EFFICIENCY OF RENDERED CHICKEN OIL AND COCONUT OIL AS FEED BINDERS TOWARDS THE GROWTH PERFORMANCE OF THE BROILER AT GROWER STAGE

AIMAN SOLIHIN BIN MOHD ROHIM

F15A0259

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

FACULTY OF AGRO BASED INDUSTRY

UNIVERSITI MALAYSIA KELANTAN

2019

DECLARATION

I hereby declare that the work embodied in this report is my own work except for the journal that used for research and the summary from it that had already mentioned the source.

____

Signature

Student name : Aiman Solihin Bin Mohd Rohim

Matric Number: F15A0259

Date :

Approved by:

____

Supervisor

Name : Dr Hasnita Binti Che Harun

Date :

ACKNOWLEDGEMENT

A very grateful to God for giving me the strength and good health to complete this project successfully under constraint period given. Firstly, I would like to thanks to all the people who are directly or indirectly involve throughout this project. I would like to thanks my supervisor, Dr Hasnita Binti Che Harun with my deepest and sincere gratitude. Without her continuously guidance, assistant and encouragement throughout all the process in this thesis, this report would have never accomplished.

Next, thanks to all Agro Techno Park staff especially Mr. Hilman Hamidi Bin Wahid and Miss Lili Amira Binti Hazinan for their help during rearing the broiler chicken and process preparation of chick brooders. Special thanks to Dr. Mohammad Amizi Bin Ayob for allowing me to use the broiler houses at Agro Techno Park. I would also like to thanks to Laboratory Assistant, Mr. Shamsul Amri for allowing me using the Animal Laboratory during animal feeding trial period. Not to forget, Mr. Faiz, laboratory assistant from Faculty Veterinary UMK Pengkalan Chepa that always helps and guide me for proximate analysis studies.

Finally, thanks to my parents, who always support me in doing the final year project. Also special thanks to my friends who always support and accompany me throughout this project. Thank you for those who involved directly or indirectly in helping me to complete this project.

TABLE OF CONTENT

CONTENT		PAGE
DECLARATION		ii
ACKNOWLEDGEMENT		iii
TABLE OF CONTENT		iv
LIST OF TABLE		vi
LIST OF FIGURE		vii
LIST OF ABBRECIATION		viii
LIST OF SYMBOLS		ix
ABSTRACT		x
ABSTRAK		xi
CHAPTER 1	**INTRODUCTION**	
	1.1 Research Background	1
	1.2 Problem Statement	3
	1.3 Objective	3
	1.4 Scope of Study	4
	1.5 Significance of Study	4
CHAPTER 2	**LITERATURE REVIEW**	
	2.1 Poultry	5
	2.1.1 Poultry Nutrition	6
	2.2 Coconut oil	7
	2.3 Utilization of the Animal by-product in Animal Feed	8
	2.4 Rendered Chicken Oil	10
CHAPTER 3	**MATERIAL AND METHODS**	
	3.1 Experiment set up	12
	3.2 Raw materials	12
	3.3 Equipment	13
	3.4 Methods	13
	3.4.1 Preparation of binder	13
	3.4.2 Feed formulation using different types of binding	14
	3.4.3 Feed preparation	15
	3.4.4 Texture profile analysis (TPA)	15
	3.5 Feeding trial	16
	3.6 Proximate Analysis of Feed Samples	17

3.6.1 Preparation of Samples for Proximate analysis 17
3.6.2 Determination of Dry Matter (DM) 17
3.6.3 Determination of Ash Content 18
3.6.4 Determination of Crude Protein (CP) content 19
3.6.5 Determination of Crude Fat (CF) content 21
3.7 Statistical analysis 22

CHAPTER 4 RESULTS AND DISCUSSION

4.1 The Physical Composition of the Feed 23
4.2 The Biochemical Composition of the Feed 25
4.3 Weight gain of broiler chicken at grower stage 28

CHAPTER 5 RECOMMENDATION AND CONCLUSION
6.1 Recommendation 32
6.2 Conclusion 33

REFERENCES 34
APPENDIX A 37
APPENDIX B 49

LIST OF TABLE

NO		PAGE
Table 3.1	Recommended nutrient level for broiler at grower stage	15
Table 4.1	Texture Profile analysis of broiler grow out feed	23
Table 4.2	Biochemical composition of broiler grow out feed	25
Table 4.3	Body weight gain of broiler chicken	28

LIST OF FIGURES

NO.		PAGE
B.1	Rendered chicken oil	49
B.2	Coconut oil	49
B.3	Raw ingredient	49
B.4	Soybean meal	49
B.5	Texture analyzer	49

LIST OF ABBRECIATION

HCL	Hydrochloric Acid
Ca	Calcium
P	Phosphorus
Na	Sodium
Mg	Magnesium
DM	Dry matter
CP	Crude protein
CF	Crude fat
ME	Metabolize energy
AOAC	Association of Official Analytical Chemists
FAO	Food and Agriculture Organization
H_2SO_4	Sulphuric acid
DCP	Dicalcium Phosphate
PBM	Poultry by product meal

LIST OF SYMBOLS

V	Volume
n	Concentration of HCL
W	Weight
%	Percentage
kg	Kilogram
mm/s	millimeters Per second
L	Liters
N	Nitrogen
ml	Milliliter
kcal/kg	Kilocalorie per kilogram
ºC	Degree Celsius
g	Gram

Efficiency of Rendered Chicken Oil and Coconut Oil as Feed Binders Towards the Growth Performance of the Broiler at Grower Stage

ABSTRACT

The nutrients in feed and the feed compositions may affect the palatability and digestibility of the feed and also influence the performance of the livestock including the body weight gain. The poultry by-product such as the rendered chicken oil and also the coconut oil has been utilized as another alternative as the feed binder for lowering the feed cost and conserving the environment. Therefore, the present study was conducted to investigate the efficiency of rendered chicken oil and coconut oil as feed binders towards the growth performance of the broiler at the grower stage. The animal feed trial was conducted at Agrotechnopark, Universiti Malaysia Kelantan (UMK), Jeli Campus. **198 broilers** were selected and randomly assigned to 3 different dietary groups. The broilers were fed with palm oil (control), feed that had been supplemented with coconut oil (treatment 1) and rendered chicken oil (treatment 2) as the feed binders. The feeds were analyzed for the determination of the physical (texture profile and colour analysis) and chemical (proximate analysis). Meanwhile, the growth of the broilers was monitored from week 3 until week 5 in terms of the increment of the body weight. The hardness of the feed range from 15.67 to 85.67 (g) and the springiness of meat range from 0.36 to 0.48 (mm). The dry matter of the feeds in the range between from 89.99 to 95.12%, the crude protein range from 17.02 to 21.01%, the crude fat range from 5.60 to 6.25% and the ash content range from 4.20 to 5.26%. There are differences in term of the weekly body weight gain of the broilers after being fed with different feeds. In conclusion, the composition of fat that added to feed affect the growth rate on broiler chicken.

Keywords: Rendered chicken oil, coconut oil, proximate composition, body weight gain.

Keupayaan Minyak Ayam dan Minyak Kelapa sebagai Bahan Pengikat dalam Makanan Terhadap Pembesaran Ayam Daging Di peringkat Tumbesaran

ABSTRAK

Nutrisi dan komponen makanan dalam makanan boleh mempengaruhi rasa dan pencernaan haiwan serta memberi kesan dalam meningkatkan berat badan haiwan. Minyak ayam yang diperolehi daripada produk sisa lemak ayam serta minyak kelapa dapat digunakan sebagai pemudah cara untuk mengurangkan kos makanan haiwan dan dapat menjaga alam sekitar. Contohnya, minyak ayam dan minyak kelapa dapat membantu bahan mentah seperti kacang soya dan jagung bercampur bersama dengan lebih kemas lagi. Oleh itu, kajian ini dijalankan untuk mengenalpasti keupayaan minyak ayam dan minyak kelapa sebagai pengikat dalam makanan serta pembesaran ayam daging di peringkat tumbesaran. Tempoh beri makan makanan kepada ayam telah dilaksanakan di AgroTechnoPark bertempat di Universiti Malaysi Kelantan (UMK), kampus Jeli. 198 ekor ayam daging telah dipilih dan di susun secara rawak untuk 3 kategori diet yang berbeza. Telah diberikan makanan yang bercampur minyak kelapa sawit untuk ayam diperingkat kawalan, manakala kumpulan 1 adalah untuk minyak kelapa dan kumpulan 2 untuk makanan yang telah dicampurkan dengan minyak ayam. Ciri-ciri fizikal dan kandungan kimia dalam makanan ayam telah ditentukan. Disamping itu, berat ayam telah diambil dar minggu ke 3 sehingga minggu ke 5 untuk melihat peningkatan berat badan ayam. Nilai kerasnya makanan ayam adalah dalam lingkungan 15.67 sehingga 85.67 (g) dan kekenyalan adalah 0.36 sehingga 0.48 (mm). Jumlah bahan kering yang ada dalam makanan adalah dalam lingkungan 89.99 % sehingga 95.12 %, manakala protein ialah 17.02 sehingga 21.01 %, kandungan lemak pula ialah 5.60 % sehingga 6.25 % dan bahan-bahan mineral adalah dalam linkungan 4.2 % sehingga 5.26 %. Terdapat perubahan berat badan ayam daging selepas diberi makan makanan yang berbeza. Kesimpulannya, penambahan lemak dalam makanan ayam telah memberi impak terhadap pembesaran ayam daging.

