (2015) who reported that FCR of steers in treatment 3 group were significantly lower ($p < 0.05$) which is (6.89 kg/kg), indicating that feeding with bagasse-vinasse mixture with pineapple peel silage resulted in the best feed conversion efficiency. However, from the table 4.5, it shows that FCR of treatment 1 (18.92) is still higher than the actual FCR for goat which is 4.5 to 5.0. Thus, from the result above, it shows that feeding goat with

Napier grass mixed with pineapple by-product silage are not effective and efficient because it takes more feed to produce one kilogram of goat. Furthermore, a good quality silage is met when it is well preserved and of high digestibility and protein concentration. Poorly made silage can caused problems in animal's health such as decreasing the body weight gain and reduce the feed intake of the animal. High quality silage also can be produced when there is a good microbial fermentation process. Stefanie *et al.* (n.d) stated that good fermentation process is not just dependent on the type and quality of the forage crop, agriculture by-products, but also depend on the harvesting and ensiling technique.

Overall, based on the results that have been statistically analysed, the null hypothesis is accepted because there is insufficient evidence ($p > 0.05$) to suggest that Napier grass mixed with pineapple by-product silage does increase the mean feed intake, BWC, BCS, ADG and FCR of the goats.

CHAPTER 5

5.1. CONCLUSION AND RECOMMENDATION

As a conclusion, the goat fed with Napier grass mixed with pineapple by-product silage showed an increasing in BWC, ADG, BCS, feed intake and also FCR. However, there was no statistically significant difference of feed intake, BWC, ADG and BCS in both groups. But, there was statistically significant difference of FCR in both groups. There was no significant difference on feed intake, BWC, BCS and ADG between goat fed with pineapple by-product silage mixed with Napier grass and commercial pellet and goat fed with Napier grass and commercial pellet. Thus, the alternative hypothesis is rejected and null hypothesis is accepted. However, the use of pineapple by-product silage can be recommended as it is not negatively affects the goat and also it can reduce the excessive production of environmental pollution. A research on pineapple by-product silage should be further studied by improving the nutrient content in the silage by adding resources that can contribute a good amount of crude protein due to the lacking of crude protein content in the silage in this presents study.

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APPENDIX

Appendix A

A1: The total of feed intake of control group during 60 days feeding trial

Period (d)	Control Group				Total
	ID 033	ID 031	ID 036	ID 038	
15	33.04	19.92	16.65	18.44	88.05
29	40.83	24.24	21.17	20.06	106.30
45	42.96	29.77	28.41	26.94	128.08
60	56.49	33.00	29.90	32.63	152.02

A2: The total of feed intake of treatment 1 group during 60 days of feeding trial

Period (d)	Treatment 1 Group				Total
	ID 034	ID 032	ID 035	ID 037	
15	22.16	17.12	10.54	15.64	65.46
29	26.42	21.09	11.67	19.15	78.33
45	29.36	25.29	15.62	24.81	95.08
60	33.93	28.04	16.55	27.61	106.13

A3: Body weight change of control group

Parameter	Control group			
	ID 033	ID 031	ID 036	ID 038
Initial weight	18.50	11.00	10.00	12.50
1st sampling	20.00	12.00	10.00	13.00
2nd sampling	21.50	14.00	11.50	13.50
3rd sampling	23.00	14.00	12.00	14.50
Final weight	23.50	15.00	12.50	15.50

A4: Body weight change of treatment 1 group

Parameter	Treatment 1 group			
	ID 034	ID 032	ID 035	ID 037
Initial weight	18.00	13.50	8.20	12.50
1st sampling	19.20	15.00	8.50	13.50
2nd sampling	20.00	16.00	10.00	15.50
3rd sampling	21.50	17.50	10.50	17.00
Final weight	23.00	18.50	11.90	17.50

A5: Body condition score of control group

Parameter	Control group			
	ID 033	ID 031	ID 036	ID 038
Initial BCS	2.15	2.00	2.00	2.00
1st sampling	2.20	2.15	2.00	2.00
2nd sampling	2.50	2.35	2.15	2.50
3rd sampling	2.50	2.35	2.20	2.50
Final BCS	3.00	2.50	2.35	2.70

A6: Body condition score treatment 1 group

Parameter	Treatment 1 group			
	ID 034	ID 032	ID 035	ID 037
Initial BCS	2.15	2.00	2.00	2.00
1st sampling	2.20	2.35	2.00	2.25
2nd sampling	2.50	2.50	2.35	2.50
3rd sampling	2.50	2.70	2.35	2.70
Final BCS	3.00	2.80	2.50	2.70

Data analysed using SPSS statistical analysis by using independent sample t-test.

