# THE MIXING OF SOLID WASTE FROM PALM ACID OIL (PAO) AND PALM KERNEL CAKE (PKC) AS A SOURCE OF ANIMAL FEED (FREE RANGE CHICKEN)

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ALI ZAINAL-ABIDIN BIN MOHAMAD TERMIZI

Thesis submitted in fulfillment of the requirements.
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# ABSTRAK

Hari ini, pengurusan sisa dan sampah telah menimbulkan banyak isu yang mendesak. Pengurusan sisa adalah kawasan penting yang berkaitan dengan status ekonomi sesebuah negara dan gaya hidup penduduknya. Pencemaran air sisa dari pengeluaran minyak sawit yang tinggi mengakibatkan pengeluaran efluen kilang kelapa sawit (POME) yang tinggi adalah masalah utama di seluruh dunia. Kajian ini adalah untuk menganalisis ciri-ciri sisa minyak sawit dalam membuat makanan ayam yang dirumus. Oleh itu, kajian ini juga memberi tumpuan kepada pengeluaran perumusan makanan ayam dengan campuran minyak asid sawit dan kek kernel sawit. Kajian ini juga untuk menyiasat kadar pertumbuhan ayam ke arah perumusan makanan ayam. Dalam eksperimen, Ayam kampung digunakan dan dibahagikan kepada 2 kumpulan ayam dengan formulasi yang berbeza iaitu Diet 1 (D1) dan Diet 2 (D2). Setiap diet mengandungi nutrien dan komposisi yang berbeza. Ayam diberi makan dengan formulasi secara berterusan selama 5 bulan. Parameter yang akan dianalisis ialah perubahan berat badan (BWC). Hasil yang diperoleh dari Diet 2 (D2) dicatat dan dibandingkan dengan Diet 1 (D1) yang merupakan diet kawalan.

# ABSTRACT

Today, waste and waste management has given rise to many pressing issues. Waste management is a crucial area related to the economic status of a country and the lifestyle of its population. Wastewater pollution from high production of palm oil results in high production of palm oil mill effluent (POME) is a main problem throughout the world. This study is to analyse palm oil waste characteristics in making of the formulated chicken feed. Therefore, this study also focuses on the chicken feed formulation production by the mixture of palm acid oil and palm kernel cake. This study also to investigate the growth rate of chicken towards the formulation of the chicken feed. In experiment, free-range chickens were used and divided into 2 groups of chickens with different formulation which are Diet 1 (D1) and Diet 2 (D2). Each diet contains different nutrient and composition. The chicken was fed with the formulation continuously for 5 months. The parameters to be analyse were body weight change (BWC). The result obtained from Diet 2 (D2) was recorded and compared with Diet 1 (D1) which are control diet.

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| | |
|---|---|
| ± | Plus Minus |

# LIST OF ABBREVIATIONS

| | |
|---|---|
| BOD | Biochemical Oxygen Demand |
| CaCO3 | Calcium Carbonate |
| CF | Crude Fibre |
| CFD | Commercial Feed Diet |
| cm | Centimetre |
| COD | Chemical Oxygen Demand |
| CP | Crude Protein |
| DM | Dry Matter |
| DOE | Department of Environment |
| EE | Ether Extract |
| EFB | Empty Fruit Brunch |
| FFA | Free Fatty Acid |
| FFB | Fresh Fruit Brunch |
| FFD | Formulated Feed Diet |
| GIT | Gastrointestinal tract |
| kg | Kilogram |
| NSPs | Non-starch polysaccharides |
| OPF | Oil Palm Frond |
| PAO | Palm Acid Oil |
| PKC | Palm Kernel Cake |
| PKS | Palm Kernel Shell |
| POME | Palm Oil Mill Effluent |
| POS | Palm Oil Sludge |
| SBM | Soybean meal |
| SSF | Solid State Fermentation |
| SWM | Solid Waste Management |

