Physical, Chemical and Microbiological Characteristics of Meat from Boer Goats Fed With Napier Grass and Oil Palm Frond

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A thesis submitted in fulfilment of the requirements for the degree of Bachelor of Applied Science Animal Husbandry Science with Honours

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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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Date:

I certify that the report of this final year project entitled "Physical, Chemical and Microbiological Characteristics of Meat from Boer Goats Fed With Napier Grass and Oil Palm Frond" by Wan Syafawati Binti Mohd Jamil, matric number F15A0250 has been examined and all the correction recommended by examiners have been done for the degree of Bachelor of Applied Science (Animal Husbandary Science) with Honours, Faculty of Agro-Based Industry, Universiti Malaysia Kelantan.

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ABSTRACT

The nutrients in feed may affect the performance of the livestock including its meat quality. Oil palm frond have been utilised as animal feed for lowering the feed cost and conserving the environment. Therefore, the present study was conducted to investigate the effect of the inclusion of pretreated oil palm frond (OPF) in the diet of Boer goats that may improve the physical, chemical and microbiological characteristics of the goat's meat. The animal feed trial was conducted at Agrotechnopark, Universiti Malaysia Kelantan (UMK), Jeli Campus. Nine (9) Boer goats were selected and randomly assigned to 3 different dietary groups. The goats were fed with Napier grass, freshly chopped OPF, pressed OPF and commercial goat pellets. The goats were slaughtered and the *longissimus dorsi* muscle of the goats was analyzed for determination of the physical (texture profile and colour analysis), chemical (proximate analysis) and microbiological characteristics. The hardness of the meat range from 169.33 to 382.33 (g) and the springiness of meat range from 2.63 to 3.66 (mm). The lightness of meat range from 24.85 to 29.46, the redness range from 10.68 to 14.18 and the yellowness of meat range from 6.27 to 7.49. The dry matter of the meat range from 24.29 to 29.4%, the crude protein range from 67.2 to 74.68%, the ether extract range from 3.41 to 8.46% and the ash content range from 4.93 to 10.11%. The total plate count of the meat range from 1000 to 4400 cfu/ml. In conclusion, if the OPF was included in the goat's diet, it resulted in the increased value of the goat meat that can increase the consumer's preference.

Keywords: oil palm frond (OPF), Boer goat, proximate composition, physical, chemical and microbiological characteristics of the goat's meat.

Ciri-ciri Fizikal, Kimia dan Mikrobiologi Daging Kambing Boer Terhadap Pengambilan Makanan Rumput Napier dan Pelepah Kelapa Sawit

ABSTRAK

Kajian ini dijalankan bagi menilai kesan yang diberikan oleh pelepah kelapa sawit (PKW) apabila disertakan di dalam diet kambing Boer yang mungkin dapat meningkatkan ciri-ciri fizikal, kimia, dan mikrobiologi daging kambing. Percubaan makanan ini dilaksanakan di Agrotechnopark, Universiti Malaysia Kelantan. Sembilan (9) ekor kambing Boer telah dipilih dan diletakkan di dalam 3 kumpulan diet yang berlainan secara rawak. Kambing-kambing tersebut diberi rumput *Napier*, PKW yang dicincang, PKW yang ditekan dan pellet kambing komersial. Kambing-kambing tersebut disembelih dan otot *longissimus dorsi* kambing-kambing tersebut dianalisis untuk menentukan ciri-ciri fizikal (analisis profil tekstur dan profil warna), kimia (analisis proksimat) dan mikrobiologinya. Kekerasan daging bernilai 169.33 hingga 382.33 (g) dan kekenyalan daging bernilai 2.63 hingga 3.66 (mm). Nilai kecerahan daging antara 24.85 hingga 29.46, nilai kemerahan daging antara 10.68 hingga 14.18 dan nilai kekuningan daging antara 6.27 hingga 7.49. Nilai bahan kering daging antara 24.9 hingga 29.4%, nilai protein mentah daging antara 67.2 hingga 74.68%, nilai lemak mentah daging antara 3.41 hingga 8.46% dan nilai abu daging antara 4.93 hingga 10.11%, Nilai pengiraan mikroorganisma daging antara 1000 hingga 4400 cfu/ml. Secara konklusinya, jika PKW disertakan didalam diet kambing, ia meningkatkan nilai daging kambing yang akan meningkatkan minat pengguna.

Kata kunci: Pelepah kelapa sawit (PKW), kambing Boer, komposisi proksimat, ciri-ciri fizikal, kimia, dan mikrobiologi daging kambing.

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LIST OF ABBRECIATION

AOAC	Association of Official Agricultural Chemists
CP	Crude Protein
DM	Dry Matter
EE	Ether Extract
FAO	Food and Agriculture Organization
H_2SO_4	Sulphuric Acid
H_3BO_3	Boric Acid
HCl	Hydrochloric Acid
ME	Metabolism Energy
MPOB	Malaysian Palm Oil Board
NaOH	Sodium Hydroxide
OPF	Oil Palm Frond
RCBD	Randomized Complete Block Design

LIST OF SYMBOLS

%	percentage
cfu/ml	Colony forming unit/ml
g	gram
mm	millimetre
M	Molarity

CHAPTER 1

INTRODUCTION

1.1 Research background

Oil palm frond (OPF) is one of the by-products from the oil palm plantation. The oil palm frond is produced during the pruning and replanting of the oil palm in 25 years duration (Ghani, Rusli, Shahudin, Goh, Zamri-Saad et. al, 2017) . Due to the mass production of the OPF, it can be innovated as the other source of feed for the livestock that can lower the cost of the feed and may decrease the cost requirements for importing the feed. Feedstuff and the nutrients in the feedstuff affect the performance of the livestock. The feed also influence the meat quality of the livestock. Nutrition and health concerns play a significant role in influencing consumers' food choices. This trend is associated with the perceived relationships between dietary type and amount of fats and fatty acids in animal tissues (Turpeinen, Ylonen, Willebrand, Basu, & Aro, 2008).

The goat meat has many nutrients, such as high protein content (Amaral, Pelicano, & Yáñez, 2007), low cholesterol content (40 mg/ 100g) (Souza & Visentainer, 2006) and lower in fat that lead to the decrease in proportion of saturated fat and calories (Madruga et al., 1999; Malan, 2000). According to Silva Sobrinho and Osório (2008), the consumption is considered low (about 0.4 kg/capita/year) compared to beef (40 kg/capita/year).

In the current study, the Boer goats were fed with Napier grass, goat pellet and the OPF. After 120 days of the feeding trial, the goats were slaughtered and the longissimus dorsi tissue of the goats was taken. In this experiment, the tissue samples of the Boer goats that had been fed by Napier grass and OPF were examined to assess their physical, chemical and microbiological composition.

1.2 Problem statement

According to Ghani, Rusli, Shahudin, Goh, Zamri-Saad and et. al (2017), the use of the OPF as feed had increased the unsaturated to the saturated fatty acid ratio in rumen content. With the current focus on reducing the saturated fatty acid content of food stuffs for human consumption, OPF were utilized to improve the availability of unsaturated fatty acid in the ruminant diet and also to increase the nutritional content of the meat of the ruminants. However, OPF contains low-fat content and low metabolisable energy value (Rahman, Abdullah, Wan Khadijah, Nakagawa, & Akashi, 2014). Thus, OPF needs to be upgraded and pretreated to improve its nutrient contents.

1.3 Hypothesis

Feeding goats with OPF and Napier grass may improve the physical, chemical and microbiological characteristics of meat of the Boer goats.

1.4 Objectives

1. To assess the physical characteristics of the carcass of Boer goats fed with Napier grass and OPF.
2. To evaluate the chemical composition of the carcass of Boer goats fed with Napier grass and OPF.
3. To evaluate the microbiological quality of the carcass of Boer goats fed with Napier grass and OPF

1.5 Scope of study

The finding of this research was to evaluate the physical, chemical and microbiological composition of the carcass of Boer goat which had been fed with Napier grass and OPF supplemented with the commercial pellet. This finding was conducted at the laboratory at University Malaysia Kelantan Jeli Campus.

1.6 Significance of study

The chemical composition of meat goat fed with OPF and Napier grass had improved from the increase of protein content.

CHAPTER 2

LITERATURE REVIEW

3.1 Meat Goat Production

In Malaysia, the goat meat industry has many obstacles and the main constraints are nutrition and parasitic problems (Kioumarsi, Yahaya, Rahman, & Chandrawatani, 2011) Some of the problems that relate to the nutrition are the high cost of feedstuff, the availability of the feedstuff and the lack of technology that can enhance the efficiency of the feedstuff.

The developing countries such as Malaysia, Thailand and Indonesia had the obstacles towards improving the agriculture and ruminant sector. Shortage and inconsistent quality of forage in developing countries are the major constraints towards the development of the ruminant sector (Khaing, Loh, Ghizan, Halim, & Samsudin, 2015).

Urbanisation associated with the increase in wealth and higher purchasing power which leads to greater demand for processed food, meat, dairy and fish (Godfray et al., 2010) while the demand for grains and other staple crops will decline. This will relate to the self-sufficiency level of the country and also the food security and food safety assurance (Suntharalingam, Sithambaram, Graff, & Saari, 2015).

Based on the research that had been done by the Botez, Nistor, Andronoiu, & Mocanu (2013), besides being the source of protein, there are few functions and roles that can be executed by the meat towards our body metabolism. The primary function is the meat will play the role in providing the nutrients that required by our body. The secondary function is expressed by sensory characteristics. The meat will play a role in providing a good test, flavour, appearance and texture of the food. The tertiary function is for prevention of the diseases by modulating physiological system. The examples of tertiary functional properties are anti-oxidative, anti-aging activities, anti-carcinogenic, anti-hypertensive and immunomodulating.

Based on the research that had been done by Otte (2012), the global human population will increase by the year 2050. The population will increase by 50% larger than the year 2000 with the increment of 2.4 higher per capita incomes. Thus, the living standard will increase as well as the consumption of the food. The high requirement and consumption of the food will increase the value of the food. Thus, this will make the people and developer pursue the shorter cycle species of plants and livestock to fulfil the requirements and needs.

In Southeast Asia (Malaysia, Vietnam, Laos, Cambodia, Thailand and Myanmar), there are moderate statistics of the livestock population that available. Because of this, the high producing livestock will be selected to produce the best traits for increasing the livestock population. Thus, it will enhance the management of the livestock and improve the disease control program of the livestock.

The ration with higher nutrient density also would be constructed because to supply the best feed ration for ensuring the good livestock management. The utilization of waste materials such as OPF also will be enhanced and these will not only providing the best feed to the livestock but also for the conservation of the environment.