Kata kunci: Minyak ayam, minyak kelapa, komposisi proximate, peningkatan berat badan.

CHAPTER 1

INTRODUCTION

1.1 Research Background

Poultry is the domesticated fowl which are raised for their meat and egg as the source of food. Poultry meat is an important source because its provide proteins, minerals and vitamins in the human diet (Governments, n.d.). Chickens, ducks, turkeys, and geese are the most common species being raised. Chicken types could be divided by broiler and layer. Broiler chickens are originated from the jungle fowl of the Indian Subcontinent (Emous, 2016). Abdurofi, Ismail, Kamal and Gabdo, (2017) stated that the domestic demand for broiler meat is one of the highest in the Malaysian markets compared to other livestock.

The feed conversion efficiency in broilers is high compared to other livestock. To make sure the broiler chickens get high energy density in feed, the fat is added in their diets. Usually, the vegetable oils are used in chicken diets. According to Engberg, Lauridsen, Jensen and Jakobsen, (1996) vegetable oils are rich in polyunsaturated fatty acids (PUFA) and highly digestible for chickens and represent traditional fat sources in broiler diets. Vegetable oils can be obtained by extraction from various types of fruits, seeds, grains and nuts (Tomkins and Drackley, 2010).

Rendered chicken oil is obtained from poultry by product that contains chicken fat. Chicken fat that undergoes chicken rendering and processing will produce rendered chicken oil. The processing of the poultry by products starts with raw material handling, followed by heat treatment to decrease the moisture content and to kill microorganisms. The oil that obtained is separated from the solids by draining and pressing methods. According to Giriprasad and Goswami (2013) stated that chicken fat is high in linoleic acids which is a beneficial omega-6 fatty acid. Linoleic acid level in chicken fat is ranged between 17.8 – 22.9 % (Giriprasad and Goswami, 2013). The effect of linoleic acid towards animal performance is reducing fat accumulation and promoting muscle growth (Gaad et al. 2016).

The composition of fatty acids in coconut oil about 99.9 % which are 91.9 % are saturated fatty acids, 6.4 % are monounsaturated fatty acids and 1.5 % are polyunsaturated fatty acids (Lockyer and Stanner, 2016). Kawsar, Rashid and Ali, (2001) reported that no growth depressing and toxic effect from coconut oil meal in poultry.

In order to increase feed intake by the broiler chickens, the pellet binders are used in feed formulation. High pellet quality is necessary because it can prevent segregation of ingredients. The growth performance of broiler chickens may increase if this broiler feeds pellets because less time eating spends by broilers. The energy that used during feeding also reduced.

The present study aims to determine the optimum amount of rendered chicken oil and coconut oil as a binder in broiler feed and to investigate the effect of rendered chicken oil and coconut oil on the growth rate on broiler chicken.

1.2 Problem Statement

Feed cost is the greatest expenditure in poultry production. The feed cost can influence the affordability of meat or eggs to consumers (Abeysekara, Mawatha and Lanka, 2016). The profitability of poultry enterprise is largely depended on the feed cost. To reduce feed cost, many important unconventional feed ingredients may be included in poultry feed (Kawsar et al. 2001). The alternative way that provides by poultry nutritionist is trying to identify locally available which can make poultry diet cheap, but high in nutrition (Kawsar et al. 2001).

1.3 Objectives

There were two objectives of the research which were:

1. To determine the optimum amount of rendered chicken oil and coconut oil as a binder in grow out broiler feed.
2. To investigate the effect of rendered chicken oil and coconut oil on the growth rate on broiler chicken.

1.4 Scope of Study

Oils are the most important energy source of broiler rations. In order to get the ideal efficiency from chickens, the protein and energy levels of the ration should be high. So, this study conducted a test on the different type of binders in the broiler grow out feeds. The first control used in this study was the vegetable oil (palm oil), and the treatment use the coconut oil and rendered chicken oil. About 206 of broiler chickens at Agro Techno Park, Universiti Malaysia Kelantan (UMK), Jeli Campus were subjected for three weeks feeding trial. The effect of coconut oil and rendered chicken oil as the binder in feed were observed by collecting body weight of the broiler.

1.5 Significance of Study

This study provides information and potential application of coconut oil and rendered chicken oil as feed binders in broiler grow out feed. Outcomes form the present study also revealed the feeding efficiency and growth performance of broiler from the feeding trial.

CHAPTER 2

LITERATURE REVIEW

2.1 Poultry

Poultry can be categorized as birds or domesticated fowl which are raised for meat and eggs (Chiba, 2014). The egg and meat from poultry used as a source of foods for humans. Usually, chickens, ducks, turkeys, and geese are widely used in the production of egg and meat. Poultry meat is an important source because its provide proteins, minerals and vitamins in the human diet (Governments, n.d.). Chicken that reared for meat is called broilers. The poultry industry dominated 80% of the livestock production and have the production approximately 23 billion (Kantarli, Kabadayi, Ucar and Yanik, 2016), ("Food and Agricultural Organization", FAO, 2015a, 2015b). In Malaysia, the demand for broiler meat is higher in the market compared to other livestock (Abdurofi et al. 2017). In order to fulfill the demand for broiler meat, many studies on the genetic selection using different breed of broilers chicken were conducted (Hafez and Hauck, 2005). The genetic selection improves the broilers body weight. The broiler chickens can be slaughtered around six weeks old when reached commercial size which about 2 kg (Hafez and Hauck, 2005).

Broiler chicken (*Gallus gallus domesticus)* needs approximately 14 weeks of age to reach a mature stage. The example breed of broiler chicken are Plymouth rock, Cronish, Sussex, Dorking, Cochin, Brahma, Asil, Star Brow, and Hi-line (Jane, 2017). The demand for broiler meat in Malaysia is high because broiler meat has fewer issues related to multi-ethnic population in Malaysia (Syahirah et al. 2015). For broiler chicken, no religious prohibition exist relative to other meats like beef and pork which are still unacceptable for consumption by specific race or religion of the population (Abdurofi et al. 2017). However, the expensive feed cost is the main problem to the poultry industry, especially to the small scale enterprise. The cost of feed also constraint the poultry production and highly rely on the price trend of the imported feed ingredients (Elsedig et al. 2015; Chanjula and Pattamarakha, 2002). The feed cost in broiler production contributes about 70% to the total variable cost while the day old chicks (DOC) contributes about 22% and the rest like labor, vitamin, and equipment jointly contributes less than 9% (Ravindran, 2013). Thus, to reduce the feed cost, many important unconventional feed ingredients may be included as dietary constituents of poultry feed (Kawsar et al. 2001)**.**

2.1.1 Poultry Nutrition

Poultry needs nutrients that help them grow well and produce their product such as egg and meat. The basic nutrients that need by poultry are water, protein, carbohydrates, fats, minerals and vitamins (Governments, n.d.). All this nutrient must be included in the diet of poultry sufficiently according to their age and breed. Young chicks require a diet rich in protein and certain vitamins with balanced mineral content (Emous, 2016).

The nutritional value in feed for broiler and layer are different. Layer chickens need to provide balanced and nutritious food from the starter phase. Protein, minerals and vitamins play a significant role in producing the desired amount of eggs (Chiba, 2014). According to Ross (2011), broiler chickens required more energy for growth of tissue, maintenance and activity. The ingredients that may provide energy to broiler are a carbohydrate such as corn and wheat, and various fats or oils.