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# CHAPTER 1

# INTRODUCTION

## 1.1 Background of Study

Every year, agricultural-based industries generate a large number of residues. If these residues are released into the environment without being properly disposed of, they can pollute the environment and damage human and animal health. Since the majority of agro-industrial wastes are untreated and underutilised, they are usually disposed of by burning, dumping, or unplanned landfilling. These untreated wastes contribute to climate change by increasing the amount of greenhouse gases released (Sadh et al., 2018). Agro-industrial waste has a huge potential for producing renewable goods and bioenergy. The majority of the residues generated are destined for landfill or are disposed of in an unregulated manner, resulting in environmental and economic harm (Beltran-Ramirez et al., 2019). With insufficient landfill space and increasing disposal costs, there is a greater need to address the waste management problem and reduce the effects on the environment and the general well-being of the population (MIDA, 2019).

In general, one of the abundant agricultural wastes is from palm oil industry. Palm oil is commonly used as a food ingredient or as a feedstock for the pharmaceutical, oleochemical, and biodiesel industries due to its high oil yield. Indonesia (43 Metric tons), Malaysia (21 Metric tons), and Thailand (3 Metric tons) have emerged as the top three crude palm oil producers in Southeast Asia, thanks to a tropical rainforest climate and favourable agricultural policies. Palm oil extraction produces a large amount of biomass wastes during wet milling, including empty fruit bunches, palm kernel shells, palm mesocarp fibres, palm sludge cake, palm oil fuel ash, and palm oil mill effluent (POME)(Cheng et al., 2021). Malaysia's palm oil industry has risen significantly in recent years to become one of the world's largest exporters and producers, contributing significantly to the country's economic growth and development. The palm oil industry's steady growth and enthralling demand in this area has resulted in it being recognised as a key commodity and a major opportunity for agribusinesses. However, as a result of the development of undesirable waste, especially palm oil mill effluent (POME) from the extraction of crude palm oil, the increase is accompanied by negative environmental pollution. As demand for palm oil grows in the coming years as it gains global acceptance as a food source and an important feedstock for the chemical industry, it is critical for the industry to recognise and explore long-term solutions to address and address environmental issues, ensuring a sustainable and profitable industry (Lek et al., 2018).

Poultry production in rural areas is extremely significant in developing countries as a major source of animal protein for the rural population (Zidane et al., 2018). Due to shortages caused by human and livestock competition for traditional foodstuffs, there has been a substantial global rise in the last decade. It is critical to incorporate cheaper and more readily available alternative feedstuffs into livestock diets in order to maintain optimum laying hen efficiency and egg productivity at the lowest cost (Saminathan et al., 2020). In recent years, the need for healthy foods has had a significant impact on meat consumer eating habits; as a result, a growing number of consumers are now more interested in consuming free-range poultry products, despite their sensory and nutritional quality. However, as compared to commercial strains, indigenous chickens have a slower growth rate, which can play a significant role in the differentiation of chemical and physical properties of their meat (Zidane et al., 2018). Although the efficiency of scavenging chickens may be improved by modifying management systems and increasing the amount and quality of food provided, (Zidane et al., 2018)found that these chickens are likely to react differently when exposed to different management and feeding systems. Therefore, one of the approaches to solve the waste management problem regarding palm oil industry wastes is by converting the palm oil industry waste into value added product such as chicken feed. As a result, the availability of nutritious, balanced, and suitable complementary foods can increase meat growth and quality (Zidane et al., 2018).

## 1.2 Problem Statement

The problem face while conducting this study is abundant of underutilized palm oil industry waste. The approach to solve this problem is by utilizing the waste from palm oil industry to manufacture chicken feed. The wastes that are used in this study from the palm oil industry are palm kernel cake (PKC) and palm acid oil (PAO). The reason for the usage of palm kernel cake is because of the contain high energy source, high quality protein and balanced material content (Feed, n.d.). The palm acid oil contain free fatty acid, low peroxide value and reasonable amount of unsaturated fatty acid (CDR Food Lab, 2020). By the manufacturing of the chicken feed, the PKC and PAO can be utilized and not become waste that being dump into the landfill as solution waste management problem.