2.2 Oil Palm Frond (OPF)

In countries like Malaysia, Indonesia and Thailand, most of the land is used for oil palm and rice cultivation activity. In Malaysia, 4.69 million hectares; which is about 60% of the whole agriculture land is used for the palm oil industry (Ng, Yew, Basiron & Sundram 2011). For a large agriculture industry like the palm oil industry, there are many by-products that were produced aside from the main product. Some of the by-products of the oil palm are oil palm trunks (9%), OPF (30%), empty fruit bunches (22%), palm kernel cake (PKC) (5.5%), palm press fibre (13.5%) and palm oil mill effluent (POME) (9%) are generated each year world-wide with an estimated production of 1.5 to 25 million tonnes of dry matter (DM) at the mill and 10 to 50 million tonnes DM in the plantations (Elbersen, Van & Bakker, 2005). The estimated value of the total oil palm by-products from the palm oil industry in 2009 is 77.24 million tonnes DM per year (Ng, Yew, Basiron & Sundram 2011).

In Malaysia, the total production of OPF is approximately 44.8 million tonnes DM per year. The oil palm frond can be found throughout the year. It is an everlasting product that was produced based on the execution of the oil palm industry. There were 26.9 million tonnes of OPF was utilised as animal feed, which is approximately 60% of the overall production of the OPF (Ng, Yew, Basiron & Sundram 2011). By the means of the mass production of the OPF, the usage of the OPF is important for lowering the feed cost and also can help for conserving the environment as the common practice is to burn the agriculture by- products.

The OPF has become the other options for feeding the livestock. It can act as the replacement of the low-quality roughage that had been used as the livestock feed without any bad damaging effect towards the health and the productivity of the animals. According to Ghani, Rusli, Shahudin, Goh, Zamri-Saad and et. al (2017), the application of the OPF had increased the unsaturated to the saturated fatty acid ratio in rumen content and increasing the possibilities for using unsaturated fatty acid content in ruminant tissues and products.

Based on the research that had been done by Ariff, Sharifah and Hafidz (2015), the targeted self-sufficiency level (SSL) of beef is 33% by the year 2020. In order to achieve that target, the production of the beef must be increased. Thus, the feed production and quality for the beef cattle must be improved so that the cattle will produce high production. In order for that, the OPF had been researched and utilized as the other alternatives for the cattle feedstuff.

The OPF had been chosen for several factors. Besides of conserving the environment, the OPF also provides the sufficient nutrient for the cattle and there are everlasting productions of the OPF. The productions of the OPF also low in cost.

The research of the OPF by Adeyemi, Ahmed, Jotham, Roslan, Jahromi et. al (2016), it also showed that the utilisation of the OPF as the feed for the cattle would produce the better result of the production of the cattle, low in cost and have the minimal negative impact on the environment.

Thus, an initiative needs to be executed to increase the self-sufficiency level for the country and also for totally manipulated the mass production of the palm oil by-products. The OPF as the mass product produced by the palm oil industry will act as the other options for increasing the quality of feedstuff for livestock and for reducing the

cost of the feedstuff of the livestock. This will lead to an increase of the meat and carcass quality and as well as increasing the food security level and self-sufficiency level.

Based on the research by Ebrahimi, Rajion, Meng, Shokryazdan, Sazili et. al (2015), the research indicates that the OPF are rich in secondary metabolites. However, it also has a high amount of tannins and phenolic compounds. The tannins influence the population of the rumen microbial organism. Tannins may decrease the number of population of rumen microbial organism population. Thus, it will decrease the digestibility and also decrease the performance of the cattle.

Most of the studies showed the results of the effect of the feed towards the performance of the cattle and the quality of the beef. However, there are less study regarding the effect of the feed towards performance of goat and the quality of goat's meat.

Table 1 showed the chemical composition (%) of OPF.

Table 1: Chemical composition (%) of OPF

Source from: Rahman, Abdullah, Wan Khadijah, Nakagawa, & Akashi (2014)

Parameter	**DM**	**CP**	**OM**	**NDF**	**Ca**	**Mg**	**K**	**Na**	**ME (MJ/kg DM)**
Oil palm frond	59.2	10.5	87.5	53.5	0.43	0.19	1.22	0.01	6.5

2.3 Napier Grass

Napier grass (*Pennisetum purpureum*) is a perennial crop that is used for the feeds for the livestock. Sometimes, they were freshly fed to the animals, however, Napier grass also being made into silage and as the pastures.

The intake and the digestibility of the roughage can be improved by supplementing commercial concentrates with low-quality grass. However, the costs for the traditional concentrates are high and there are uncertain availabilities of the resources. Thus, the other option for overcoming these problems is the usage of the by-products and waste products from the processing of the various food and fibre crops, or crop residues. These alternatives of feed can be used as the main supplement to the regular ration. (Rahman, Abdullah, Wan Khadijah, Nakagawa, & Akashi, 2014).

The availability of the Napier sources is low and this lead towards the initiative of creating other alternatives to provide the nutrients to the animals by using the palm oil by-products, the OPF.

Table 2 showed the chemical composition (%) of Napier grass.

Table 2: Chemical composition (%) of Napier grass

Source from: Rahman, Abdullah, Wan Khadijah, Nakagawa, & Akashi (2014)

Parameter	**DM**	**CP**	**OM**	**NDF**	**Ca**	**Mg**	**K**	**Na**	**ME (MJ/kg DM)**
Napier grass	24.0	9.5	88.9	55.7	0.34	0.47	3.38	0.01	7.5

2.4 Factors That Influence Fat Deposition in Goats

Based on the previous studies, the fat sources in the diet can influence the energy level in the ruminant diet and also can influence the tissue of the carcass and the carcass composition (Brandt & Anderson (1990) Marinova, Banskalieva, Alexandrov, Tzvetkova and Stanchev (2001) Rosa et al. (2013) as cited in the journal by Adeyemi, Ebrahimi, Samsudin, Sabow and Sazili (2015).

Adeyemi, Ebrahimi, Samsudin, Sabow and Sazili (2015) reported that the fatty acid composition of the meat can be altered by the dietary fat of the ruminant and also to increase the meat quality for achieving the nutritional demands by the consumers (Kim, Adesogan, Badinga, & Staples, 2007; Loor J, Herbein J, 2002). The fat that was deposited and distributed in the ruminants influence greatly in increasing the quality of the carcasses (Bas, Dahbi, El Aich, Morand-Fehr, & Araba, 2005; Brandt & Anderson, 1990; Marinova et al., 2001). The deposition and distribution of the fat also can increase the commercial value of the meat as they assist in consumer's preferences and acceptability of the meat (Bas et al., 2005; Marinova et al., 2001).

According to the journal by Sousa et al. (2015), glucose acts as the carbon source of the deposition of the fat in the tissues. Propionate is the precursor of the glucose and the composition of the propionate in the rumen will be affected by the crude glycerin (Schoonmaker, Fluharty, & Loerch, 2004). Goats deposit more visceral fat and less subcutaneous, inter and intra muscular fat compared with sheep and cattle (Tshabalala et al., 2003; Webb et al., 2005).

2.5 Chemical Composition of Goat Tissue

Goats are raised for the meat, hides and milk. However, there are also many ruminants that able to supply the same product. For example, the cow can supply the milk while sheep can supply the hides. Both of these animals can produce a good quality of meat. However, the demand on the goat's products is still higher as the chemical composition of the meat differs based on their origins. For example, the goat meat has higher protein value than beef, lamb, and veal. Furthermore, the goat meat contained low ether extract value (James, Berry, Kotula, Lamikanra, & Ono, 1990).

According to the research by Sousa, Parente, Oliveira and Parente (2015), the value of the ash content in the goat's meat was obtained between 1.06 to 1.14%. Meanwhile, the value of the crude protein was between 22.53 to 43.18%, the value of dry matter was 27.6 to 28 % and the value of moisture content was 72.4 to 72%.

The carcass of the meat can be affected by several crucial factors such as the breed, sex, weight, management and nutritional factors of the animals. (Gonzaga Neto, Cézar, & Medeiros, 2005 as stated in Freitas et al., 2011).

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2.6 Meat Quality

Meat is usually appealing the consumer's preferences by its appearances such as the texture, colour, marbling and tenderness. The consumers also concerned about the nutrient and chemical contents in the meat such as fat content, moisture content, protein content, the pH and the drip loss of the meat. The consumers also prefer meat with good biological attributes for maintaining the shelf-life of the meat and can retain the freshness of the meat. One of the biological attributes is the total bacterial count during the inoculation of the sample of the meat (Huang, Li, & Michael, 2014). Thus, the producers, manufacturers and retailers must overcome all these demands for producing a high-quality of meat and for ensuring the product safety and security.

However, the customer’s demands and acceptance also depend on other factors such as regional consumption habits and customs (Pinheiro, Jorge, Souza, & Boiago, 2010 as stated in Sousa et al., 2015). Thus, it cannot be concluded that consumers can only be satisfied with the best physical, chemical and microbiological attributes only since there are many other extrinsic factors that can influence the consumer’s preferences.

CHAPTER 3

MATERIALS AND METHODS

3.1 Experimental site and animals

The animal feed trial was conducted at Agrotechnopark, Universiti Malaysia Kelantan (UMK), Jeli Campus. Nine (9) Boer goats were selected and randomly assigned to 3 different dietary groups. The animals were housed in individual pen 2 meters above the ground. Prior to feeding trial, the animals were adapted for 10 days. The goats were fed with Napier grass, freshly chopped OPF, pressed OPF and commercial goat pellets. The animals were given water ad libitum. The goats were cared according to the animal ethics guidelines of the Universiti Putra Malaysia (UPM/IACUC/AUP-R03/2016).

3.2 Experimental design

The trial was conducted using randomised complete block design (RCBD). A total of 9 Boer goats were assigned individually based on their initial body weight. The dietary treatment is shown in Table 3.

Table 3: The experimental design of different dietary treatments

GROUP **(5 kids per group)**	**NAPIER GRASS (70%)**	**GOAT PELLET (20%)**	**OPF (10%)**
Control T1	**80%**	√	**-**
T2	√	√	**Fresh (chopped)**
T3	√	√	**Pressed OPF**

3.3 Slaughtering

After 120 days of feeding trial, the goats were slaughtered and the tissue (*longissimus dorsi*) was obtained. The samples were kept in the freezer at -80 °C and were analysed for physical, chemical and microbiological.

3.3 Physical analysis

The physical analyses were conducted based on the research by Putra, Wattanachant, & Wattanachant (2017).

3.4.1 Preparation of samples for physical analysis.

The samples were defrosted for 24 hours before the physical analysis were performed.

3.4.2 Texture profile analysis (TPA)

The texture profile of the meat; the hardness and the tenderness of the meat were determined using the TPA analyser. The meat was cut into a cubical size (2 cm X 2 cm X 2 cm in size) and was placed on the heavy duty platform. TPA was performed using a 25 kg load cell and a 75 mm diameter compression platen (SMSP/75) which was forced to compress 75% of the sample height in two cycles of compression tests. The test conditions were pretested speed 5.0 mm/s, tested speed 1.0 mm/s and post-tested speed 8.0 mm/s. The distance of penetration was at 5 mm and there will be a rest period of 5 seconds between two cycles. The trigger force was1.0 N.

3.4.3 Colour profile analysis

The colour profile analysis was conducted for determining the colour properties of the meat. The lightness (L*), redness (a*) and yellowness (b*) attributes of the samples were determined using the colour instrumentation (chroma meter).