2.2 Coconut oil

Coconut oil is the one of the by product that comes from coconut or scientifically known as *Cocos nucifera*. Edible coconut oil is derived from the mature coconut. According to Lockyer and Stanner (2016), coconut oil is a colorless to brown-yellow edible oil derived from mature coconuts. Standard coconut oil is normally produced by firstly drying the kernel and secondly refining, bleaching and deodorizing the extracted oil (Lockyer and Stanner, 2016). Coconut oil is produced by squeezing and solvent extraction. The composition of fatty acids in coconut oil is about 99.9 %, which are 91.9 % are saturated fatty acids, 6.4 % are monounsaturated fatty acids and 1.5 % are polyunsaturated fatty acids (Public Health England, 2014). Furthermore, coconut oil is a food supplement that had proved safe for human consumption, hence it is assumed to be safe for the chicken (Yuniwarti, Asmara, Artama and Tabbu, 2012). In coconut oil, Yuniwarti et al. (2012) had stated the coconut oil nutritional value which contains 51.23 % lauric acids, 17.13 % myristic acid, 7.30 % palmitic acid, 9.18 caprilic acid, 7.07 % capric acid, 5.42 % oleic acid, 2.17 % stearic acid and 0.51 % caproic acid. The lauric acid present in coconut oil has antiviral, antiprotozoal, and antibacterial properties (Aderolu and Akinremi, 2009). According to Kawsar et al. (2001), coconut oil can be used in the ration of growing chicks as a protein supplement.

2.3 Utilization of the Animal by-product in Animal Feed

Sánchez-muros, Barroso, and Manzano-Agugliaro (2014) indicated that the feed contributed most to the land occupation, primary production use, acidification, climate change, energy use and water dependence.

The demand towards livestock production is increasing as the population of the people increase. Thus, the feed cost plays an important role in producing livestock products. However, according to the Bay-Larsen, Risvoll, Vestrum, and Bjørkhaug (2018), the feed cost for the livestock are increasing as the resources for producing the feed such as the soybean meal and fishmeal have the limited availability. Other factors such as climatic changes and the food-feed-fuel competition also contributed to the increase in the feed cost. Due to this circumstance, another alternative needed for producing the feed with the lower cost and a feature for overcoming this issue is by utilizing the animal by-product as one of the feed components.

Based on the study by Granby and Mortensen (2012), the term "by-product" is defined as the derivative (secondary product) that was produced from the main (primary) product or the discarded product from manufacturing. The examples of the secondary products that had been produced are peels, pulpettes, molasses, whey, mask and oil cakes.

Meanwhile, according to the Hekmatpour, Kochanian, Marammazi, Zakeri, and Mousavi (2018), the term "poultry by-product meal (PBM)" referred to the products that were made from the products that were ground and also the rendered parts of poultry carcasses.

Based on the research conducted by the Martínez-alvarez, Chamorro, and Brenes (2015), the livestock industry had produced a tremendous amount of waste and by-products. The examples of the wastes and the by-products that were generated viscera, meat, fat or lard, skin, feet, abdominal and intestinal contents, bone, feather and blood.

According to the Martínez-alvarez, Chamorro, and Brenes, (2015), the study indicated that the amount of the waste that had been generated was around 33% to 43% (w/w) of the live weight of the animal. Moreover, Jamdar and Harikumar (2005) and Lasekan, Abu Bakar, and Hashim (2013), for the poultry production, specifically in the chicken production, the blood represents 2 to 6% of the birds weight while the feathers consist about 10% of the total weight of the bird.

Meeker (2009), stated that the generation of the animal by-products was approximately 54 billion pounds per year. Due to the massive generation of the animal by-products, those by products must be fully utilized with the effective strategy for avoiding the loss of potential revenue and also lead to the increasing cost for the disposal purpose of the product. The study by Hamilton (2004) also indicated that the rendering industries process approximately 60 million tonnes of animal by-products annually in the global stage.

There are some issues that can be connected to the utilization of the animal by-product as one of the feed components. One of the issues that are lingering around the production of the by-products of the livestock is the threat of the contaminations. Based on the study that had been conducted by Granby and Mortensen (2012), the generation of the livestock by-products may become a threat as it may become one of the contamination sources that may cause health effects in livestock. The by-products may contain contaminants and natural toxins due to the natural occurrence or due to the environmental contaminants, from applications of pesticides, or via the introduction to the products during handling, processing, fractioning, storage or transportation. Due to the composition of the contaminants and the natural toxins, they may be transferred to the animal products such as meat, milk, eggs or organs where the contaminants may accumulate. The possible accumulation of the contaminants and the natural toxins may reside in the liver and kidney. Thus, this may become a hazardous threat to the consumer's health due to the consumption of the products.

However, according to the study conducted by Hekmatpour et al. (2018), the PBM has a major contribution to the growth performance and feed utilization of the animals without any negative effects towards the animals.

2.4 Rendered Chicken Oil

Fats and oils provide the different application in the animal diets. According to Balevi and Coskun (2000), oils are an important energy source of broiler rations. For broiler chicken, adding the oils in the feed will help the chicken attained the optimum productivity because oils can make compensation of energy requirement for broiler (Baião and Lara, 2005). Fats and oils supply the dietary essential fatty acids which are linoleic and linolenic acids that cannot be synthesized by the animal, but necessary for the formation of the cell membrane (Rahman, Akbar, Islam, Iqbal and Assaduzzaman, 2010). The consumption of feed by livestock animal that contains dietary fats and oils aid in the absorption of the fat-soluble vitamins A, D, E, and K (Giriprasad and Goswami, 2013). Digestion of fats and oil is occurring differently depending on species and physiological states (Tomkins and Drackley, 2010).

Animal by products that produce after the slaughter process has been used in animal feeding for many years (Oliveira et al. 2010). There are many animals by product such as blood, skin and abdominal fat tissues. This animal by product can be further process and turn into any various product that had many applications. Processing of the animal by product could add the value to the animal by product (Giriprasad and Goswami, 2013). One example of the product that can be obtained from the animal by product is the rendered oil. Rendered oil is the purified fats from rendering process of animal fatty tissue from various animal food production chains such as meat processing plants, butcher's shops and slaughterhouse (Lin and Tan, 2017). In this process, the utilization of heat will release the fat from the cells of fatty tissues and separate the fat from the other surrounding non-fat matrix. The oil that obtained is separated from the solids by draining and pressing methods.

Chicken fat is high in linoleic acids which is beneficial omega-6 fatty acid (Giriprasad and Goswami, 2013). Linoleic acid level in chicken fat is between 17.8 – 22.9 % (Giriprasad and Goswami, 2013). The effect of linoleic acid towards animal performance is reduced fat accumulation and promoting muscle growth (Gaad et al. 2016). Rendered chicken oil can be used in animal feed production and bio-diesel (Giriprasad and Goswami, 2013). Chicken fat is one type of animal fate referred to as *schmaltz,* while other is goose fat.

CHAPTER 3

MATERIAL AND METHODS

3.1 Experiment set up

The preparation and processing of the feed were carried out at Animal Laboratory and the feeding trial was conducted at the Agro Techno Park in the Universiti Malaysia Kelantan (UMK) Jeli Campus. The experiment was started when broiler chickens reached day 15 aged. At day 15, about 198 broiler chickens were subjected for feeding trials with three different feeds, control (vegetable oil), treatment 1 (coconut oil) and treatment 2 (rendered chicken oil) in triplicate.

3.2 Raw Materials

Raw materials that used to make broiler feed were maize, soybean meal, fish meal, Dicalcium Phosphate (DCP), limestone, antioxidant, premix, rendered chicken oil, palm oil, and coconut oil. The raw materials such as maize, soybean meal, fish meal, Dicalcium Phosphate (DCP), limestone, antioxidant, and premix were bought and was supplied here by Huat Lai Feedmill Sdn. Bhd, while the palm oil was purchased at the market.

3.3 Equipment

Equipment that were used in this experiment were 250 ml measuring cylinder, sealed plastic bag, container, big spatula, weighing scale, animal feed crusher machine, commercial blender, oven, mixer machine, and palletizer machine.

3.4 Methods

3.4.1 Preparation of binder

Rendered chicken oil.

About 2 kg of chicken skin and coconut milk were purchased and collected from wet markets at Kok Lanas. The chicken skin was washed carefully in order to remove unwanted foreign particles such as dirt and soil. To get the rendered chicken oil, the chicken skin was put into the non-sticky pot and cooked over low heat. Next, put some water and stirred the chicken skin until the chicken scraps showed a golden brown colour and crispy. Turn off the heat and let cool for a few minutes. The oil that comes out from chicken skin was filtered using cloth coffee filter into the bottle jar.

Coconut oil.

To get the coconut oil, about 2 kg of coconut milk were cooked over low heat and continuously stirred for about six hours. Then, the heat was turned off and let cool for few minutes. The oil from the coconut milk was filtered with cloth coffee filter into the bottle jar.

3.4.2 Feed formulation using different types of binding.

The feed formulation of broiler at the grower stage was calculated using Microsoft excel word 2016. All the percentage of raw materials were converted into energy value (Kcal). The recommended nutrient for grower broiler was shown in Table 3.1.