A7: Data of feed intake for control and treatment 1 groups during 60 days of feeding trial

Group statistics

	Group	N	Mean	Std. Deviation	Std. Error Mean
Feed intake	Control	4	119.1125	36.41281	18.20641
	Treatment 1	4	86.2500	23.81167	11.90584

Independent Sample Test

		Levene's Test for Equality of Variances	
		F	Sig.
Feed intake	Equal variances assumed	0.868	0.387
	Equal variances not assumed		

t-test for Equality of Means						
t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
					Lower	Upper
1.511	6	0.182	32.86250	21.75367	-20.36681	86.09181
1.511	5.169	0.189	32.86250	21.75367	-22.51123	88.23623

A8: Data of initial body weight for control and treatment 1 groups

Group statistics

	Group	N	Mean	Std. Deviation	Std. Error Mean
Initial weight	Control	4	13.0000	3.80789	1.90394
	Treatment 1	4	13.0500	4.02202	2.01101

Independent Sample Test

		Levene's Test for Equality of Variances	
		F	Sig.
Initial weight	Equal variances assumed	0.001	0.977
	Equal variances not assumed		

t-test for Equality of Means						
t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
					Lower	Upper
-0.018	6	0.986	-0.05000	2.76933	-6.82630	6.72630
-0.018	5.982	0.986	-0.05000	2.76933	-6.83121	6.73121

A9: Data of first sampling (BWC) for control and treatment 1 groups

Group statistics

	Group	N	Mean	Std. Deviation	Std. Error Mean
1st sampling	Control	4	13.7500	4.34933	2.17466
	Treatment 1	4	14.0500	4.41701	2.20851

Independent Sample Test

		Levene's Test for Equality of Variances	
		F	Sig.
1st sampling	Equal variances assumed	0.002	0.968
	Equal variances not assumed		

t-test for Equality of Means						
t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
					Lower	Upper
-0.097	6	0.926	-0.30000	3.09946	-7.88411	7.28411
-0.097	5.999	0.926	-0.30000	3.09946	-7.88455	7.28455

A10: Data of second sampling (BWC) for control and treatment 1 groups

Group statistics

	Group	N	Mean	Std. Deviation	Std. Error Mean
2nd sampling	Control	4	15.1250	4.38511	2.19255
	Treatment 1	4	15.3750	4.11045	2.05523

Independent Sample Test

		Levene's Test for Equality of Variances	
		F	**Sig.**
2nd sampling	Equal variances assumed	0.077	0.790
	Equal variances not assumed		

t-test for Equality of Means						
t	**df**	**Sig. (2-tailed)**	**Mean Difference**	**Std. Error Difference**	**95% Confidence Interval of the Difference**	
					Lower	**Upper**
-0.083	6	0.936	-0.25000	3.00520	-7.60347	7.10347
-0.083	5.975	0.936	-0.25000	3.00520	-7.61091	7.11091

A11: Data of third sampling (BWC) for control and treatment 1 groups

Group statistics

	Group	N	Mean	Std. Deviation	Std. Error Mean
3rd sampling	Control	4	15.8750	4.87126	2.43563
	Treatment 1	4	16.6250	4.55293	2.27646

Independent Sample Test

		Levene's Test for Equality of Variances	
		F	**Sig.**
3rd sampling	Equal variances assumed	0.067	0.805
	Equal variances not assumed		

t-test for Equality of Means						
t	**df**	**Sig. (2-tailed)**	**Mean Difference**	**Std. Error Difference**	**95% Confidence Interval of the Difference**	
					Lower	**Upper**
-0.225	6	0.829	-0.75000	3.33385	-8.90765	7.40765
-0.225	5.973	0.830	-0.75000	3.33385	-8.91666	7.41666

A12: Data of final body weight for control and treatment 1 groups

Group statistics

	Group	N	Mean	Std. Deviation	Std. Error Mean
Final weight	Control	4	16.6250	4.76751	2.38376
	Treatment 1	4	17.7250	4.56098	2.28049

Independent Sample Test

		Levene's Test for Equality of Variances	
		F	**Sig.**
Final weight	Equal variances assumed	0.044	0.841
	Equal variances not assumed		

t-test for Equality of Means						
t	**df**	**Sig. (2-tailed)**	**Mean Difference**	**Std. Error Difference**	**95% Confidence Interval of the Difference**	
					Lower	**Upper**
-0.333	6	0.750	-1.10000	3.29893	-9.17218	6.97218
-0.333	5.988	0.750	-1.10000	3.29893	-9.17602	6.97602