3.5 Chemical analysis

The chemical analyses were conducted based on the Association of Official Agricultural Chemists (AOAC, 1995).

3.5.1 Preparation of samples for chemical analysis.

The samples were defrosted for 24 hours before the proximate analysis was done. Then, the samples were dried at 60°C for 7 days in the oven.

3.5.2 Determination of dry matter

Empty containers were first weighed using electronic balance (w1). Next, each fresh sample was weighed approximately 1 g (w2). Then, all samples were put into force air oven for drying at 110˚C for 24 hours based on the Association of Official Agricultural Chemists (AOAC, 1995). Dry weight (w3) took on the next day to determine DM content and the loss of feed samples.

$$\text{DM (\%)} = \frac{(w3 - w1)}{w2} \times 100$$

Where;

% DM = percentage of dry matter

w1 = Weight of empty container

w2 = Weight of approximately 2.0 g sample

w3 = Weight of dried sample

3.5.3 Determination of crude protein

Crude protein of the samples was determined by the method described by AOAC 1995. Dried samples were ground and used for determination of crude protein by Kjeldahl method to obtain the nitrogen content which was multiplied by 6.25.

Approximately 1 g of the sample was transferred to the Kjeldahl flask. The samples were digested in 12 ml concentrated sulphuric acid (H_2SO_4) with the addition of 1 Kjeldahl tablet as a catalyst using digester system. The digestion process was continued for about three hours until the colour of solution become clear. The tubes were allowed to cool before underwent the distillation process. The samples were distilled by Foss distillation system. N in digested samples was collected in 4% boric acid. 2.5ml bromocressol green and 1.75ml methyl red were added as the indicator to observe the colour change. The samples were titrated with 0.1N hydrochloric acid which was added drop by drop until the colour change from green to pink. The percentage of CP was determined as follow:

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

Where;

V= volume of acid neutralized sample (ml)

n= concentration of HCl

W= weight of the sample

$$CP\ (\%) = N(\%) \times 6.25$$

3.5.4 Determination of ether extract (EE)

The EE was analysed using the Soxtec system by AOAC 1995. The aluminium cups were heated at 103˚C for 30 minutes and dried in desiccators for 20 minutes to cool off before starting to determine the EE content. Each sample was weighed with a precision of 1.5 g. Petroleum ether was used as the solvent. Next, the temperature and the program of the equipment was set-up according to the test. Then, the water tap was opened for reflux condensers. Thimbles were then prepared to attach on adapters. The following is the calculation of percentage EE as below,

$$\% \text{ EE} = (w3 - w1)/ w2 \times 100$$

Where,

% EE = Percentage of EE

w1 = Weight of the empty crucible

w2 = Weight of the sample approximately 1.5 g

w3 = Weight of the crucible with ash

3.5.5 Determination of ash content

The ash content was detrmined by the method of AOAC 1995. The empty crucible was weighed as W1. Approximately 1 g of the sample was weighed and recorded as W2. The samples were incinerated in the furnace at 600˚C for 4 hours and were allowed to cool. The final weight is the W3.

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

Where;

W1= weight of empty crucible (g)

W2= weight of the sample (g)

W3= weight of crucible and ash

3.6 Microbiological analysis

The numbers of viable or living microorganisms present in the meat samples were determined by the Total Plate Count method. The samples were diluted and then, inoculated. The inoculation was done according to the spread plate method. The diluted sample was released from the pipette onto the solidified agar and it was spread on the surface by means of a sterile bent glass stick. The alternative was the pour plate method. Then, the samples were incubated for 12 to 24 hours at 35 to 37°C. The colony forming units (CFU) were counted including those of pinpoint size.

$$\text{Total Plate Count} = \text{Colonies} \times \frac{10}{0.1}$$

3.7 Statistical analysis

The results of the physical, chemical and microbiological analyses of the *longissimus dorsi* muscle were expressed as the mean ± standard deviation (SD) and were subjected to one-way analysis of variance (ANOVA). The least significant difference (LSD) was performed for the pair wise mean comparisons, to determine the significant treatment dose at a 95% level of confidence. Values were considered statistically significant at ($P<0.05$). If there were significant differences, the data were compared using Duncan Multiple Range Test.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 The Physical Composition of the Meat

Table 1 and Table 2 show the texture profile of the meat according to the hardness 1 (g), hardness 2 (g) and springiness (mm). Table 4 shows the texture profile of the meat for 0 hour post-mortem period while Table 5 shows the texture profile of the meat for 24 hour post-mortem period. The comparison of the texture profile of the meat that differs according to the post-mortem period (Figure 1, 2 and 3)

Table 4 : Texture profile of the meat for 0 hour postmortem

Meat sample / Texture Profile	Control (80% NG, 20% GP)	Treatment 1 (70% NG, 20% GP, 10% fresh (chopped) OPF)	Treatment 2 (70% NG, 20% GP, 10% pressed OPF)
Hardness 1 (g)	236.67 ± 159.64[a]	382.33 ± 123.71[a]	322.0 ± 305.49[a]
Hardness 2 (g)	234.67 ± 131.07[a]	320.0 ± 121.66[a]	296.0 ± 218.0[a]
Springiness (mm)	2.63 ± 0.48[a]	3.60 ± 0.12[ab]	3.66 ± 0.73[b]

Note: NG, Napier grass; GP, goat pellet; OPF, oil palm frond.

[a] [b] Means in the same row with different superscripts are significant different at 5% level ($P < 0.05$) by Duncan Multiple Range Test.

Table 5: Texture profile of the meat for 24 hour of postmortem.

Meat sample / Texture profile	Control (80% NG, 20% GP)	Treatment 1 (70% NG, 20% GP, 10% fresh (chopped) OPF)	Treatment 2 (70% NG, 20% GP, 10% pressed OPF)
Hardness 1 (g)	372.67 ± 163.39[a]	204.0 ± 98.56[a]	321.33 ± 412.1[a]
Hardness 2 (g)	266.67 ± 92.38[a]	169.33 ± 79.15[a]	270.0 ± 352.73[a]
Springiness (mm)	3.20 ± 0.33[ab]	3.33 ± 0.20[ab]	3.00 ± 0.80[ab]

Note: NG, Napier grass; GP, goat pellet; OPF, oil palm frond.

[a] [b] Means in the same row with different superscripts are significant different at 5% level ($P < 0.05$) by Duncan Multiple Range Test.

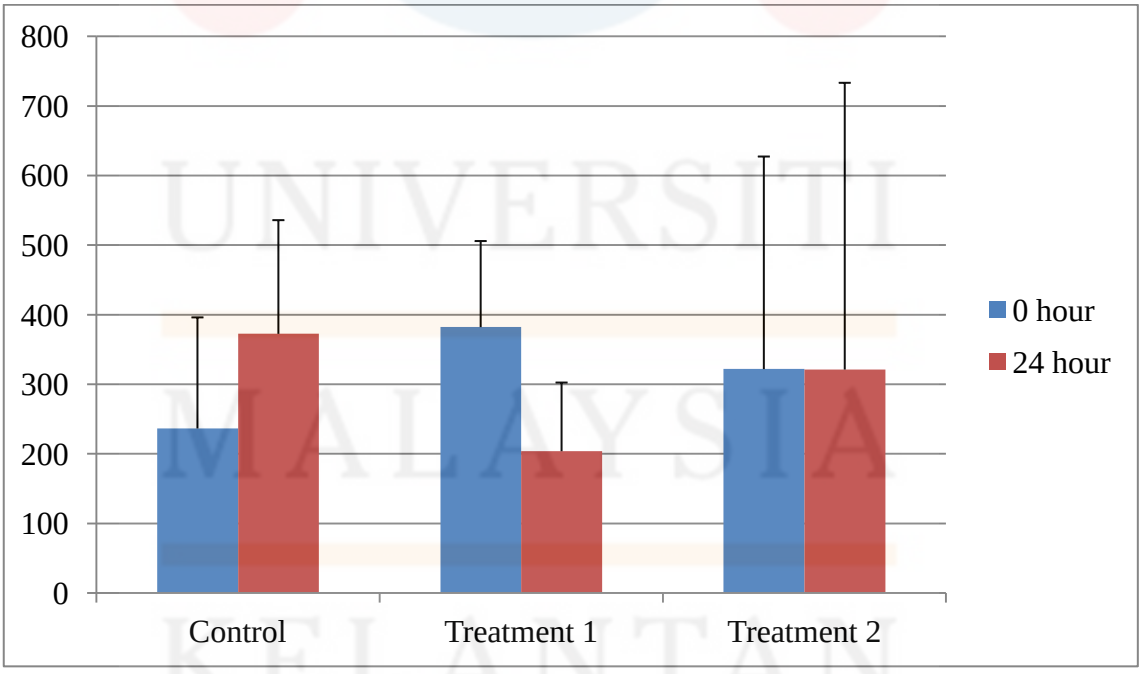

Figure 1: The comparison of the hardness 1 (g) of the meat at 0 and 24-hour following postmortem

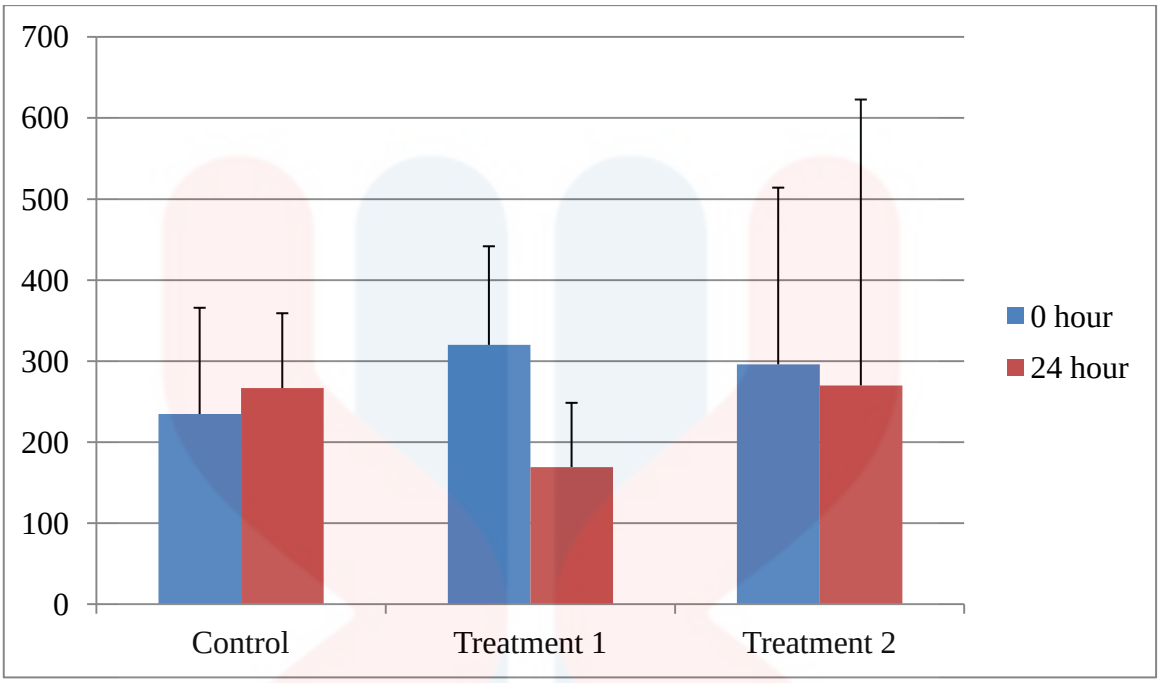

Figure 2: The comparison of hardness 2 (g) of the meat at 0 and 24-hour following postmortem