Table 3.1: Recommended nutrient level for broiler at the grower stage (Rahman et al. 2010)

Ingredient	**Proportion (%)**	**ME (kcal/kg)**	**CP %**	**Calcium %**	**Lysine**	**Methionine**
Maize	63.2	2110.88	5.688	0.01896	0.17064	0.1264
Soybean	28	596.4	12.6	0.0924	0.7812	0.1764
Fishmeal	3	92.4	1.977	0.126	0.1602	0.0594
DCP	0.3	0	0	0.3	0	0
Limestone	0.8	0	0	0.304	0	0

Lysine	0	0	0	0	0	0
Methionine	0	0	0	0	0	0
Antioxidant	0.1	0	0	0	0	0
Premix	0.6	0	0	0	0	0
Vegetable oil	4	360	0	0	0	0
Total	**100**	**3159.68**	**20.265**	**0.84136**	**1.11204**	**0.3622**

Note: CP= crude protein; ME= metabolize energy; DCP= Dicalcium Phosphate

3.4.3 Feed preparation

Each of the raw materials was weighed according to the result from 3.4.2 which follow the nutrient requirement as in Table 3.1. The maize and soybean were ground using commercial animal feed crusher at the Agro Park. Then, the maize and soybean were ground again using the commercial blender to turn into finest particle size. After the grinding process, 30 kg of ingredients feed were mixed in a mixer (BKE, 130 L). Rendered chicken oil and coconut oil were added separately and mixed thoroughly at the end of the mixing process. Then, feed that was already mixed with oil was put into pelletizer machine to make the pellet. The poultry feed pellet mill that used was 8 mm mold.

3.4.4 Texture profile analysis (TPA)

The texture profile analysis of the feed that were observed were the hardness and springiness. The texture profile of the feed was determined using TPA analyser. About 30 g of broiler grow out feed from control, treatment 1 and treatment 2 were put into 50 ml beaker and was placed on the heavy-duty platform. Then, texture profile analysis was performed using a 10 kg load cell and a 0.5 mm diameter compression. The test condition that set up is pretested speed that applied at 2 mm/s, tested speed 10.00 mm/s and post-tested speed 10 mm/s.

3.5 Feeding trial

The feeding trial was conducted on broiler chickens at the grower stage until the finisher stage. The feeding trial was carried out for 21 days. A total of 198 broiler chicken were separated into three groups. Each experimental group contained 22 broiler chicken with three replicated for each. Vegetable oil as the binder was used as the control treatment while treatment 2 used the coconut oil and treatment 3 used the rendered chicken oil. The feed was given according to the body weight of the broiler chicken two times a day. The broiler chicken weight data were collected weekly. The weight of five broiler chickens from each group were collected randomly.

3.6 Proximate Analysis of Feed Samples

Proximate analysis is a method to determine the quantitative analysis of the different of the macronutrient in the feed. The proximate analysis that was done in this study is to determine the content of dry matter, ash, crude protein and acid detergent fibre. Feed samples that formulated in 3.4.2 were subjected for proximate analysis based on the standard analytical method (AOAC, 1990).

3.6.1 Preparation of Sample for Proximate Analysis

About 600 grams of the pellets from each sample (control, treatment 1, treatment 2) were grind by using the blender. All samples were stored in airtight container at 27ºC.

3.6.2 *Determination of Dry Matter (DM)*

The empty aluminium foils were weighed first by using electronic balance (w1). Then, each samples were weighed approximately 5.0 g (w2). Next, all samples were put into the air oven for drying at 110 ºC for 24 hours (AOAC, 1995). On the next day, dry weight (w3) of the samples was taken to determine dry matter (DM) content and loss of feed samples. The calculation of the dry matter content in the feed was shown as below:

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

Where:

% DM = percentage of dry matter

w1 = Weight of empty aluminium foil

w2 = Weight of approximately 5.0 g sample

w3 = Weight of dried sample

3.6.3 *Determination of Ash Content*

According to the method by Thiex et al., (2012), the empty crucible was weighed (w1). Next, approximately one gram of sample was weighed (w2) and placed it into porcelain crucible. All weight of samples were recorded. Then, the porcelain crucible with containing sample will be placed into the furnace. The sample will be incinerated in the furnace at the 600 ºC for 4 hours. After that, crucibles were taken from the furnace and left it cool before entering them into desiccator for 20 minutes. Lastly, the weight of the crucible was calculated (w3). The following formula was used to determine the total as content in the samples:

$$\% \, Ash = \frac{w3 - w1}{w2} \times 100$$

Where,

% Ash = Percentage of ash

w1 = Weight of the empty crucible

w2 = Weight of the sample approximately 1.0 g

w3 = Weight of the crucible with ash

3.6.4 *Determination of Crude Protein (CP) content*

The determination of crude protein content in the formulated feed was achieved by using the Kjeldahl method. Three parts had undergone for Kjeldahl methods which are digestion, distillation and titration.

For digestion parts, about 1 gram of feed sample was weighed approximately by using analytical balance. To avoid the error in the reading value, the air condition was turned off. Then, the feed sample was put in the digestion tube. 10 ml of distilled water, 2 Kjeldahl tablet and 12 ml sulphuric acid (H_2SO_4) were put into digestion tube. The Kjeldahl flask was digested in digester system about one hour and a half until the solution colour becomes clear. After the digestion process, the sample was cool before proceeding with the next process which is the distillation process.

Next, Kjeldahl distillation system was warm up for ten minutes. About 30 ml of the receiver in a conical flask containing 4% of boric acid, 1 ml of bromocressol green, 0.7 ml of methyl red and 100 ml of distilled water was correlated to the distillation unit.

The sample in the conical flask was titrated with 0.1 ml of hydrochloric acid (HCl) until the green colour change to pink. The titre value of the nitrogen content and crude protein will be calculated by multiplying 6.25. The crude protein was determined as below:

$$\% N = \frac{[(V - V(blank)] \times n \ \times 14.01}{W} \times 100$$

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

where:

V=volume of acid neutralized sample (ml)

n= concentration of HCl

14.01= atomic weight of N

W= weight (g) of sample

3.6.5 *Determination of Crude Fat (CF) content*

The determination of crude fat was started by heating the aluminium cups at 103ºC for 30 minutes and dried in desiccators for 20 minutes. It needs to cool off first, before start determines the crude fat content in the sample. Each sample was weight approximately 1.5 g. Next, the temperature was set accordingly to the suitability of solvent. The petroleum ether was used as the solvent. The proper program from 1-9 was selected and checked the time setting for boiling, rinsing, recovery and pre-drying on the control unit. Then, thimbles were prepared to attach on adapters. The percentage of crude protein was calculated 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

3.7 Statistical analysis

All the data were expressed as the mean ± standard deviation (SD) and were subjected to one-way analysis of variance (ANOVA) and Duncan multiple range test with significance ($p < 0.05$) using the Statistical Package for the Social Sciences (SPSS) Software Program for Windows, version 25.0

CHAPTER 4

RESULT AND DISCUSSION

4.1 The Physical Composition of the Feed

Table 4.1 shows the texture profile of the broiler grow out feed according to the hardness (g) and springiness (mm).

Table 4.1: Texture profile (mean ± standard deviation) of the broiler grow out feed.

Texture composition	Treatment		
	T0	T1	T2
Hardness (g)	85.67 ± 0.58^c	15.67 ± 0.58^a	70.33 ± 0.58^b
Springiness (mm)	0.36 ± 0^a	0.48 ± 0^c	0.46 ± 0.01^b

Note: T0= control; T1= coconut oil; T2= Rendered chicken oil

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

According to table 4.1, the hardness of feed sample for treatment 1 which use coconut oil as binder showed the lowest value from control and treatment 2. According to Plassen, Lekang and Schüller (2007), the physical quality of animal feed pellets is mainly determined by the components added and their treatment during manufacturer.

For example, the moisture content that had in the mash before pelleting. According to Abdollahi, Ravindran, Wester, Ravindran and Thomas (2012), the addition of pellet binder and moisture improved pellet durability and hardness to different degrees compared pellet binder and moisture. Kiran (2018), mentioned that the moisture content that presents in coconut oil depends on the methods of extraction of coconut milk and also on the processing done on it.

The hardness and springiness of pellets on the control, treatment 1 and treatment 2 in table 4.1 showed significance level. The significance level is lower than 0.05. Kenny (2007), reported that grinding, conditioning and procedure to make pellet has an influence on pellet quality. The pellet quality of pelleted feed will vary as the factors of ingredients vary (Chewning, Stark and Brake2018). Each of the ingredients that use to make feed has unique characteristics depends on the factors such as fat content, protein, fiber, starch and moisture. According to Zimonja, Stevnebø and Svihus (2007), stated that the inclusion of fats such as vegetable oil and animal fats in the feed will change the moisture content in the pellet and altered the solubility of protein and gelatinization of the starch in the pellets. Thus, the durability of the pellets will be altered (Zimonja, Stevnebø and Svihus, 2007).