Based on data published by R. Hirschmann . In 2020, the poultry consumption per capita in Malaysia was approximately 49.3 kilograms. In 2025, this was forecasted to reach around 51.28 kilograms per capita. Malaysia's poultry meat consumption in 2019 was above the OECD average of that year. This shows a high demand on poultry to meet market need. To cater the increase in poultry production in the country, the alternative resource from the local industry is needed to reduce the dependency to the imported chicken feed. The PKC are reliable resource as palm oil industry is one of Malaysia’s main exports. This can help replace the initial chicken feed to chicken feed made from the PKC as the current chicken feed contain corn that been imported from other countries. By manufacturing the chicken feed, the country can improve the economy.

## 1.3 Research Objectives

In general, this study aims:

i. To analyse palm oil waste characteristics in making of the formulated chicken feed.
ii. To produce chicken feed formulation by the mixture of palm acid oil and palm kernel cake.
iii. To investigate the growth rate of chicken towards the formulation of the chicken feed.

## 1.4 Scope of Study

In this research, the parameter to analyse the composition of palm oil waste are free fatty acid, moisture content, impurities and peroxide value. This parameter needs to be analysed to ensure the formulated chicken feed are meeting the requirement for the chicken to grow healthily and safe to consume. The optimum value of the parameter is essential for reducing the side effect

In this research, the parameter to produce the formulated chicken feed are temperature, time consumption for mixing the ingredients and cooling of chicken feed. The temperature used for the machine increase the palatability of the chicken feed is 160°C. The time for the ingredient to be mixed in the mixer is around 10-15 minutes. The chicken feed was cooled at the cooler by conveyor belt before it goes to the packaging silo.

In this research, six free-range chicks are used and divided into two groups (A and B) which different feeds; A is chicken feed which are already sold in market; B is formulation based on mixing of the palm acid oil and palm kernel cake. The chicks are used in this experiment as to compare the growth rate of each chicken feed (A and B). Each chick is weighed once a week until the $8^{th}$ week (the age of adult). The chickens are fed the formulated palm acid oil (PAO) and palm kernel cake (PKC) feed continuously for 2 months. In this study, two diets were used (D1 and D2) to be compared. Six chicks were fed with the feed (two chicks each diet feed). Each diet feed contains different composition and nutrient. The sample produced have the nutrition needed by the chicks for growth and have a potential to become an animal feed. The parameter in the study to be analyse are growth rate (body size and mass of the chicken). The result obtained were recorded and compared to each other (D1 and D2) chicken.

## 1.5 Significant of Study

The significance for this study is for the country. As the production in the poultry industry is increasing the alternative for the chicken feed obviously will cater to the needs of chicken feed and reduce the imported chicken feed dependency. This will reduce the cost for the poultry industry to buy chicken feed from other countries. Then, this study can contribute to the community, which is the need for the worker in the palm oil industry sector and the chicken feed manufacturing sector. This creates a new job opportunity for the community near the palm oil plantation that will thrive the poultry industry in the country. In the economic perspective, this study will help increase Malaysia's income because the optimum use of waste in palm oil industry. The PKC and PAO utilization can produce a chicken feed more or less the same chicken feed with corn. So, the excess production for this chicken feed can be sold to other country for improving Malaysia's economy.

# CHAPTER 2

# LITERATURE REVIEW

## 2.1 Solid Waste Management

Solid waste management (SWM) is becoming a serious concern in worldwide development plans, particularly in cities that are rapidly expanding. Malaysia is regarded as one of the most successful transitional countries in the world. Malaysia's most important environmental concern is solid waste management, with landfilling serving as the principal disposal technique for the country's annual growth in solid waste creation (Moh & Abd Manaf, 2017). If Malaysians' attitudes and behaviours toward waste management do not change, solid waste creation would unavoidably rise as a result of rising living standards. Despite the existence of alternative ways for processing and reducing solid waste, the future of solid waste management is uncertain. Given the world's ever-increasing population, it's unsurprising that arable land is becoming increasingly scarce. Typical solid waste management firms had to contend with improper collection services (such as low collection coverage, inconsistent collection schedules), illegal dumping, and scavenging activities (Moh & Abd Manaf, 2017).