A13: Data of average BWC for control and treatment 1 group for 60 days feeding trial

Group statistics

	Group	N	Mean	Std. Deviation	Std. Error Mean
Average for 60 days	Control	5	14.8780	1.49468	0.66844
	Treatment 1	5	15.3680	1.88958	0.84505

Independent Sample Test

		Levene's Test for Equality of Variances	
		F	Sig.
Average for 60 days	Equal variances assumed	0.235	0.641
	Equal variances not assumed		

t-test for Equality of Means						
t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
					Lower	Upper
-0.455	8	0.661	-0.49000	1.07746	-2.97463	1.99463
-0.455	7.597	0.662	-0.49000	1.07746	-2.99774	2.01774

A14: Average BWC (kg/group) between groups (Mean ± SE)

Period (d)	Group		p-value
	Control	**Treatment 1**	
1	13.00 ± 1.90	13.05 ± 2.01	0.99
15	13.75 ± 2.17	14.05 ± 2.21	0.93
29	15.13 ± 2.19	15.38 ± 2.06	0.94
45	15.88 ± 2.44	16.63 ± 2.28	0.83
60	16.63 ± 2.38	17.73 ± 2.28	0.75
Average for 60 days	14.88 ± 0.69	15.37 ± 0.85	0.66

A15: Data of initial BCS for control and treatment 1 groups

Group statistics

	Group	N	Mean	Std. Deviation	Std. Error Mean
Initial BCS	Control	4	2.0375	0.07500	0.03750
	Treatment 1	4	2.0375	0.07500	0.03750

Independent Sample Test

		Levene's Test for Equality of Variances	
		F	**Sig.**
Initial BCS	Equal variances assumed	0.000	1.000
	Equal variances not assumed		

t-test for Equality of Means						
t	**df**	**Sig. (2-tailed)**	**Mean Difference**	**Std. Error Difference**	**95% Confidence Interval of the Difference**	
					Lower	**Upper**
0.00	6	1.000	0.00000	0.05303	-0.12977	0.12977
0.00	6.000	1.000	0.00000	0.05303	-0.12977	0.12977

A16: Data of first sampling (BCS) for control and treatment 1 groups

Group statistics

	Group	N	Mean	Std. Deviation	Std. Error Mean
1st sampling	Control	4	2.0875	0.10308	0.05154
	Treatment 1	4	2.2000	0.14720	0.07360

Independent Sample Test

		Levene's Test for Equality of Variances	
		F	Sig.
1st sampling	Equal variances assumed	0.071	0.798
	Equal variances not assumed		

t-test for Equality of Means						
t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
					Lower	Upper
-1.252	6	0.257	-0.11250	0.08985	-0.33235	0.10735
-1.252	5.372	0.262	-0.11250	0.08985	-0.33874	0.11374

A17: Data of second sampling (BCS) for control and treatment 1 groups

Group statistics

	Group	N	Mean	Std. Deviation	Std. Error Mean
2^{nd} sampling	Control	4	2.3750	0.16583	0.08292
	Treatment 1	4	2.4625	0.07500	0.03750

Independent Sample Test

		Levene's Test for Equality of Variances	
		F	**Sig.**
2^{nd} sampling	Equal variances assumed	2.342	0.177
	Equal variances not assumed		

t-test for Equality of Means						
t	**df**	**Sig. (2-tailed)**	**Mean Difference**	**Std. Error Difference**	**95% Confidence Interval of the Difference**	
					Lower	**Upper**
-0.962	6	0.373	-0.08750	0.09100	-0.31017	0.13517
-0.962	4.178	0.389	-0.08750	0.09100	-0.33597	0.16097

A18: Data of third sampling (BCS) for control and treatment 1 groups

Group statistics

	Group	N	Mean	Std. Deviation	Std. Error Mean
3rd sampling	Control	4	2.3875	0.14361	0.07181
	Treatment 1	4	2.5625	0.17017	0.08509

Independent Sample Test

		Levene's Test for Equality of Variances	
		F	Sig.
3rd sampling	Equal variances assumed	0.333	0.585
	Equal variances not assumed		

t-test for Equality of Means						
t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
					Lower	Upper
-1.572	6	0.167	-0.17500	0.11134	-0.44743	0.09743
-1.572	5.835	0.168	-0.17500	0.11134	-0.44931	0.09931

A19: Data of final BCS for control and treatment 1 groups

Group statistics

	Group	N	Mean	Std. Deviation	Std. Error Mean
Final BCS	Control	4	2.6375	0.28100	0.14050
	Treatment 1	4	2.7500	0.20817	0.10408