4.2 The Biochemical Composition of the Feed

Table 4.2 shows the chemical composition of 3 samples broiler grow out feed. The control feed consisted of 93.30 ± 0.01% DM, 17.02 ± 0.13% CP, 6.13 ± 0.06% EE and 4.20 ± 0.06% ash. The treatment 1 feed consisted of 89.99 ± 0.03% DM, 21.01 ± 0.09% CP, 6.25 ± 0.05% EE and 5.26 ± 0.07% ash. The treatment 2 feed consisted of 95.12 ± 0% DM, 20.68 ± 0.09% CP, 5.60 ± 0.01% EE and 4.30 ± 0.03% ash.

Table 4.2: Biochemical composition (mean ± standard deviation) of the broiler grow out feed.

Feed sample / Proximate composition	T0 (4% Palm oil)	T 1 (4% Coconut oil)	T 2 (4% Rendered chicken oil)
DM (%)	93.30 ± 0.01[b]	89.99 ± 0.03[a]	95.12 ± 0[c]
CP (%)	17.02 ± 0.13[a]	21.01 ± 0.09[c]	20.68 ± 0.09[b]
CF (%)	6.13 ± 0.06[b]	6.25 ± 0.05[c]	5.60 ± 0.01[a]
Ash (%)	4.20 ± 0.06[a]	5.26 ± 0.07[b]	4.30 ± 0.03[a]

Note: T0= control; T1= treatment 1; T2= treatment 2; DM= dry matter; CP= crude protein; CF= crude fat.

[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.

Pali et al. (2012), stated that quality control of animal feeds is commonly based on chemical analysis for determining the composition of the nutrients contents in the feed. A balanced poultry ration should contain carbohydrate, proteins, fats, minerals and vitamins. Poultry feeds are designed to be complete to provide all the nutrients required for proper growth, egg production and health of birds (Okafor and Ezebuo, 2014).

Based on results, the dry matter for feed sample in control, treatment 1 and treatment 2 showed that significance level. The crude protein and crude fat showed the significance level between control, treatment 1 and treatment 2. Meanwhile, no significance level in ash between control and treatment 2.

Based on Table 4.2, feed sample for treatment 2 had the highest dry matter content followed by control and the lowest dry matter content is treatment 1. Treatment 2 had use rendered chicken oil as binder broiler chicken feeds. The moisture content that has in pellet may affect the value of the dry matter. According to Zhang, Yin and Rui (2013), the incomplete separation of fat and water in the process making the binder might be partially responsible for the high moisture content of these samples.

The result showed that the treatment 1 had the highest crude protein, crude fat and ash. Treatment 2 use coconut oil as the binder in broiler chicken feed. According to Vakili et al. (2015), crude protein is one of the most important nutrients to quantify in a prospective feed because crude protein most costly to supply and a deficiency of protein has a drastic effect on growth and production. The protein that supply in broiler chickens feed can help in replacing lost tissue and growth. Usually, the broiler chickens at grower and finisher stage need less protein than the starter. In this study, the crude protein was the second major and found at the range between 17 % and 22 %. Based on the study by Vakili et al. (2015), the range of crude protein is between 19.9 % and 20.84

%. Since the feed processing involves grinding, combination, and time storage, it may result in partial denaturation of proteins in the feed (Winowiski, 2012).

Most feed ingredients contain enough fat to supply the essential fatty acids to the young chicks because lacks of present fatty acids lead to poor growth and become more susceptible to infection (Okafor and Ezebuo, 2014). In this experimental diets, the crude fat for control is 6.13 % while treatment 1 is 6.25 % and 5.60 % for treatment 2. According to Okafor and Ezabuo (2014), stated that the percentage of crude fat in their study between 6.2 % and 7.0 % respectively, and these consider lower than in commercial feed (7.9 %) for the crude fat level.

The ash content in the feed can relate to the inorganic mineral content such as Ca, P, Na and Mg. In this study, there is no significance level between control and treatment 2. The ash content was found in the range of 4.20-5.26 for broiler at grower stage. According to Vakili et al. (2015), stated that the ash content in their study is in the range between 4.15 and 5.39.

4.3 Weight gain of broiler chicken at grower stage

Table 4.3 shows the body weight gain of broiler chicken between different treatments. The control showed no significant difference ($p > 0.05$) between treatment 1 and treatment 2. Figure 4.1 shows the comparison of body weight gain by broiler chicken at week 3, week 4 and week 5.

Table 4.3: Body weight gain (mean ± standard deviation) of broiler chicken

Week	Treatment		
	T0	T1	T2
3	420.00 ± 9.54[a]	352.53 ± 137.42[a]	399.53 ± 9.74[a]
4	509.20 ± 8.38[a]	444.80 ± 132.06[a]	498.67 ± 9.52[a]
5	623.07 ± 12.23[a]	542.00 ± 127.85[a]	600.93 ± 10.44[a]

Note: T0, control, palm oil; T1, treatment 1, coconut oil; T2, treatment 2, rendered chicken oil

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

The results showed that the significance level of the weight gain of the broiler between control treatment, treatment 1 and treatment 2 for week 3 is 0.596. Meanwhile, the significance level of the weight gain of the broiler between control treatment, treatment 1 and treatment 2 for week 4 is 0.574.

Based on the results, the significance level of the weight gain of the broiler between control treatment, treatment 1 and treatment 2 for week 5 is 0.438. The significance levels between the treatment for week 3 until week 5 are higher than 0.05. Thus, this indicated that the results are not significant.

Based on Table 4.3, the broilers that had been fed with control treatment had the highest weight and highest growth rate followed by treatment 2 and the lowest weight and lowest growth rate is the treatment 1. Treatment 1 is the feed that had been supplemented with 4% coconut oil as the binder. Meanwhile, treatment 2 is the feed that had been supplemented with 4% rendered chicken oil as the binder.

The result showed that there were differences in the weight gain between the treatments. However, this result is not supported by the previous studies. According to Mahmood, Mirza, Nawaz and Shahid (2017), stated that the inclusion of the poultry by-product meal did not have any effects on the performances of the broilers. This may be due to the composition of the feed and also the digestibility and palatability of the feed.

The broilers in all of the treatments have an increment in their body weight. However, the broilers in the control group have the highest weight compared to the treatment 1 and treatment 2. This may be due to several factors such as the pellet binders and also the composition of the feed. The study done by the Classen (2016), stated that the composition of the feed may influence the quality of the feed after being pelleted. Thus, the pellet binders are crucial for minimizing the consequences of the composition of the feed towards the efficiency of the palatability and digestibility of the pelleted diet.

Based on the journal by Vakili et al. (2015), broiler growth and feed efficiency are improved by pelleting feed. Poor quality crumbles or pellets will result in reduced feed intake and poorer biological performance (Chowdhury, Mandal and Patra, 2018).

Based on Abdollahi, Ravindran and Svihus (2013), the performance of the broilers was influenced by the form of the diets. The broilers that were fed with the pelleted diets had grown more rapidly. This may due to the increase in productivity of the flock that is related to the bird behaviour. The energy used was reduced due to the reduction of time for eating and more time was spent on resting (McKinney & Teeter, 2004). Furthermore, according to Classen (2016), the heat and the moisture content in the pelleted diets also contributing to increasing the nutrient digestibility by the broilers.

As reported by Classen (2016), the particle size of the feed affected the digestibility of the feed and also the palatability of feed and the growth of the broilers. The volumetric density of mash feed is lower. Thus, this may lead to the low in nutrient density and this may cause low consumption of the nutrients that needed by the broilers. However, this may be altered by introducing a different level of dietary fat into the feed by pelleting the feed. It also may affect the caloric value of the feed. Thus, this can lead to the full absorption of the dietary energy and may cause an increase in the growth and development of the broilers (McKinney and Teeter, 2004).

According to table 4.3, it showed that the treatment 2 is better than the treatment 1. As reported by Ovaska et al. (2016), the penetration and blending of the fats differ according to their composition, length and saturation of the fatty acids and also the viscosity of the fat. The penetration and blend of the poultry fat are faster than coconut oil (Ovaska and Backfolk, 2013). The efficiency of the penetration and blend of the fat are influenced by the penetration time and the ambient temperature (Esteban, Riba, Baquero, Rius, and Puig, 2012). The other factors that may influence the penetration and the blend of the oil are the size of the unsaturated fatty acid and the number of the double bonds in the oil (Olafsson and Hildingsson, 1995). The surface tension of the poultry fat is also different than the coconut oil (Ovaska and Backfolk, 2013).