### 2.1.1 Agro-Industrial Waste

Agricultural-based companies produce a large number of residues every year (Sadh et al., 2018). If these residues are not properly disposed of, they may pollute the environment and have a harmful influence on human and animal health. Although the residues exist in large quantities, they have such a high nutritional potential that they are being considered as agro-industrial by-products during quality control (Sadh et al., 2018). Malaysia's climate is categorised as hot, wet, and rainy throughout the year due to its proximity to the equator and proximity to the sea. Due to its high temperature and humidity paired with rain, Malaysia is perfect for agricultural operations such as plantation, fruits, vegetables, and other crops (Neh & Ali, 2020).


Figure 2.1 Percentage share by kind of economic activity.
Sources: Department of Statistics Malaysia (2020)

In Malaysia, agriculture is a big sector. This industry has long been the backbone of the Malaysian economy, generating agricultural products for domestic consumption while also earning foreign currency (Neh & Ali, 2020). According to estimates from the Malaysian Department of Statistics, the agriculture sector contributed 7.1 percent (RM101.5 billion) to the country's Gross Domestic Product in 2019. (GDP). Oil palm accounted for 37.7% of the agricultural sector's value added, with other agriculture (25.9%), livestock (15.3%), fishery (12.0%), forestry and logging (6.3%), and rubber (3.0%) following (Dato' Sri Dr. Mohd Uzir Mahidin, 2020). Agriculture exports increased by 0.9 percent to RM115.5 billion in 2019, up from RM114.5 billion in 2018.

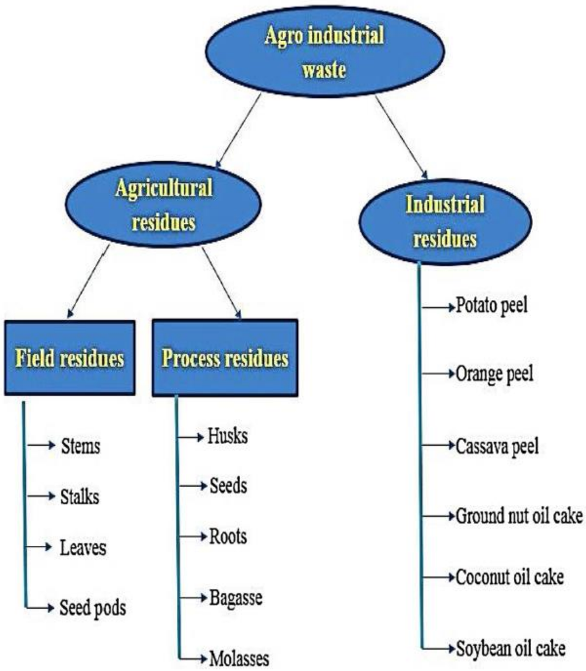



Figure 2.2 Agro-industrial wastes and their types.
Source: (Sadh et al., 2018)

There are two different types of agro-industrial wastes which are agriculture residues and industrial residues as shown in Figure 2.2. Field residues and process residues are two types of agriculture residues. Field residues are leftovers from the crop harvesting process that remain in the field (Sadh et al., 2018). Leaves, stalks, seed pods, and stems are among the field waste, whereas process waste are those that remain after the crop has been processed into a different valuable resource. Molasses, husks, bagasse, seeds, leaves, stem, straw, stalk, shell, pulp, stubble, peel, roots, and other residues are used in animal feed, soil improvement, fertilisers, manufacturing, and other processes (Sadh et al., 2018). Field residues are produced in large quantities, with the majority of them going unused.