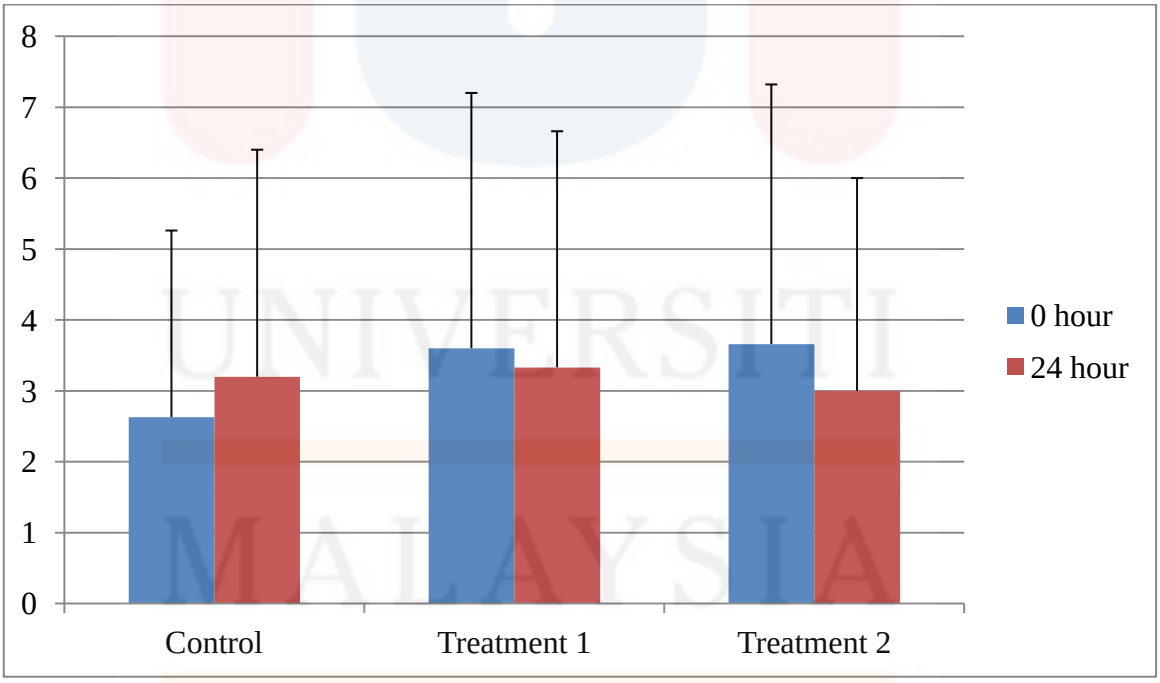

Figure 3: The comparison of springiness (mm) of the meat at 0 and 24-hour following post-mortem

Based on the previous studies by Anaeto, Adeyeye, Chioma, Olarinmoye, & Tayo (2010) and Yangilar (2013), the worldwide demands on goats are meat, milk and skin. The trend of consumption of the goat's meat is changing as it is becoming more well-known and can be usually available at the fine dining level (Packaged Facts, 2007).

According to the Figure 1, the meat sample of treatment 1(0h) was the highest value of hardness 1 and as well as in Figure 2, the meat sample of treatment 1(0h) had the highest value of hardness 2. It also had a high value of the springiness. Thus, this indicates the meat sample of treatment 1(0h) is the most tender. However, the meat has many differences on the 24h post-mortem period. During the 24h, the meat of the treatment 1 has decline in hardness and also the springiness.

As stated in Brassard et al. (2017), the tenderness of the lamb meat influenced by the interplay between proteolytic systems and muscle shortening. However, Webb et al. (2005) indicate that the goat meat however has been reported to be generally less tender than lamb. Although the subcutaneous fat and the sarcomere length of the goat meat had not being measured, the goat meat had resulted in the reduction of the capacity of the subcutaneous fat to prevent cold shortening during post-mortem chilling.

Table 6 and Table 7 shows the colour profile of the meat according to the L*, a* and b*. L* represents the lightness, a* represents the redness and b* represent the yellowness. Figure 4, Figure 5 and Figure 6 show the comparison of the colour profile of the meat that differs according to the post-mortem period.

Table 6: Colour profile of the meat for 0 hour postmortem

Meat sample / Colour profile	Control (80% NG, 20% GP)	Treatment 1 (70% NG, 20% GP, 10% fresh (chopped) OPF)	Treatment 2 (70% NG, 20% GP, 10% pressed OPF)
L (lightness)	28.27 ± 4.72[a]	29.46 ± 7.82[a]	28.27 ± 8.89[a]
a (redness)	10.68 ± 5.47[a]	10.97 ± 2.59[a]	10.69 ± 3.09[a]
b (yellowness)	7.49 ± 2.62[a]	7.03 ± 0.09[a]	6.27 ± 1.63[a]

Note: NG, Napier grass; GP, goat pellet; OPF, oil palm frond.

[a] Means in the same row with different superscripts are significant different at 5% level ($P < 0.05$) by Duncan Multiple Range Test.

Table 7: Colour profile of the meat for 24 hour postmortem

Meat sample / Colour profile	Control (80% NG, 20% GP)	Treatment 1 (70% NG, 20% GP, 10% fresh (chopped) OPF)	Treatment 2 (70% NG, 20% GP, 10% pressed OPF)
L (lightness)	27.75 ± 2.49[a]	24.85 ± 0.76[a]	28.37 ± 3.62[a]
a (redness)	13.34 ± 1.94[a]	13.05 ± 2.53[a]	14.18 ± 3.60[a]
b (yellowness)	7.39 ± 0.13[a]	7.19 ± 1.80[a]	7.48 ± 1.66[a]

Note: NG, Napier grass; GP, goat pellet; OPF, oil palm frond.

[a] Means in the same row with different superscripts are significant different at 5% level ($P < 0.05$) by Duncan Multiple Range Test.

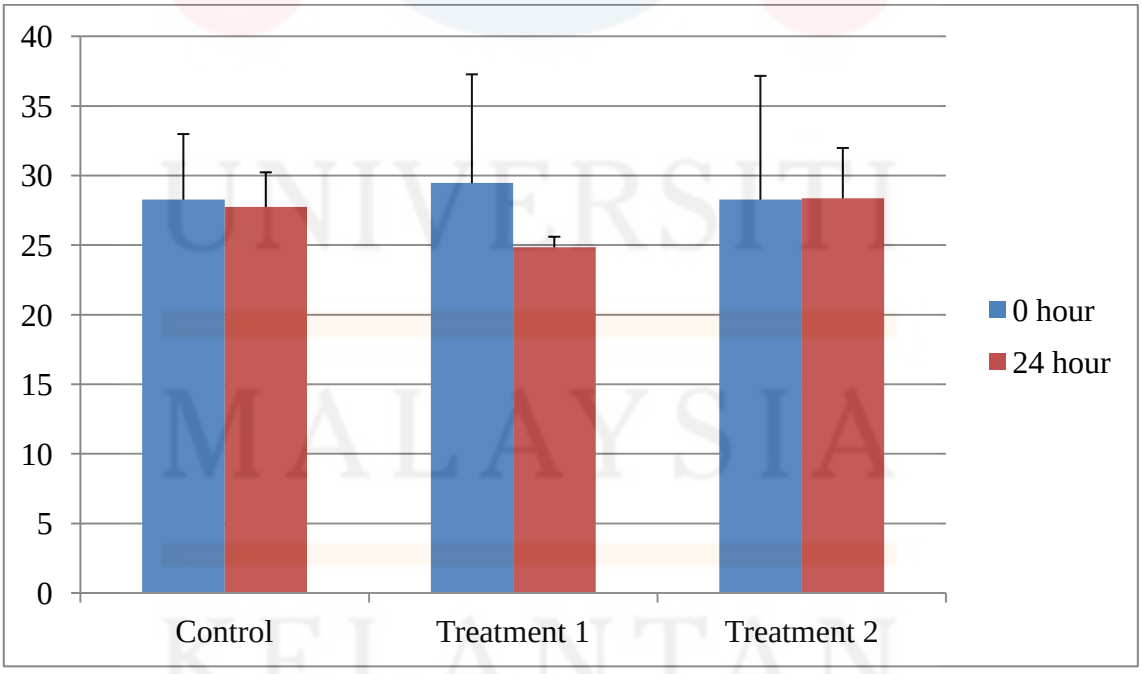

Figure.4: The comparison of the L* (lightness) of the meat at 0 and 24-hour following postmortem

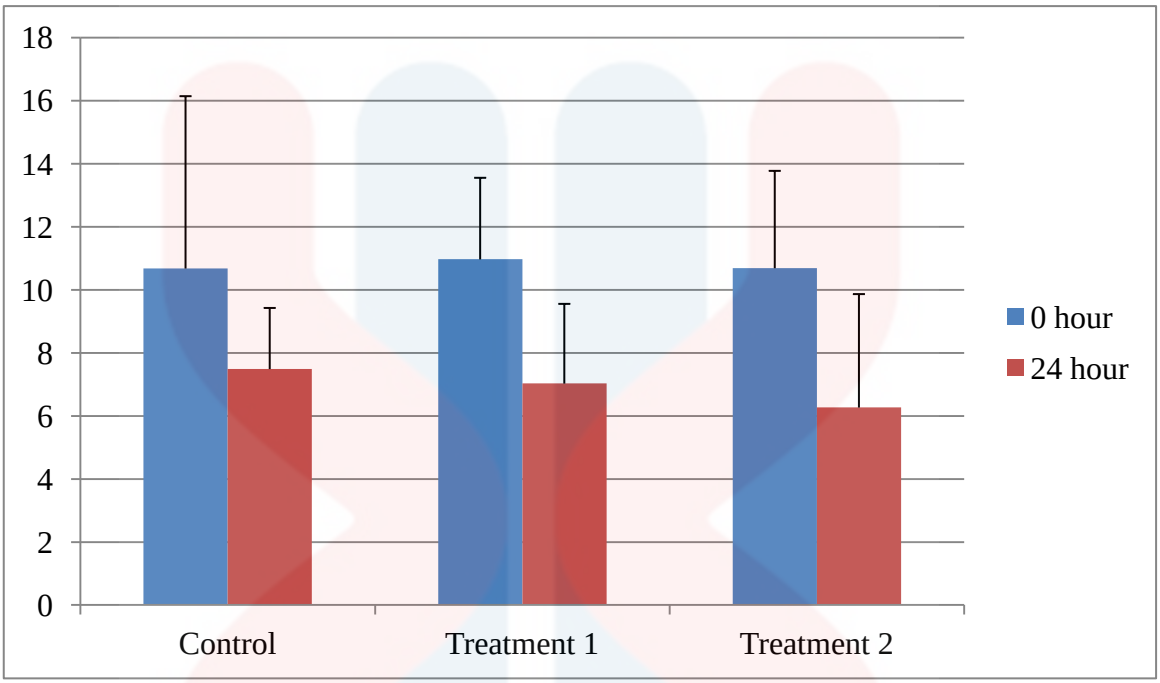

Figure 5: The comparison of the b* (redness) of the meat at 0 and 24-hour following postmortem