The increment of the body weight gain of the broilers also influenced by the chemical composition of the feed. According to the table 4.2, the percentages of the crude protein content of treatment 1 (21.01% ± 0.09^{c}) is higher than treatment 2 (20.68 ± 0.09^{b}) and control treatment (17.02% ± 0.13^{a}). Based on the study by Mahmood, Mirza, Nawaz and Shahid (2017), mentioned that the digestibility of energy and amino acids improve the performance of the broilers.

The young broiler chickens have limited secretion of HCl and endogenous proteolytic enzymes early post-hatch. This occurrence also reported in the study by Yu et. al (2002). The study indicated that the effective digestion and degradation of protein in the gastrointestinal tract of the broilers may be affected by the based on the gastric and pancreatic secretions. Thus, it becomes a constraint for the broilers to fully digest the feed with high protein content and this factor will lead to the lower performance of the broilers. Therefore, the broilers that had been fed by treatment 1 which had the highest crude protein content had lower performance in terms of lower weight gain.

CHAPTER 5

RECOMMENDATION AND CONCLUSION

6.1 Recommendation

From this study, the binder that used in this experiment is not strong enough to bind the feed ingredients. The alternative way is by adding the other binder product in the feed ingredients. The physical quality of the pellet can increase if the other binder is added in the feed ingredients. The pellet of the broiler chicken feed needs to store in airtight container in order to prevent the spoilage. Improper storage can influence the moisture content in the pellet. During making the feed pellets, make sure to observed the temperature in the pelletizer machine because the different temperature can influence the pellet quality. The raw materials need to grind until be in the flour state. The raw materials that grind very well can make the ingredients mixed nicely. The value of fats that add in the feed pellet needs to study further in order to make sure the growth of broiler is suitable for their age.

6.2 Conclusion

In conclusion, the optimum level of the rendered chicken oil and coconut oil is 4 % that can use as the binder in broiler chicken pellet. The use of rendered chicken oil and coconut oil in broiler chicken feed had influenced the growth rate of the broiler chicken. The feed that used coconut oil as binder showed the lowest body weight gain of broiler chicken. Even so, there is no significance level in the result body weight gain of broiler chicken.

REFERENCES

Abdollahi, M. R., Ravindran, V., & Svihus, B. (2013a). Influence of grain type and feed form on performance, apparent metabolisable energy and ileal digestibility of nitrogen, starch, fat, calcium and phosphorus in broiler diets, 193–203.

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

Abdurofi, I., Ismail, M. M., Kamal, H. A. W., & Gabdo, B. H. (2017). Economic analysis of broiler production in Peninsular Malaysia. *International Food Research Journal*, *24*(2), 761–766.

Abeysekara, T. S., Veterinary, G., Office, S., Mawatha, M., & Lanka, S. (2016). Effects of Dietary Coconut Oil Meal with or without an Enzyme Mixture on Laying Performance and physical parameters of eggs of Japanese Quail (Coturnix coturnix), *27*(4), 414–419.

Aderolu, A. Z., & Akinremi, O. A. (2009). Dietary effects of coconut oil and peanut oil in improving biochemical characteristics of clarias gariepinus juvenile. *Turkish Journal of Fisheries and Aquatic Sciences*, *9*(1), 105–110.

Baião, N. C., & Lara, L. J. C. (2005). Oil and fat in broiler nutrition. *Braz J Poultry Sci*, *7*, 129–141. https://doi.org/10.1590/S1516-635X2005000300001

Balevi, T., & Coskun, B. (2000). Effects of some dietary oils on performance and fatty acid composition of eggs in layers *, 847–854.

Brickett, K. E., Dahiya, J. P., Classen, H. L., & Gomis, S. (2007). Influence of dietary nutrient density, feed form, and lighting on growth and meat yield of broiler chickens. *Poultry Science*, 2172–2181.

Chiba, L. I. (2014). Poultry Nutrition and Feeding. *Animal Nutrition Handbook*, *1*(12), 410–425.

Chowdhury, S., Mandal, G. P., & Patra, A. K. (2018). Different essential oils in diets of chickens: 1. Growth performance, nutrient utilisation, nitrogen excretion, carcass traits and chemical composition of meat. *Animal Feed Science and Technology*, *236*, 86–97. https://doi.org/10.1016/j.anifeedsci.2017.12.002

Classen, H. L. (2016). Diet energy and feed intake in chickens. *Animal Feed Science and Technology*. https://doi.org/10.1016/j.anifeedsci.2016.03.004

Emous, R. Van. (2016). Characteristics of broilers, (June), 1–6.

Engberg, R. M., Lauridsen, C., Jensen, S. K., & Jakobsen, K. (1996). Inclusion of Oxidized Vegetable Oil in Broiler Diets. Its Influence on Nutrient Balance and on the Antioxidative Status of Broilers. *Poultry Science*, *75*(8), 1003–1011. https://doi.org/10.3382/ps.0751003

Esteban, B., Riba, J.-R., Baquero, G., Rius, A., & Puig, R. (2012). Temperature dependence ofdensity and viscosity of vegetable oils. *Biomass Bioenergy*, 164–171.

Food and Agricultural Organization. (2015).

Gaad, A. H., Shabir Barham, G., Shah, A. H., Ali Mughal, G., Pirzado, S. A., Khaskheli, G. B., … Soomro, A. A. (2016). Effect of Linoleic Acid Supplimentation on Growth of Broiler. *IOSR Journal of Agriculture and Veterinary Science*, *09*(08), 77–80. https://doi.org/10.9790/2380-0908017780

Giriprasad R, H. S., & Goswami, M. (2013). Animal fat-Processing and Its Quality Control. *Journal of Food Processing & Technology*, *04*(08). https://doi.org/10.4172/2157-7110.1000252

Governments, S. (n.d.). Poultry Broiler Farming 1., 1–8.

Hafez, H. M., & Hauck, R. (2005). Genetic selection in turkeys and broilers and their impact on health conditions. *World Poultry Science Association, 4th European Poultry Genetics Symposium, Dubrownik, Croatia*. Retrieved from http://www.cabi.org/Uploads/animal-science/worlds-poultry-science-association/WPSA-croatia-2005/Hafez.pdf

Kantarli, I. C., Kabadayi, A., Ucar, S., & Yanik, J. (2016). Conversion of poultry wastes into energy feedstocks. *Waste Management*, *56*, 530–539. https://doi.org/10.1016/j.wasman.2016.07.019

Kawsar, M. ., Rashid, M. ., & Ali, M. E. (2001). Replacement of Sesame Oil Meal by Coconut Oil Meal in Diets with or without Fish Meal on the Performance of Laying Hen. *Online Journal of Biological Sciences*, *1*(6), 516–518.

Kenny, M. (2007). Feed Physical Quality, (October).

Lamichhane, S., Sahtout, K., Smillie, J., & Scott, T. A. (2015). Vacuum coating of pelleted feed for broilers : Opportunities and challenges. *Animal Feed Science and Technology*, *200*, 1–7. https://doi.org/10.1016/j.anifeedsci.2014.11.015

Lange, J., Pelletier, C., & Wyser, Y. (2002). Novel method for testing the grease resistanceof pet food packaging. *Packaging Technology Science*, 65–74.

Lin, L., & Tan, F. (2017). Influence of rendering methods on yield and quality of chicken fat recovered from broiler skin, *30*(6), 872–877.

Lockyer, S., & Stanner, S. (2016). Coconut oil - a nutty idea? *Nutrition Bulletin*, *41*(1), 42–54. https://doi.org/10.1111/nbu.12188

McKinney, L. J., & Teeter, R. G. (2004). Predicting effective caloric value of nonnutritive factors: I. Pellet quality and II. Prediction of consequential formulation dead zones. *Poultry Science*, 1165–1174.

Noureddini, H., Teoh, B. C., & Clements, L. D. (1992). Viscosities of vegetable oils and fattyacids, 1189–1191.

Okafor, I. N., & Ezebuo, F. C. (2014). Proximate Analysis and Antinutrient Composition of Poultry Feed Containing Two Replacement Levels of Mucuna pruriens for Soy Bean Meal, *32*(2), 201–206. https://doi.org/10.5829/idosi.wasj.2014.32.02.84301

Olafsson, G., & Hildingsson, I. (1995). Sorption of fatty acids into low-densitypolyethylene and its effects on adhesion with aluminum foil laminatedpackaging material. *Journal of Agriculture of Food Chemistry*, 306–312.

Oliveira, R. P., Ducatti, C., Denadai, J. C., Cruz, V. C., Sartori, J. R., Carrijo, A. S., & Caldara, F. R. (2010). Traceability of poultry offal meal in broiler feeding using isotopic analysis (δ δ 13 C and δ 15 N) of different tissues. *Brasilian Journal of Poultry Science*, *12*, 13–20.