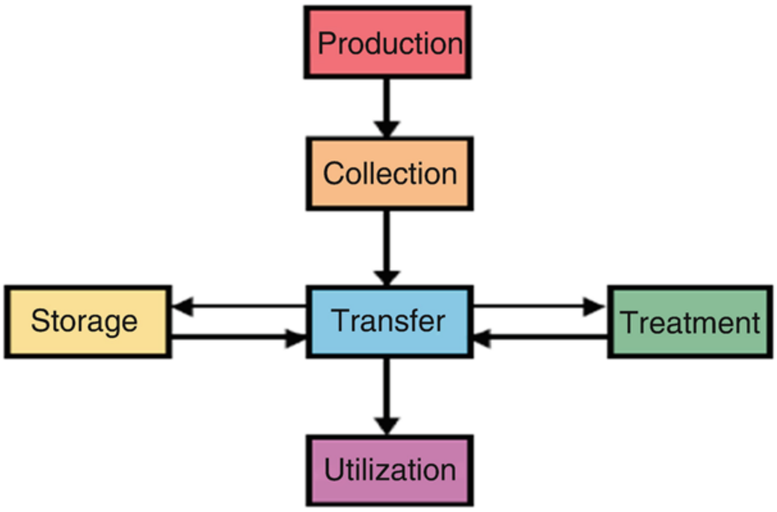



Figure 2.3 Agricultural waste management functions.
Sources: (Obi et al., 2016)

Figure 2.3 shows the concept of waste minimization, which reduces the quantity and negative effects of waste generation by reducing the quantity of wastes, reusing waste products with simple treatments, and recycling wastes by using them as resources to produce the same or modified products (Obi et al., 2016). Some waste products can be used as resources in the manufacture of other goods or the same product. The waste reduction principle aims to achieve efficient waste generation minimization by choosing to use items with care to reduce the amount of waste generated, repeated use of items or parts of items that still have usable aspects, and the use of waste itself as a resource (Obi et al., 2016).

## 2.2 Palm Oil Industry in Malaysia

Palm oil is the world's most traded vegetable oil. The increase in domestic oilseed supplies in the top buyer, India, as well as increased demand in Europe and China, is driving up demand for palm oil(Abdul-Hamid et al., 2020). With rising consumer income and population growth, demand for it is expected to rise further(Choong & McKay, 2014). Recently, the palm oil industry has faced a major crisis as a result of the oil palm sustainability inquiry, which involves the palm oil sector's negative contributions to the environment. Environmental activists have long criticised the palm oil industry from both an environmental and a social standpoint (Tan

& Lim, 2019). Another source of criticism is the massive waste generation associated with current palm oil industry practises, such as liquid palm oil mill effluent (POME), solid residues in the form of biomass, and green house gaseous(GHG) emissions(Tan & Lim, 2019).

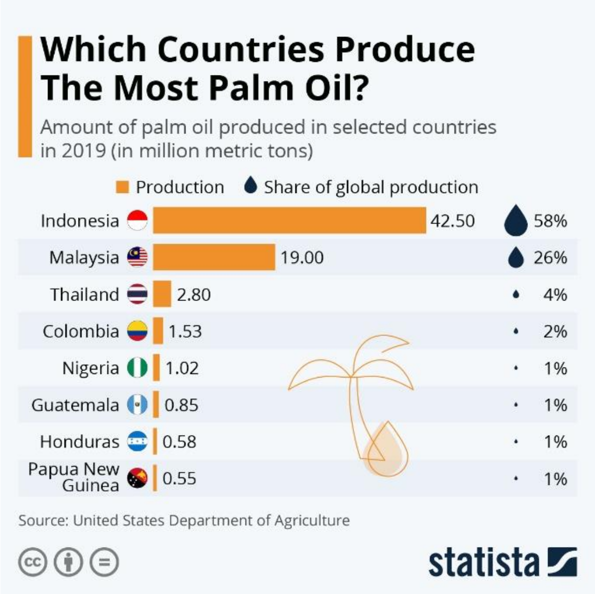



Figure 2.4 Amount of palm oil produces in selected countries in 2019.
Source:(McCarthy, 2020)

Malaysia produces about quarter of world palm oil production making Malaysia the second largest producer and exporter of palm oil in the world after Indonesia. Palm oil production has increased significantly over the last five decades as a result of its versatility and resilience (McCarthy, 2020). Palm oil is grown in tropical rainforests, its rises has had disastrous environmental consequences. This has resulted in widespread and uncontrolled deforestation, destroying the habitat of several endangered species such as the orangutan, Sumatran tiger, and Sumatran rhino (McCarthy, 2020).