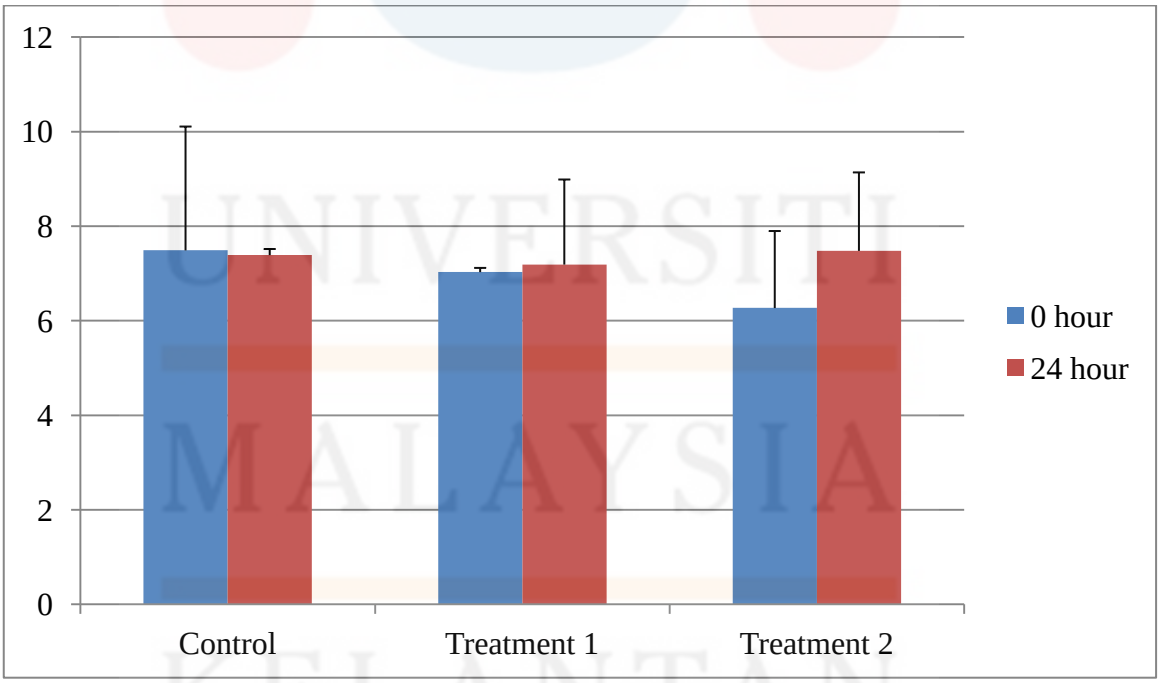

Figure 6: The comparison of the b* (yellowness) of the meat at 0 and 24-hour following postmortem

Based on the journal by Mancini and Hunt (2005), as stated in the journal by Sousa, Parente, Oliveira, and Parente (2015), the colour of the meat plays an important role for pleasing the consumers. The colour values in all treatment diets were changed during the different post-mortem period. According to Figure 5, the colour of the meat based on the control diet has more redness than treatment 1 and treatment 2. However, the redness of the 0 hour post-mortem period is higher than 24 hour post-mortem period. This outcome indicates that the inclusion of the OPF into the animal's diet can cause changes in the colour of the meat and this occurrence may affect the consumer's preference as the consumers prefer to have reddish meat.

The results of the colour profile showed the different value of the colour profile between the 0h and 24h post-mortem period. As stated in Ebrahimi et al. (2018), the results of this study are not consistent with those of Juarez et al. (2011) indicated no significant effects of dietary flaxseed and (or) α-tocopheryl acetate supplements on lightness, redness and yellowness values of pig meat, but the post-mortem period showed a significant change in the colour of the pig meat. Based on figure 5, the saturation value of the red colour of the meat seems to decrease with the post-mortem period. The result is similar to Karami, Ponnampalam and Hopkins (2013) that shows the tendency towards a significantly different effect of the meat colour by the post-mortem period. The texture attributes of the meat also not affected by the dietary treatments. It is similar to the Lee, Kouakou and Kannan (2018) that indicates the dietary treatment does not affect the texture attributes of the meat.

4.2 The Chemical Composition of the Meat

Table 8 shows the chemical composition of the meat for 0 hour post-mortem period. The control meat consists of 25.66 ± 0.71% DM, 73.89 ± 5.38% CP, 5.37 ± 1.24% EE and 4.93 ± 0.4% ash. The treatment 1 meat consists of 29.09 ± 1.04% DM, 67.20 ± 1.55% CP, 8.46 ± 3.16% EE and 6.09 ± 0.68% ash. The treatment 2 meat consists of 29.40 ± 1.83% DM, 72.42 ± 0.68% CP, 4.50 ± 1.98% EE and 5.88 ± 1.07% ash.

Table 8: Chemical composition of the meat for 0 hour post-mortem

Meat sample / **Proximate composition**	**Control (80% NG, 20% GP)**	**Treatment 1 (70% NG, 20% GP, 10% fresh (chopped) OPF)**	**Treatment 2 (70% NG, 20% GP, 10% pressed OPF)**
DM (%)	25.66 ± 0.71[a]	29.09 ± 1.04[b]	29.40 ± 1.83[b]
CP (%)	73.89 ± 5.38[a]	67.20 ± 1.55[a]	72.42 ± 0.68[a]
EE (%)	5.37 ± 1.24[ab]	8.46 ± 3.16[b]	4.50 ± 1.98[a]
Ash (%)	4.93 ± 0.41[a]	6.09 ± 0.68[a]	5.88 ± 1.07[a]

Note: NG, Napier grass; GP, goat pellet; OPF, oil palm frond; DM, dry matter; CP, crude protein; EE, ether extract.

[a] [b] Means in the same row with different superscripts are significant different at 5% level ($P < 0.05$) by Duncan Multiple Range Test.

Table 9 shows the chemical composition of the meat for 24 hours post-mortem period. The control meat consists of 25.64 ± 0.79% DM, 69.38 ± 5.41% CP, 4.87 ± 1.29% EE and 10.11 ± 3.14% ash. The treatment 1 meat consists of 24.29 ± 0.75% DM, 74.68 ± 4.70% CP, 3.41 ± 1.07% EE and 6.56 ± 0.83% ash. The treatment 2 meat consists of 28.34 ± 0.61% DM, 70.99 ± 6.41% CP, 5.68 ± 0.30% EE and 5.77 ± 1.77% ash.

Table 9: Chemical composition of the meat for 24 hour post-mortem

Meat sample / Proximate composition	Control (80% NG, 20% GP)	Treatment 1 (70% NG, 20% GP, 10% fresh (chopped) OPF)	Treatment 2 (70% NG, 20% GP, 10% pressed OPF)
DM (%)	25.64 ± 0.79[a]	24.29 ± 0.75[a]	28.34 ± 0.61[b]
CP (%)	69.38 ± 5.41[a]	74.68 ± 4.70[a]	70.99 ± 6.41[a]
EE (%)	4.87 ± 1.29[a]	3.41 ± 1.07[a]	5.68 ± 0.30[ab]
Ash	10.11 ± 3.14[b]	6.56 ± 0.83[a]	5.77 ± 1.77[a]

Note: NG, Napier grass; GP, goat pellet; OPF, oil palm frond; DM, dry matter; CP, crude protein; EE, ether extract.

[a] [b] Means in the same row with different superscripts are significant different at 5% level ($P < 0.05$) by Duncan Multiple Range Test

Figure 7, Figure 8, Figure 9 and Figure 10 show the comparison of the chemical composition of the meat according to the post-mortem period.

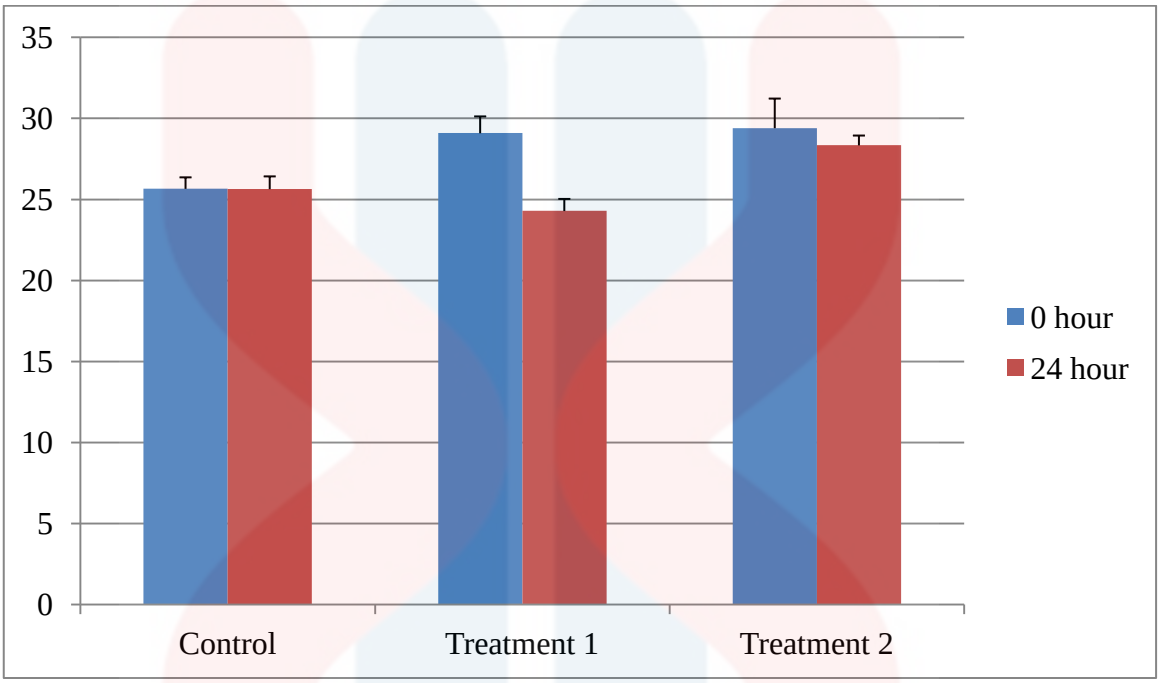

Figure 7: The comparison of the dry matter composition (%) of the meat at 0 and 24-hour following postmortem