Ovaska, S.-S., & Backfolk, K. (2013). Optimizing grease resistance of dispersion barriercoatings for heterogeneous grease mixtures. In *Proceedings of PTS CoatingSymposium, Munich, Germany* (pp. 412–423).

Ovaska, S.-S., Geydt, P., Österberg, M., Johansson, L.-S., & Backfolk, K. (2015). Heat-inducedchanges in oil and grease resistant hydroxypropylated-starch-based barriercoatings, 488–496.

Ovaska, S., Hiltunen, S., Ernstsson, M., Schuster, E., Altskär, A., & Backfolk, K. (2016). Progress in Organic Coatings Characterization of rapeseed oil / coconut oil mixtures and their penetration into hydroxypropylated-starch-based barrier coatings containing an oleophilic mineral. *Progress in Organic Coatings*, *101*, 569–576. https://doi.org/10.1016/j.porgcoat.2016.10.001

Pali, D., Okanovi, D., Psodorov, D., Džini, N., Lili, S., Zeki, V., & Mili, D. (2012). Prediction of metabolisable energy of poultry feeds by estimating in vitro organic matter digestibility, *11*(28), 7313–7317. https://doi.org/10.5897/AJB11.3335

Plassen, L., Lekang, O., & Schüller, R. B. (2007). Measuring physical quality of pelleted feed by texture profile analysis , a new pellet tester and comparisons to other common measurement devices, *15*.

Rahman, M. S., Akbar, M. A., Islam, K. M. S., Iqbal, A., & Assaduzzaman, M. (2010). Effect of Dietary Inclusion of Palm Oil on Feed Consumption , Growth Performance and Profitability of Broiler, *39*, 176–182.

Skinner-Noble, D. O., McKinney, L. J., & Teeter, R. G. (2005). Predicting effective caloric value of nonnutritive factors: III. Feed form affects broiler performance by modifying behavior patterns. *Pertanika Journal of Tropical Agricultural Science*, 403–411.

Tester, R. F., & Morrison, W. R. (1990). Swelling and gelatinization of cereal starches. I. Effects of amylopectin, amylose, and lipids. *Cereal Chemistry*, 551–557.

Thomas, M., Vliet, T. Van, & Poe, A. F. B. Van Der. (1998). Physical quality of pelleted animal feed 3 . Contribution of feedstuff components, *8401*(97).

Tomkins, T., & Drackley, J. K. (2010). Applications of palm oil in animal nutrition. *Journal of Oil Palm Research*, *22*(DECEMBER), 835–845.

Vakili, R., Torshizi, M. E., Yaghobzadeh, M. M., & Khadivi, H. (2015). Determination of Chemical Composition and Physical Feed Quality with Different Processing Parameters in Broiler Feed Mill Factories, *7*(1), 1098–1103.

Yuniwarti, E. Y. W., Asmara, W., Artama, W. T., & Tabbu, C. R. (2012). Virgin Coconut Oil Increases the Productivity of Broiler Chicken Post Avian Influenza Vaccination, *14*(September), 192–198.

Zimonja, O., Stevnebø, A., & Svihus, B. (2007). Nutritional value of diets for broiler chickens as affected by fat source, amylose level and diet processing. *Journal Animal Science*, 553–562.

APPENDIX A

Table A.1: Texture profile of the broiler grow out feed

Descriptives

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean Lower Bound	95% Confidence Interval for Mean Upper Bound	Minimum	Maximum	Between-Component Variance
hardness 1	Control	3	85.6667	.57735	.33333	84.2324	87.1009	85.00	86.00	
	Coco.Oil	3	15.6667	.57735	.33333	14.2324	17.1009	15.00	16.00	
	Ren.Chic.Oil	3	70.3333	.57735	.33333	68.8991	71.7676	70.00	71.00	
	Total	9	57.2222	31.86996	10.62332	32.7248	81.7196	15.00	86.00	
	Model Fixed Effects			.57735	.19245	56.7513	57.6931			
	Model Random Effects				21.24403	-34.1834	148.6279			1353.81481
hardness 2	Control	3	43.6667	.57735	.33333	42.2324	45.1009	43.00	44.00	
	Coco.Oil	3	6.6667	.57735	.33333	5.2324	8.1009	6.00	7.00	
	Ren.Chic.Oil	3	20.3333	.57735	.33333	18.8991	21.7676	20.00	21.00	
	Total	9	23.5556	16.21042	5.40347	11.0951	36.0160	6.00	44.00	
	Model Fixed Effects			.57735	.19245	23.0846	24.0265			
	Model Random Effects				10.80181	-22.9209	70.0320			349.92593
springiness	Control	3	.3600	.00000	.00000	.3600	.3600	.36	.36	
	Coco.Oil	3	.4800	.00000	.00000	.4800	.4800	.48	.48	
	Ren.Chic.Oil	3	.4633	.00577	.00333	.4490	.4777	.46	.47	
	Total	9	.4344	.05637	.01879	.3911	.4778	.36	.48	
	Model Fixed Effects			.00333	.00111	.4317	.4372			
	Model Random Effects				.03753	.2730	.5959			.00422

Test of Homogeneity of Variances

		Levene Statistic	df1	df2	Sig.
Hardness1	Based on Mean	.000	2	6	1.000
	Based on Median	.000	2	6	1.000
	Based on Median and with adjusted df	.000	2	6.000	1.000
	Based on trimmed mean	.000	2	6	1.000
Hardness2	Based on Mean	.000	2	6	1.000
	Based on Median	.000	2	6	1.000
	Based on Median and with adjusted df	.000	2	6.000	1.000
	Based on trimmed mean	.000	2	6	1.000
Springiness	Based on Mean	16.000	2	6	.004
	Based on Median	1.000	2	6	.422
	Based on Median and with adjusted df	1.000	2	2.000	.500
	Based on trimmed mean	12.603	2	6	.007

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Hardness1	Between Groups	8123.556	2	4061.778	12185.333	.000
	Within Groups	2.000	6	.333		
	Total	8125.556	8			
Hardness2	Between Groups	2100.222	2	1050.111	3150.333	.000
	Within Groups	2.000	6	.333		
	Total	2102.222	8			
Springiness	Between Groups	.025	2	.013	1141.000	.000
	Within Groups	.000	6	.000		
	Total	.025	8			

Robust Tests of Equality of Means[b]

		Statistic[a]	df1	df2	Sig.
Hardness1	Welch	10444.571	2	4.000	.000
	Brown-Forsythe	12185.333	2	6.000	.000
Hardness2	Welch	2700.286	2	4.000	.000
	Brown-Forsythe	3150.333	2	6.000	.000
Springiness	Welch	.	.	.	.
	Brown-Forsythe	.	.	.	.

a. Asymptotically F distributed.

b. Robust tests of equality of means cannot be performed for springiness because at least one group has 0 variance.

Post Hoc Test

Homogenous Subset

Hardness1

Duncan[a]

Sample	N	Subset for alpha = 0.05		
		1	2	3
Coco.Oil	3	15.6667		
Ren.Chic.Oil	3		70.3333	
Control	3			85.6667
Sig.		1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

Hardness2

Duncan[a]

Sample	N	Subset for alpha = 0.05		
		1	2	3
Coco.Oil	3	6.6667		
Ren.Chic.Oil	3		20.3333	
Control	3			43.6667
Sig.		1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

Springiness

Duncan[a]

Sample	N	Subset for alpha = 0.05		
		1	2	3
Control	3	.3600		
Ren.Chic.Oil	3		.4633	
Coco.Oil	3			.4800
Sig.		1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