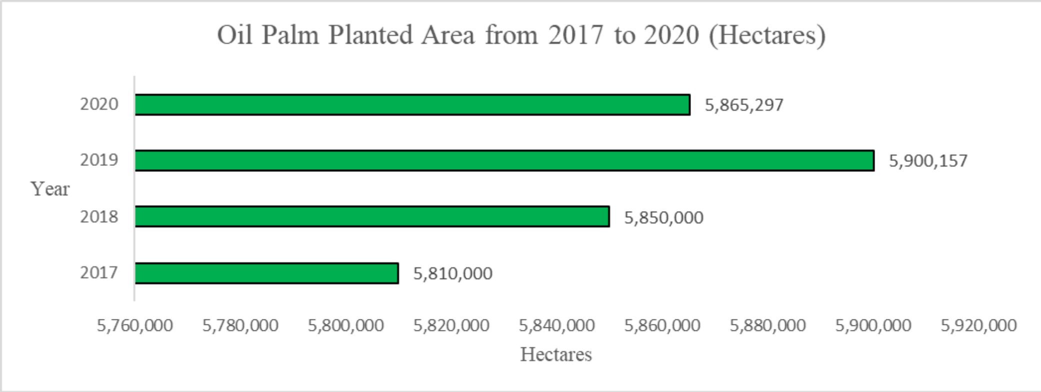



Figure 2.5 Oil palm planted area from 2017 to 2020
Source: (MPOB, 2020)

To meet demand, the plantation area for palm oil trees is growing year after year. According to data available until December 2020, the oil palm area in 2020 decreased by 0.6 percent to 5.865 million hectares, down from 5.900 million hectares in 2019 due to global outbreak of COVID-19 pandemic (MPOB, 2020). The decreasing of area for palm oil trees are caused by migrant workers not allowed to return and resume work in local plantations which contributed to lower production with the prohibition on air travel (BERNAMA, 2020). During the processing of palm oil fresh fruit brunch (FFB), the palm oil industry expanded, resulting in an abundance of by-products such as POME, empty fruit brunch (EFB), palm kernel shell (PKS), and mesocarp fibre in palm oil mills (FFB). POME was relatively untapped among these by-products and will be a threat to the environment if directly discharged into a watercourse (Amalina Ishak et al., 2019).

### 2.2.1 Effect of Palm Oil Industry to Environment

The oil palm industry is always being linked to the environment as it is a land intensive industry. To make way for vast monoculture oil palm plantations, large areas of tropical forests and other ecosystems with high conservation values have been cleared. Many endangered species, including rhinos, elephants, and tigers, have lost critical habitat as a result of this clearing. The burning of forests to make way for the crop is also a significant source of greenhouse gas emissions. Intensive cultivation methods pollute the soil, cause erosion, and pollute the water.

The number of palm oil mills grows rapidly each year, increasing the capacity of fresh fruit bunch waste or effluent discharge. However, approximately 5–5.7 tonnes of water were required to sterilise the palm fruit bunches and clarify the extracted oil in order to produce 1 tonne of crude palm oil, resulting in 50% of the water being converted into palm oil mill effluent (POME) (Hesam Kamyab et al., 2018). POME is 100 times more polluted than municipal sewage due to its high biochemical oxygen demand (BOD) and chemical oxygen demand (COD) (COD). In addition, the effluent contains a higher concentration of organic nitrogen, phosphorus, and various supplement substances (Hesam Kamyab et al., 2018). This huge quantity of POME will pollute the water courses nearby the palm oil mills if proper management were not implemented in palm oil mills (Amalina Ishak et al., 2019).