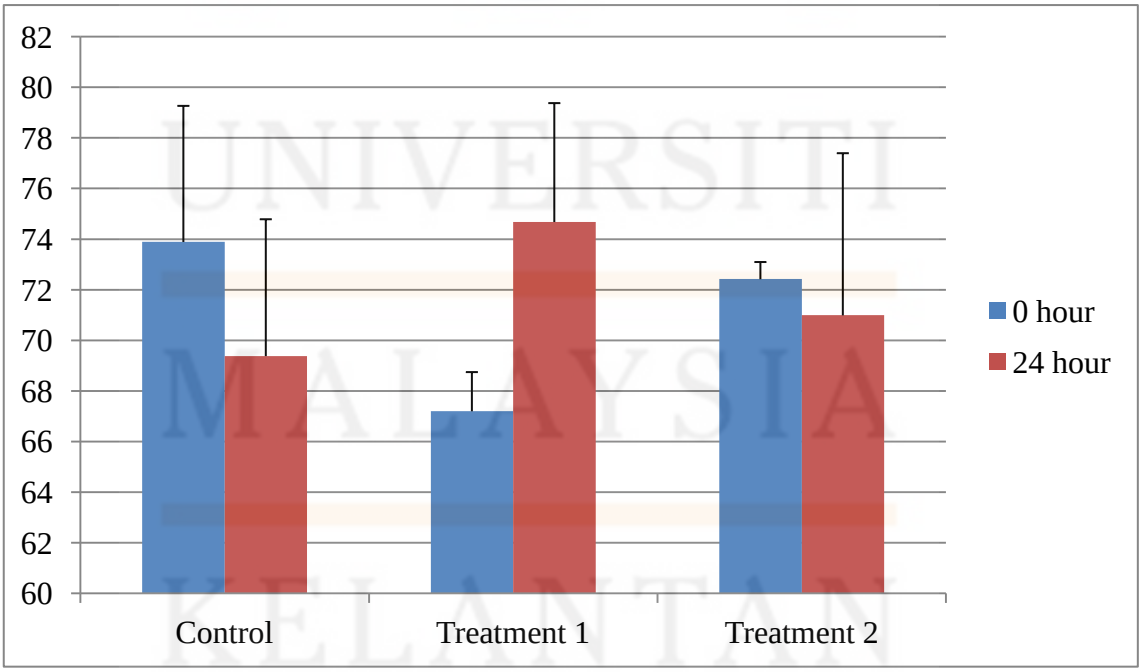

Figure 8: The comparison of the crude protein composition (%) of the meat at 0 and 24-hour following postmortem

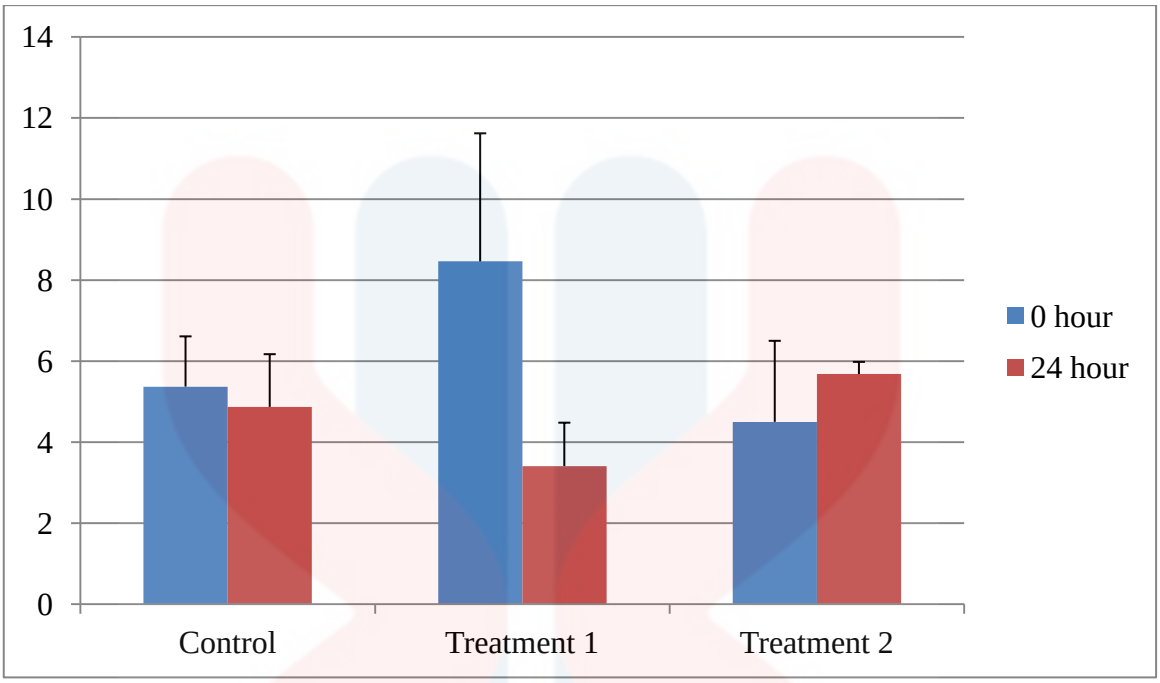

Figure 9: The comparison of the ether extract composition (%) of the meat at 0 and 24-hour following postmortem

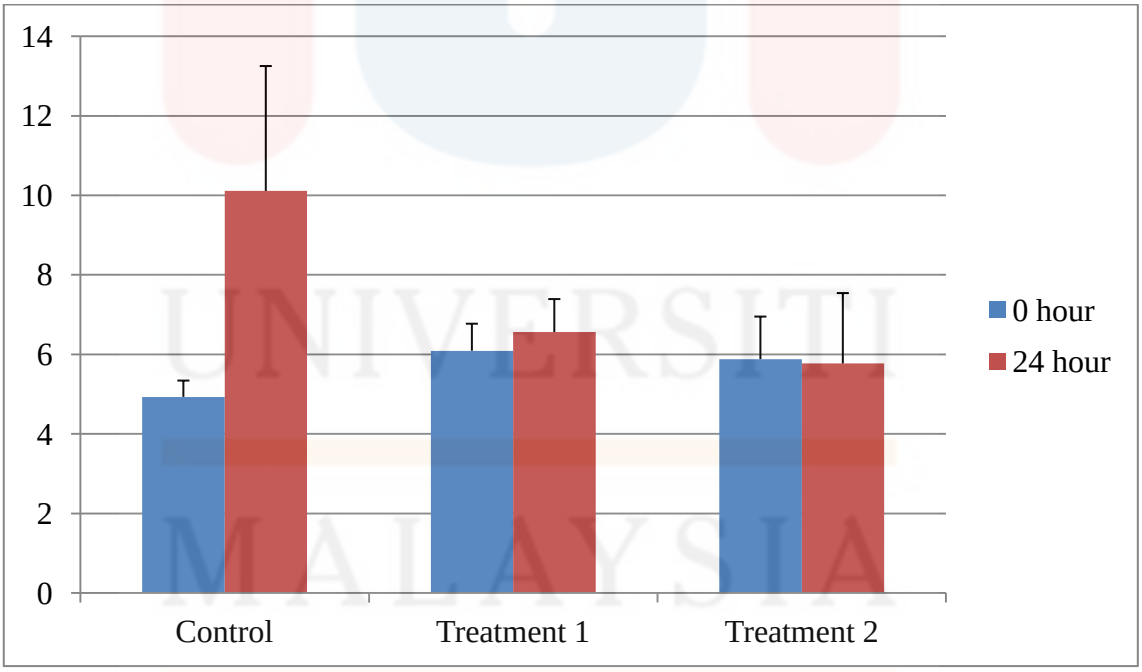

Figure 10: The comparison of the ash composition (%) of the meat at 0 and 24-hour following postmortem

According to the table 8 and 9, treatment 2 meat sample has the highest percentage of the dry matter composition (29.04%) for the 0h post-mortem period as well as the 24h post-mortem period (28.34%) This result is different from the research conducted by Akharaiyi & Isunu (2015), which got 32.26 to 58.6% of dry matter of the meat. However, the result is quite similar with the research conducted by Sousa et al., (2015) which have the result of the dry matter composition of the goat meat that ranges between 27.65-28%. Based on figure 7, there are not many differences between the 0h and 24h post-mortem period based on the dry matter composition of the meat samples.

According to table 8, control meat sample has the highest percentage of the crude protein composition (73.89%) for the 0h post-mortem period. However, the treatment 1 meat sample has the highest value of crude protein (74.68%) as stated in table 9 for 24h. This result is different from the research conducted by Akharaiyi & Isunu (2015) and Sousa et al., (2015) which have the result of the dry matter composition of the goat meat that ranges between 22.53 to 43.18%. Based on figure 8, the crude protein value between 0h and 24h post-mortem period has many differences among the control and treatment 1. However, it shows fewer differences in treatment 2.

According to the table 8, treatment 1 has the highest value of the ether extract composition for the 0h pot-mortem period (8.46%) while in table 9, it shows that the treatment 2 has the highest value of the ether extract composition for 24h of post-mortem period (5.68%). This varies to the Akharaiyi & Isunu (2015) that indicates the value of the ether extract is range between 13.2 to 16.3%

Based on table 8, the treatment 1 showed the highest value of the ash (6.09%). Meanwhile, in table 9, the control meat sample showed the highest value of the ash (10.11%). However, the result obtained has differences than other researches.

According to Akharaiyi & Isunu (2015), the ash content of the meat range between 3.12 to 3.27%. Meanwhile, based on the research by (Sousa et al., 2015), the ash content that was obtained is range between 1.06 to 1.14%. Madruga et al. (1999), it stated that the ash content is usually affected by the age of the animal and not by diet effects.

A study by Brassard et al. (2017) previous observations in beef cattle established no difference in meat composition after the cattle being fed with corn and barley (Wismer, Okine, Stein, Seibel, & Goonewardene, 2008).

The different chemical composition of the meat may be influenced by the chemical content of the diet. Based on the study by Adeyemi et al. (2015), it showed that the proximate analysis of OPF used in the study showed that it contained on DM basis: 4.6 % crude protein, 2 % ether extract, 39 % crude fiber, 78.5 % NDF, 56.4 % ADF, 3.2 % ash, and 5.7 MJ/kg metabolizable energy. The proximate analysis of the feed used for treatment 1 in the current study showed that it contained on DM basis: 9.23 % crude protein, 0.82% ether extract, 22.6% crude fiber, 78.5 % and 1.36% ash. Meanwhile, the treatment 2 showed that it contained on DM basis: 6.14 % crude protein, 0.19% ether extract, 27.71% crude fiber, 78.5 % and 0.21% ash.

The meat composition in the current study showed a high concentration of the crude protein that has the values range from 67.2% to 74.68%. It can relate to the formation of collagen. According to the journal by Putra, Wattanachant, and Wattanachant (2017), a higher protein contents obtained from Saanen samples related to this matter. The result is quite similar with the journal (Lizaso, Beriain, Horcada, Chasco and Purroy (2011) that showed the composition of crude protein in the meat of the dairy cattle (22.39%) and the meat of the beef cattle (20.85%). The maturity level

of animal breed determines collagen properties. The animals that matured earlier will have higher collagen deposition than the immature animals (Jurie et al., 2007)

The composition of the goat meat showed that it contains a high value of ether extract of the crude fat that ranges from 3.41% to 8.46%. Based on the journal by Putra, Wattanachant, and Wattanachant (2017), a higher fat contents that were obtained may be related with the fat deposition between breeds is more associated with different locations of fat deposite.