Table A.2: Chemical composition of the broiler grow out feed

Descriptives

			N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean Lower Bound	95% Confidence Interval for Mean Upper Bound	Minimum	Maximum	Between-Component Variance
DM	Control		3	93.3033	.00577	.00333	93.2890	93.3177	93.30	93.31	
	Coco.Oil		3	89.9900	.02646	.01528	89.9243	90.0557	89.96	90.01	
	Ren.Chic.Oil		3	95.1200	.00000	.00000	95.1200	95.1200	95.12	95.12	
	Total		9	92.8044	2.25269	.75090	91.0729	94.5360	89.96	95.12	
	Model	Fixed Effects			.01563	.00521	92.7917	92.8172			
		Random Effects				1.50176	86.3429	99.2660			6.76581
Ash	Control		3	4.2033	.05508	.03180	4.0665	4.3401	4.15	4.26	
	Coco.Oil		3	5.2600	.07211	.04163	5.0809	5.4391	5.20	5.34	
	Ren.Chic.Oil		3	4.3033	.02517	.01453	4.2408	4.3658	4.28	4.33	
	Total		9	4.5889	.50738	.16913	4.1989	4.9789	4.15	5.34	
	Model	Fixed Effects			.05437	.01812	4.5445	4.6332			
		Random Effects				.33679	3.1398	6.0380			.33931
CP	Control		3	17.0200	.12767	.07371	16.7028	17.3372	16.88	17.13	
	Coco.Oil		3	21.0067	.09452	.05457	20.7719	21.2415	20.90	21.08	
	Ren.Chic.Oil		3	20.6833	.09074	.05239	20.4579	20.9087	20.60	20.78	
	Total		9	19.5700	1.91980	.63993	18.0943	21.0457	16.88	21.08	
	Model	Fixed Effects			.10562	.03521	19.4839	19.6561			
		Random Effects				1.27841	14.0694	25.0706			4.89929
EE	Control		3	6.1333	.05774	.03333	5.9899	6.2768	6.10	6.20	
	Coco.Oil		3	6.2467	.05033	.02906	6.1216	6.3717	6.20	6.30	
	Ren.Chic.Oil		3	5.6033	.00577	.00333	5.5890	5.6177	5.60	5.61	
	Total		9	5.9944	.29988	.09996	5.7639	6.2250	5.60	6.30	
	Model	Fixed Effects			.04435	.01478	5.9583	6.0306			
		Random Effects				.19827	5.1413	6.8475			.11728

Test of Homogeneity of Variances

		Levene Statistic	df1	df2	Sig.
DM	Based on Mean	9.571	2	6	.014
	Based on Median	1.500	2	6	.296
	Based on Median and with adjusted df	1.500	2	2.306	.383
	Based on trimmed mean	8.398	2	6	.018
Ash	Based on Mean	1.440	2	6	.308
	Based on Median	.553	2	6	.602
	Based on Median and with adjusted df	.553	2	3.830	.615
	Based on trimmed mean	1.367	2	6	.324
CP	Based on Mean	.313	2	6	.743
	Based on Median	.105	2	6	.902
	Based on Median and with adjusted df	.105	2	5.424	.902
	Based on trimmed mean	.293	2	6	.756
EE	Based on Mean	3.927	2	6	.081
	Based on Median	.628	2	6	.565
	Based on Median and with adjusted df	.628	2	3.086	.590
	Based on trimmed mean	3.494	2	6	.099

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
DM	Between Groups	40.595	2	20.298	83035.955	.000
	Within Groups	.001	6	.000		
	Total	40.597	8			
Ash	Between Groups	2.042	2	1.021	345.410	.000
	Within Groups	.018	6	.003		
	Total	2.059	8			
CP	Between Groups	29.418	2	14.709	1318.539	.000
	Within Groups	.067	6	.011		
	Total	29.485	8			
EE	Between Groups	.708	2	.354	179.904	.000
	Within Groups	.012	6	.002		
	Total	.719	8			

Robust Tests of Equality of Means[b]

		Statistic[a]	df1	df2	Sig.
DM	Welch	.	.	.	.
	Brown-Forsythe	.	.	.	.
Ash	Welch	210.604	2	3.338	.000
	Brown-Forsythe	345.410	2	4.291	.000
CP	Welch	916.156	2	3.929	.000
	Brown-Forsythe	1318.539	2	5.420	.000
EE	Welch	291.803	2	2.727	.001
	Brown-Forsythe	179.904	2	3.971	.000

a. Asymptotically F distributed.

b. Robust tests of equality of means cannot be performed for DM because at least one group has 0 variance.

Post Hoc Test

Homogenous Subset

DM

Duncan[a]

		Subset for alpha = 0.05		
Sample	N	1	2	3
Coco.Oil	3	89.9900		
Control	3		93.3033	
Ren.Chic.Oil	3			95.1200
Sig.		1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

Ash

Duncan[a]

		Subset for alpha = 0.05	
Sample	N	1	2
Control	3	4.2033	
Ren.Chic.Oil	3	4.3033	
Coco.Oil	3		5.2600
Sig.		.065	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

CP

Duncan[a]

sample	N	Subset for alpha = 0.05		
		1	2	3
control	3	17.0200		
ren.chic.oil	3		20.6833	
coco.oil	3			21.0067
Sig.		1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

EE

Duncan[a]

sample	N	Subset for alpha = 0.05		
		1	2	3
ren.chic.oil	3	5.6033		
control	3		6.1333	
coco.oil	3			6.2467
Sig.		1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

Table A.3: Weight gain of broiler chicken at grower stage

Descriptives

			N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum	Between-Component Variance
							Lower Bound	Upper Bound			
Week3	Control		3	420.0000	9.53939	5.50757	396.3028	443.6972	410.00	429.00	
	Treatment 1		3	352.5333	137.42115	79.34014	11.1603	693.9064	194.40	443.00	
	Treatment 2		3	399.5333	9.73516	5.62060	375.3499	423.7168	389.00	408.20	
	Total		9	390.6889	75.26647	25.08882	332.8340	448.5438	194.40	443.00	
	Model	Fixed Effects			79.72943	26.57648	325.6586	455.7192			
		Random Effects				26.57648[a]	276.3395[a]	505.0382[a]			-922.32148
Week4	Control		3	509.2000	8.38093	4.83873	488.3806	530.0194	500.00	516.40	
	Treatment 1		3	444.8000	132.06241	76.24627	116.7388	772.8612	292.40	525.60	
	Treatment 2		3	498.6667	9.51910	5.49586	475.0199	522.3134	488.40	507.20	
	Total		9	484.2222	72.76898	24.25633	428.2870	540.1574	292.40	525.60	
	Model	Fixed Effects			76.59707	25.53236	421.7468	546.6976			
		Random Effects				25.53236[a]	374.3654[a]	594.0791[a]			-762.38222
Week5	Control		3	623.0667	12.23165	7.06195	592.6816	653.4518	609.00	631.20	
	Treatment 1		3	542.0000	127.84788	73.81301	224.4083	859.5917	394.40	618.20	
	Treatment 2		3	600.9333	10.44095	6.02808	574.9966	626.8701	590.00	610.80	
	Total		9	588.6667	73.94444	24.64815	531.8279	645.5054	394.40	631.20	
	Model	Fixed Effects			74.39468	24.79823	527.9876	649.3457			
		Random Effects				24.79823[a]	481.9685[a]	695.3648[a]			-89.05185

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

Test of Homogeneity of Variances

		Levene Statistic	df1	df2	Sig.
Week3	Based on Mean	12.906	2	6	.007
	Based on Median	1.131	2	6	.383
	Based on Median and with adjusted df	1.131	2	2.018	.468
	Based on trimmed mean	10.628	2	6	.011
Week4	Based on Mean	13.632	2	6	.006
	Based on Median	.960	2	6	.435
	Based on Median and with adjusted df	.960	2	2.017	.509
	Based on trimmed mean	10.924	2	6	.010
Week5	Based on Mean	13.031	2	6	.007
	Based on Median	.863	2	6	.468
	Based on Median and with adjusted df	.863	2	2.041	.535
	Based on trimmed mean	10.367	2	6	.011

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Week3	Between Groups	7179.636	2	3589.818	.565	.596
	Within Groups	38140.693	6	6356.782		
	Total	45320.329	8			
Week4	Between Groups	7159.929	2	3579.964	.610	.574
	Within Groups	35202.667	6	5867.111		
	Total	42362.596	8			
Week5	Between Groups	10534.827	2	5267.413	.952	.438
	Within Groups	33207.413	6	5534.569		
	Total	43742.240	8			

Robust Tests of Equality of Means

		Statistic[a]	df1	df2	Sig.
Week3	Welch	3.069	2	3.561	.168
	Brown-Forsythe	.565	2	2.039	.638
Week4	Welch	1.129	2	3.542	.418
	Brown-Forsythe	.610	2	2.037	.620
Week5	Welch	2.749	2	3.536	.190
	Brown-Forsythe	.952	2	2.064	.509

a. Asymptotically F distributed.

Post Hoc Test

Homogenous Subsets

Week3

Duncan[a]

Treatment	N	Subset for alpha = 0.05 1
Treatment 1	3	352.5333
Treatment 2	3	399.5333
Control	3	420.0000
Sig.		.354

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

Week4

Duncan[a]

Treatment	N	Subset for alpha = 0.05 1
Treatment 1	3	444.8000
Treatment 2	3	498.6667
Control	3	509.2000
Sig.		.357

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

Week5

Duncan[a]

Treatment	N	Subset for alpha = 0.05
		1
Treatment 1	3	542.0000
Treatment 2	3	600.9333
Control	3	623.0667
Sig.		.244

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

APPENDIX B

B.1: Rendered chicken oil

B.2: Coconut oil

B.3: Raw ingredient

B.4: Soybean meal

B.5: Texture analyzer