## 2.3 Palm Oil Mill Effluent (POME)

Raw palm oil mill effluent (POME) contains a lot of organic materials and residual oil, so it has a lot of biological oxygen demand (BOD) and chemical oxygen demand (COD) (COD) (Zainal et al., 2017). It is dark brownish in colour and has a high acidic content as well as a high total suspended solids (TSS) (Zainal et al., 2017). POME is a highly polluting wastewater that cannot be dumped freely and/or directly into any source of water or river. Untreated POME discharge has an adverse effect on the environment.

Generally, palm oil mill wastewater is low in pH because of the organic acids produced during the fermentation process, palm oil mill wastewater typically has a pH of 4-5 (Hesam Kamyab et al., 2018). It also has a high total solids content (40,500 mg/L), oil and grease content (4000 mg/L), COD content (50,000 mg/L), and BOD content (25,000 mg/L). It does, however, contain significant amounts of N, P, K, Mg, and Ca, which are essential nutrients for plant growth (Hesam Kamyab et al., 2018). The degradable organic matter content of raw or partially treated POME is extremely high as shown in Table 2.1. However, because of its nontoxic nature and fertilising properties, POME can be used as a fertiliser or animal feed substitute in terms of meeting mineral requirements.

Table 2.1 Characteristics of Palm Oil Mill Effluent (POME)

| Parameter | POME (Average) | Range |
|---|---|---|
| pH | 4.2 | 3.4-5.2 |
| Oil and grease | 4,000 | - |
| Biochemical oxygen demand (BOD) | 25,000 | 10,250-43,750 |
| Chemical oxygen demand (COD) | 51,000 | 15,000-100,000 |
| Total solids | 40,000 | 11,500-79,000 |
| Suspended solids | 18,000 | 5,000-54,000 |
| Total volatile solids | 34,000 | 9,000-72,000 |
| Ammoniacal nitrogen (NH3-N) | 35 | 4-80 |
| Phosphorus (P) | 180 | - |
| Potassium (K) | 2,270 | - |
| Magnesium (Mg) | 615 | - |
| Calcium (Ca) | 439 | - |
| Boron (B) | 7.6 | - |
| Iron (Fe) | 46.5 | - |
| Manganese (Mn) | 2.0 | - |
| Copper (Cu) | 0.89 | - |
| Zinc (Zn) | 2.3 | - |

*Units is mg/L except for pH

Source:(Hesam Kamyab et al., 2018)

## 2.4 Palm Acid Oil (PAO)

Palm acid oil (PAO) is derived from palm oil mill effluent (POME), which contains between 3% and 5% PAO and 95–97% water (Noge et al., 2021).

Approximately 5–5.7 tonnes of water were required to sterilise the palm fruit bunches and clarify the extracted oil in order to produce 1 tonne of crude palm oil, resulting in 50% of the water being converted into palm oil mill effluent (POME) (Hesam Kamyab et al., 2018). Palm acid oil (PAO) is an alkaline refinery by-product of palm oil. It is used in the production of laundry soaps as well as calcium soaps for animal feed formulations (Amalina Ishak et al., 2019). The properties and composition of PAO can vary depending on the palm oil feedstock and the alkaline refining process.