According to the journal by Mehjabin, Faruque and Sarker (2011), the chemical composition of the goat meat were influenced by the aging and maturity of the goat. The dry matter content of the goat meat is range between 26.69% to 30.79% (Islam, 2007) while according to the journal by Abedin, Alam and Faruque (2005) and Moniruzzaman, Hashen, Akther and Hossain (2002) the dry matter content of the goat meat is range between 25.63% to 26.80%.

The crude protein content of the goat meat that was obtained is range from 19.98% to 22.76% (Mehjabin et al., 2011). The crude protein content differs and influenced by the aging of the goat. Based on the journal by Abedin et al. (2005), the crude protein content of the goat meat Abedin (2005) found CP content of Black Bengal goat meat was slightly lower than Mehjabin et al. (2011). Asaduzzaman (2008) reported that the crude protein of the goat meat was 21.9% while Islam (2007) reported that the composition of the crude protein of the goat meat range from 23.91% to 24.98%.

Mehjabin et al. (2011) stated that the ether extract content of the goat meat is range from 1.20% to 3.96%. However, Islam (2007) showed that the ether extract content of the goat meat was slightly higher that range from 7.47% to 8.22%. (Abedin et

al., 2005) and (Asaduzzaman, 2008) also had found the ether extract composition of the goat meat was slightly higher which has 3.29% and 3.72% respectively.

According to the journal by (Mehjabin et al., 2011), the ash content of the goat meat was range from 1.10% to 1.63%. The similar content of the ash was found by Abedin et al. (2005) and Asaduzzaman (2008) which has 1.23% and 1.15% of the ash content respectively.

4.3 The Microbiological Quality of the Meat

Table 10 and Table 11 show the microbiological quality of the meat for 0 and 24 hours post-mortem period. Figure 11 shows the comparison of the microbiological composition of the meat according to the post-mortem period.

Table 10: Microbiological composition of the meat for 0 hour post-mortem period

Meat sample / **TPC**	**Control (80% NG, 20% GP)**	**Treatment 1 (70% NG, 20% GP, 10% fresh (chopped) OPF)**	**Treatment 2 (70% NG, 20% GP, 10% pressed OPF)**
TPC (cfu/ml)	1200.00 ± 400.00a	3400.00 ± 400.00b	4400.00 ± 200.00c

Note: NG, Napier grass; GP, goat pellet; OPF, oil palm frond.

[a] [b] [c] Means in the same row with different superscripts are significant different at 5% level ($P < 0.05$) by Duncan Multiple Range Test.

Table 11: Microbiological composition of the meat for 24 hour postmortem.

Meat sample / TPC	Control (80% NG, 20% GP)	Treatment 1 (70% NG, 20% GP, 10% fresh (chopped) OPF)	Treatment 2 (70% NG, 20% GP, 10% pressed OPF)
TPC (cfu/ml)	1000.00 ± 350.00a	1200.00 ± 100.00a	4300.00 ± 200.00c

Note: NG, Napier grass; GP, goat pellet; OPF, oil palm frond.

[a] [b] [c] Means in the same row with different superscripts are significant different at 5% level ($P < 0.05$) by Duncan Multiple Range Test.

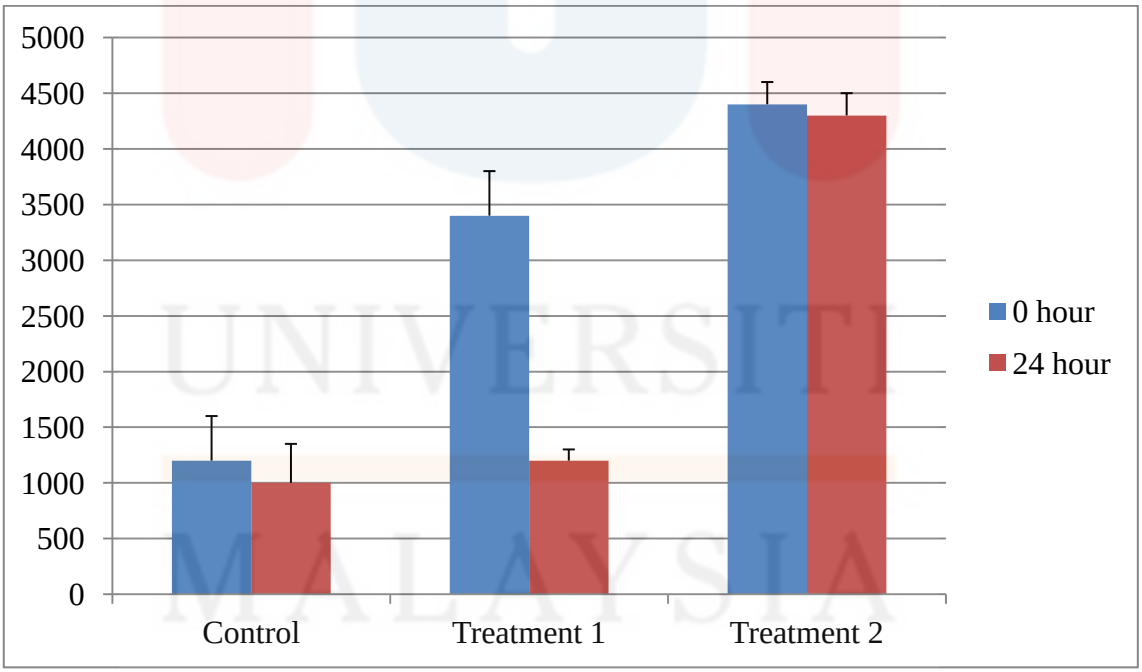

Figure 11: Microbiological composition (cfu/ml) of the meat at different time points following post-mortem

As stated in Komba et al. (2012), the meat is one of the protein sources in the consumer's diet. However, due to its nature, it is highly susceptible to the contaminations by the microorganisms. The microbial contamination will cause spoilage to the meat and also may lead to the food borne infection towards mankind and then, in the worst case, may cause the decline in the economy and other health problems.

Public Health Laboratory Service Guidelines for the bacteriological quality of ready-to-eat foods at the point of sales considers a food unacceptable if the level of Salmonella and S. *aureus* are in the order > 105 CFU/g and > 103 CFU/g respectively (PHLS, 2000).

According to Figure 11, the highest colony forming unit of the microorganisms is the treatment 2 for both 0h and 24h post-morterm period. Meanwhile, the control meat sample has the least colony forming unit of the microorganisms for both 0h and 24h post-mortem period.

However, the identified microorganisms may be not directly from the meat samples. The environment during the microbiological process also may affect the number of microorganisms as well as the other contaminations such as human contamination.

CHAPTER 5

RECOMMENDATION & CONCLUSION

5.1 Conclusion

In conclusion, the diet of the goat can influence the physical, chemical and microbiological characteristics of the goat meat. The best result is the treatment 1 (0h) meat sample from the goat that had been fed with 70% Napier grass, 20% goat pellet and 10% OPF. It has high ether extract composition (8.46%) , high value of protein content (67.20%) and the redness of the meat is 10.97.

5.2 Recommendation

During the microbiological analysis procedure, precautions must be taken in order for obtaining a precise result of total plate count and to avoid the contamination from the surroundings. During the thawing of the meat, the meat must be thawed in the refrigerator not at room temperature to avoid the spoilage of the meat. During the chemical analysis, the chemicals must be prepared according to the concentration that is needed. Extra precaution needed when handling those chemicals. The imprecise concentration of the chemicals also may influence the result. During the physical examination of the meat, the meat must be precisely cut before putting it on the platform of the texture analyser from obtaining the accurate value of the tenderness of the meat.

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APPENDIX A

SPSS Analysis

Table A.1: Duncan‟s multiple range tests for texture profile of meat

Descriptives

			N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean	
							Lower Bound	Upper Bound
hardness1	C0		3	236.6667	159.64440	92.17074	-159.9120	633.2453
	T10		3	382.3333	123.71068	71.42440	75.0190	689.6477
	T20		3	322.0000	305.49632	176.37838	-436.8949	1080.8949
	C24		3	372.6667	163.39013	94.33333	-33.2169	778.5502
	T124		3	204.0000	98.65090	56.95612	-41.0624	449.0624
	T224		3	321.3333	412.09991	237.92599	-702.3796	1345.0463
	Total		18	306.5000	211.25152	49.79246	201.4471	411.5529
	Model	Fixed Effects			238.17827	56.13916	184.1833	428.8167
		Random Effects				56.13916a	162.1897a	450.8103a
hardness2	C0		3	234.6667	131.07377	75.67548	-90.9386	560.2720
	T10		3	320.6000	121.65805	70.23931	18.3847	622.8153
	T20		3	296.0000	217.99771	125.86103	-245.5363	837.5363
	C24		3	266.6667	92.37604	53.33333	37.1919	496.1415
	T124		3	169.3333	79.15386	45.69950	-27.2958	365.9624
	T224		3	270.0000	352.73078	203.64921	-606.2318	1146.2318
	Total		18	259.5444	167.92237	39.57968	176.0386	343.0503
	Model	Fixed Effects			190.92829	45.00223	161.4930	357.5959
		Random Effects				45.00223a	143.8625a	375.2264a
springiness	C0		3	2.6333	.48014	.27721	1.4406	3.8261
	T10		3	3.6033	.12097	.06984	3.3028	3.9038
	T20		3	3.6567	.73330	.42337	1.8350	5.4783

	C24		3	3.1967	.33486	.19333	2.3648	4.0285
	T124		3	3.3300	.19925	.11504	2.8350	3.8250
	T224		3	3.0033	.79727	.46030	1.0228	4.9839
	Total		18	3.2372	.56149	.13234	2.9580	3.5164
	Model	Fixed Effects			.51159	.12058	2.9745	3.5000
		Random Effects				.15701	2.8336	3.6408

Warning: Between-component variance is negative. It was replaced by 0.0 in computing this random effects measure

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
hardness1	Between Groups	77915.833	5	15583.167	.275	.918
	Within Groups	680746.667	12	56728.889		
	Total	758662.500	17			
hardness2	Between Groups	41921.344	5	8384.269	.230	.942
	Within Groups	437443.360	12	36453.613		
	Total	479364.704	17			
springiness	Between Groups	2.219	5	.444	1.696	.210
	Within Groups	3.141	12	.262		
	Total	5.360	17			

POST HOC TEST

hardness1

Duncan[a]

		Subset for alpha = 0.05
treatment	N	1
T124	3	204.0000
C0	3	236.6667
T224	3	321.3333
T20	3	322.0000
C24	3	372.6667
T10	3	382.3333
Sig.		.420

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

hardness2		
Duncan[a]		
		Subset for alpha = 0.05
treatment	N	1
T124	3	169.3333
C0	3	234.6667
C24	3	266.6667
T224	3	270.0000
T20	3	296.0000
T10	3	320.6000
Sig.		.395
Means for groups in homogeneous subsets are displayed.		
a. Uses Harmonic Mean Sample Size = 3.000.		

springiness			
Duncan[a]			
		Subset for alpha = 0.05	
treatment	N	1	2
C0	3	2.6333	
T224	3	3.0033	3.0033
C24	3	3.1967	3.1967
T124	3	3.3300	3.3300
T10	3	3.6033	3.6033
T20	3		3.6567
Sig.		.055	.178
Means for groups in homogeneous subsets are displayed.			
a. Uses Harmonic Mean Sample Size = 3.000.			