Independent Sample Test

		Levene's Test for Equality of Variances	
		F	Sig.
Final BCS	Equal variances assumed	0.487	0.511
	Equal variances not assumed		

t-test for Equality of Means						
t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
					Lower	Upper
-0.643	6	0.544	-0.11250	0.17485	-0.54035	0.31535
-0.643	5.531	0.546	-0.11250	0.17485	-0.54930	0.32430

A20: Data of average BCS for control and treatment 1 groups for 60 days feeding trial

Group statistics

	Group	N	Mean	Std. Deviation	Std. Error Mean
Average BCS for 60 days	Control	5	2.3080	0.24570	0.10988
	Treatment 1	5	2.4020	0.28341	0.12674

Independent Sample Test

		Levene's Test for Equality of Variances	
		F	**Sig.**
Average BCS for 60 days	Equal variances assumed	0.163	0.697
	Equal variances not assumed		

t-test for Equality of Means						
t	**df**	**Sig. (2-tailed)**	**Mean Difference**	**Std. Error Difference**	**95% Confidence Interval of the Difference**	
					Lower	**Upper**
-0.560	8	0.591	-0.09400	0.16774	-0.48082	0.29282
-0.560	7.842	0.591	-0.09400	0.16774	-0.48218	0.29418

A21: Average of BCS between groups (Mean ± SE)

Period (d)	Group		p-value
	Control	**Treatment 1**	
1	2.04 ± 0.04	2.04 ± 0.04	1.00
15	2.09 ± 0.05	2.20 ± 0.07	0.26
29	2.38 ± 0.08	2.46 ± 0.04	0.37
45	2.39 ± 0.07	2.56 ± 0.09	0.17
60	2.64 ± 0.14	2.75 ± 0.10	0.54
Average for 60 days	2.31 ± 0.11	2.40 ± 0.13	0.59

A22: Data of ADG for control and treatment 1 groups during 60 days of feeding trial

Group statistics

	Group	N	Mean	Std. Deviation	Std. Error Mean
ADG	Control	4	0.0600	0.01826	0.00913
	Treatment 1	4	0.0750	0.01000	0.00500

Independent Sample Test

		Levene's Test for Equality of Variances	
		F	**Sig.**
ADG	Equal variances assumed	3.857	0.097
	Equal variances not assumed		

t-test for Equality of Means						
t	**df**	**Sig. (2-tailed)**	**Mean Difference**	**Std. Error Difference**	**95% Confidence Interval of the Difference**	
					Lower	**Upper**
-1.441	6	0.200	-0.01500	0.01041	-0.04047	0.01047
-1.441	4.651	0.213	-0.01500	0.01041	-0.04237	0.01237

A23: Data of FCR for control and treatment 1 groups during 60 days of feeding trial

Group statistics

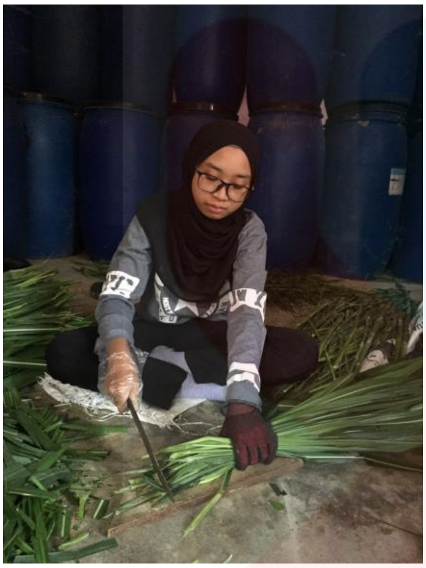
	Group	N	Mean	Std. Deviation	Std. Error Mean
FCR	Control	4	33.7450	6.16808	3.08404
	Treatment 1	4	18.9150	3.38492	1.69246

Independent Sample Test

		Levene's Test for Equality of Variances	
		F	**Sig.**
FCR	Equal variances assumed	0.967	0.363
	Equal variances not assumed		

t-test for Equality of Means						
t	**df**	**Sig. (2-tailed)**	**Mean Difference**	**Std. Error Difference**	**95% Confidence Interval of the Difference**	
					Lower	**Upper**
4.216	6	0.006	14.83000	3.51792	6.22197	23.43803
4.216	4.657	0.010	14.83000	3.51792	5.58266	24.07734

APPENDIX B



B1: Chopping the Napier grass

B2: Mixing the Napier grass with pineapple by-product silage

B3: Feeding the goat

B4: Weighing the goat

B5: Recording the leftovers

B6: Pineapple by-product silage

B7: Cleaning goat's feces

B8: Treating the goat's wound