Table A.2: Duncan's multiple range tests for the colour profile of meat

			N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean	
							Lower Bound	Upper Bound
L	C0		3	28.2667	4.72369	2.72722	16.5324	40.0010
	T10		3	29.4567	7.81533	4.51218	10.0423	48.8710
	T20		3	28.2700	8.89482	5.13543	6.1740	50.3660
	C24		3	27.7500	2.49237	1.43897	21.5586	33.9414
	T124		3	24.8533	.76173	.43979	22.9611	26.7456
	T224		3	28.3667	3.62370	2.09215	19.3649	37.3684
	Total		18	27.8272	4.85934	1.14536	25.4107	30.2437
	Model	Fixed Effects			5.51413	1.29969	24.9954	30.6590
		Random Effects				1.29969[a]	24.4863[a]	31.1682[a]
a	C0		3	10.6800	5.46545	3.15548	-2.8969	24.2569
	T10		3	10.9700	2.59444	1.49790	4.5251	17.4149
	T20		3	10.6900	3.09175	1.78502	3.0097	18.3703
	C24		3	13.3400	1.94425	1.12251	8.5102	18.1698
	T124		3	13.0533	2.52922	1.46024	6.7704	19.3363
	T224		3	14.1800	3.59629	2.07632	5.2463	23.1137
	Total		18	12.1522	3.20529	.75550	10.5583	13.7462
	Model	Fixed Effects			3.39783	.80088	10.4073	13.8972
		Random Effects				.80088[a]	10.0935[a]	14.2109[a]
b	C0		3	7.4933	2.62233	1.51400	.9791	14.0076
	T10		3	7.0333	.09292	.05364	6.8025	7.2641
	T20		3	6.2667	1.62586	.93869	2.2278	10.3055
	C24		3	7.3867	.13051	.07535	7.0625	7.7109
	T124		3	7.1867	1.79918	1.03875	2.7173	11.6561
	T224		3	7.4800	1.65653	.95640	3.3649	11.5951
	Total		18	7.1411	1.42016	.33473	6.4349	7.8473
	Model	Fixed Effects			1.60867	.37917	6.3150	7.9672
		Random Effects				.37917[a]	6.1664[a]	8.1158[a]

ANOVA						
		Sum of Squares	df	Mean Square	F	Sig.
L	Between Groups	36.556	5	7.311	.240	.937
	Within Groups	364.868	12	30.406		
	Total	401.424	17			
a	Between Groups	36.114	5	7.223	.626	.684
	Within Groups	138.543	12	11.545		
	Total	174.657	17			
b	Between Groups	3.233	5	.647	.250	.932
	Within Groups	31.054	12	2.588		
	Total	34.286	17			

POST HOC TEST

L		
Duncan[a]		
		Subset for alpha = 0.05
treatment	N	1
T124	3	24.8533
C24	3	27.7500
C0	3	28.2667
T20	3	28.2700
T224	3	28.3667
T10	3	29.4567
Sig.		.371
Means for groups in homogeneous subsets are displayed.		
a. Uses Harmonic Mean Sample Size = 3.000.		

a

Duncan[a]

treatment	N	Subset for alpha = 0.05
		1
C0	3	10.6800
T20	3	10.6900
T10	3	10.9700
T124	3	13.0533
C24	3	13.3400
T224	3	14.1800
Sig.		.275

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

b

Duncan[a]

treatment	N	Subset for alpha = 0.05
		1
T20	3	6.2667
T10	3	7.0333
T124	3	7.1867
C24	3	7.3867
T224	3	7.4800
C0	3	7.4933
Sig.		.412

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

Table A.3: Duncan's multiple range tests for chemical composition of meat

			N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean	
							Lower Bound	Upper Bound
DM	C0		3	25.6600	.70767	.40857	23.9020	27.4180
	T10		3	29.0900	1.03504	.59758	26.5188	31.6612
	T20		3	29.3967	1.83413	1.05894	24.8404	33.9529
	C24		3	25.6400	.79303	.45786	23.6700	27.6100
	T124		3	24.2847	.74476	.42999	22.4346	26.1347
	T224		3	28.3433	.60476	.34916	26.8410	29.8456
	Total		18	27.0691	2.19209	.51668	25.9790	28.1592
	Model	Fixed Effects			1.03967	.24505	26.5352	27.6030
		Random Effects				.87381	24.8229	29.3153
CP	C0		3	73.8900	5.37501	3.10326	60.5377	87.2423
	T10		3	67.2033	1.55159	.89581	63.3490	71.0577
	T20		3	72.4233	.67892	.39198	70.7368	74.1099
	C24		3	69.3800	5.41307	3.12524	55.9332	82.8268
	T124		3	74.6833	4.70334	2.71548	62.9996	86.3671
	T224		3	70.9867	6.41081	3.70129	55.0613	86.9120
	Total		18	71.4278	4.65403	1.09696	69.1134	73.7422
	Model	Fixed Effects			4.55120	1.07273	69.0905	73.7650
		Random Effects				1.15306	68.4638	74.3918
EE	C0		3	5.3733	1.23557	.71336	2.3040	8.4427
	T10		3	8.4567	3.15605	1.82214	.6166	16.2967
	T20		3	4.4967	1.97751	1.14171	-.4157	9.4091
	C24		3	4.8667	1.29276	.74638	1.6553	8.0781
	T124		3	3.4133	1.06959	.61753	.7563	6.0704
	T224		3	5.6833	.30238	.17458	4.9322	6.4345
	Total		18	5.3817	2.16954	.51137	4.3028	6.4606
	Model	Fixed Effects			1.74664	.41169	4.4847	6.2787
		Random Effects				.69449	3.5964	7.1669
Ash	C0		3	4.9333	.40550	.23412	3.9260	5.9407
	T10		3	6.0867	.68311	.39439	4.3897	7.7836
	T20		3	5.8800	1.07037	.61798	3.2210	8.5390
	C24		3	10.1067	3.13790	1.81167	2.3117	17.9016
	T124		3	6.5567	.83002	.47921	4.4948	8.6186
	T224		3	5.7700	1.77392	1.02417	1.3633	10.1767
	Total		18	6.5556	2.17640	.51298	5.4733	7.6379
	Model	Fixed Effects			1.60514	.37834	5.7312	7.3799
		Random Effects				.74241	4.6471	8.4640

ANOVA						
		Sum of Squares	df	Mean Square	F	Sig.
DM	Between Groups	68.719	5	13.744	12.715	.000
	Within Groups	12.971	12	1.081		
	Total	81.690	17			
CP	Between Groups	119.659	5	23.932	1.155	.385
	Within Groups	248.561	12	20.713		
	Total	368.219	17			
EE	Between Groups	43.408	5	8.682	2.846	.064
	Within Groups	36.609	12	3.051		
	Total	80.017	17			
Ash	Between Groups	49.606	5	9.921	3.851	.026
	Within Groups	30.918	12	2.576		
	Total	80.524	17			

POST-HOC TEST

DM			
Duncan[a]			
Treatment	N	Subset for alpha = 0.05	
		1	2
T124	3	24.2847	
C24	3	25.6400	
C0	3	25.6600	
T224	3		28.3433
T10	3		29.0900
T20	3		29.3967
Sig.		.149	.261
Means for groups in homogeneous subsets are displayed.			
a. Uses Harmonic Mean Sample Size = 3.000.			

CP

Duncan[a]

Treatment	N	Subset for alpha = 0.05
		1
T10	3	67.2033
C24	3	69.3800
T224	3	70.9867
T20	3	72.4233
C0	3	73.8900
T124	3	74.6833
Sig.		.094

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

EE

Duncan[a]

Treatment	N	Subset for alpha = 0.05	
		1	2
T124	3	3.4133	
T20	3	4.4967	
C24	3	4.8667	
C0	3	5.3733	5.3733
T224	3	5.6833	5.6833
T10	3		8.4567
Sig.		.172	.061

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

Ash			
Duncan[a]			
		Subset for alpha = 0.05	
Treatment	N	1	2
C0	3	4.9333	
T224	3	5.7700	
T20	3	5.8800	
T10	3	6.0867	
T124	3	6.5567	
C24	3		10.1067
Sig.		.280	1.000
Means for groups in homogeneous subsets are displayed.			
a. Uses Harmonic Mean Sample Size = 3.000.			

Table A.4: Duncan's multiple range tests for the microbiological composition of meat

						95% Confidence Interval for Mean	
		N	Mean	Std. Deviation	Std. Error	Lower Bound	Upper Bound
C0		3	1200.0000	400.00000	230.94011	206.3449	2193.6551
T10		3	3400.0000	400.00000	230.94011	2406.3449	4393.6551
T20		3	4400.0000	200.00000	115.47005	3903.1725	4896.8275
C24		3	1000.0000	350.00000	202.07259	130.5518	1869.4482
T124		3	1200.0000	100.00000	57.73503	951.5862	1448.4138
T224		3	4300.0000	200.00000	115.47005	3803.1725	4796.8275
Total		18	2583.3333	1549.38318	365.19312	1812.8432	3353.8235
Model	Fixed Effects			297.90938	70.21791	2430.3416	2736.3250
	Random Effects				664.53827	875.0833	4291.5833

ANOVA					
TPC					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	39745000.000	5	7949000.000	89.566	.000
Within Groups	1065000.000	12	88750.000		
Total	40810000.000	17			

Post Hoc Test

TPC				
Duncan[a]				
		Subset for alpha = 0.05		
treatment	N	1	2	3
C24	3	1000.0000		
C0	3	1200.0000		
T124	3	1200.0000		
T10	3		3400.0000	
T224	3			4300.0000
T20	3			4400.0000
Sig.		.449	1.000	.688
Means for groups in homogeneous subsets are displayed.				
a. Uses Harmonic Mean Sample Size = 3.000.				

APPENDIX B

B.1: Texture analyzer

B.3: Chroma meter

B.5: Drying the samples in the oven

B.2: Cutting the meat

B.4: Probes for chroma meter

B.6: The Kjeltec 8200 (distillation machine for Kjeldahl method)

B. 7: The preparation of the sample for Kjeldahl (digestion)

B. 8: Soxhlet extraction

B. 9: chemicals for Kjeldahl method (Boric acid, NaOH, Kjeldahl tablet and indicators; bromocresol green and methyl red)

B. 10: Microbiological test