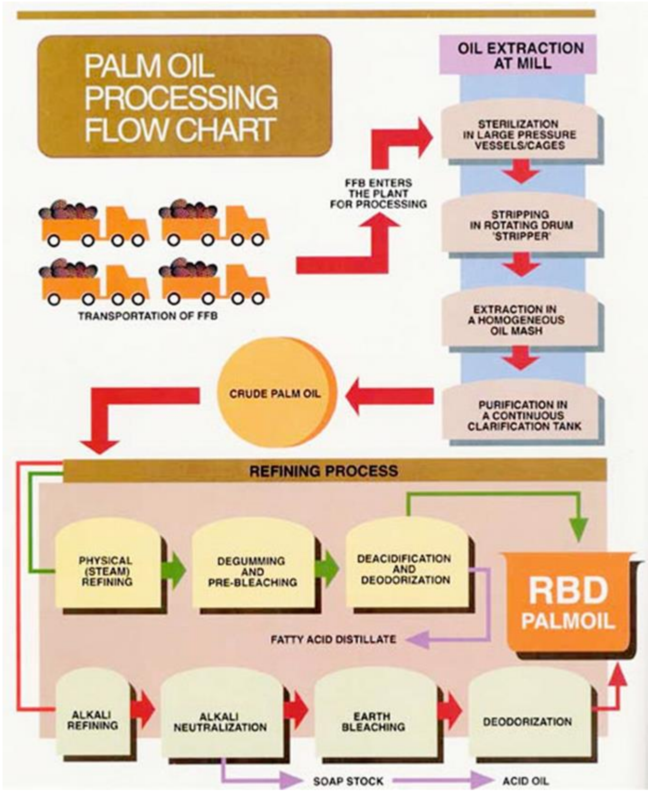



Figure 2.6 Palm oil processing flow chart.
Source:(MPOC, 2019)

PAO is obtained from the refining of the crude palm oil. There are two types of refining which are physical refining and alkali refining (Amalina Ishak et al., 2019). The alkali refining involves the neutralization with alkali which will produce soap stock. In order to produce PAO, soap stock will go through acidification by using sulphuric acid (Amalina Ishak et al., 2019).


Figure 2.7 Palm acid oil.

### 2.4.1 PAO Characteristics

PAO has generally low free fatty acid (FFA) compared to Palm Fatty Acid Distillate. PAO consists of over 50% free fatty acid (FFA) and neutral oil, 2-3% moisture and other impurities (Global Mandiri Sentosa, 2020). It has a low peroxide value which means low rancid taste. The iodine value in PAO indicates there is a reasonable amount of unsaturated fatty acid in palm acid oil (CDR Food Lab, 2020). Table 2.2 below shown the quality and oxidative parameter of PAO based on previous study.

Table 2.2 Quality and Oxidative Parameters of Palm Acid Oils

| Parameter | Mean value of 27 samples | Standard deviation | Range |
|---|---|---|---|
| Moisture content (%) | 0.98 | 0.53 | 54.08 |
| Free fatty acid (%) | 62.6 | 11.5 | 18.49 |
| Peroxide value (meq/kg) | 4.1 | 3.8 | 92.68 |
| Iodine value | 50.2 | 5.3 | 10.56 |
| Saponification value | 18 | 5.6 | 3.01 |
| Unsaponifiable matter | 0.53 | 0.42 | 79.25 |

Source: (Kuntom et al., 1994)

## 2.5 Palm Kernel Cake (PKC)

Palm kernel cake (PKC), a by-product of palm oil extraction via expeller presses or solvent extraction, is one of the region's most abundant and potentially low-cost agricultural products. PKC is a suitable partial substitute for soybean meal (SBM) and corn in poultry feeding since it contains 14–18% crude protein (CP), 12–20% crude fibre (CF), 3–9% ether extract (EE), and varying amounts of various minerals. Poultry digestibility has been reported to be impaired as a result of the high fibre content, making PKC potentially unsuitable for poultry feeding. However, by increasing CP and decreasing CF, solid-state fermentation (SSF) can be used to improve the nutritional efficiency of PKC. PKC has been licenced for use as one of the ingredients in animal feeds. Due to its nutritional qualities, attractive prices compared to other meals, and long-term availability, PKC is more competitive in the international meal market (Azizi et al., 2021).

PKC is produced in two stages from palm fruit: the first is the primary extraction of palm oil from the pericarp portion of the fruit, which also produces the kernel and by-products such as palm oil sludge (POS) and palm press fibre (PPF), and the second is the extraction of oil from crushed kernels, which also produces PKC and palm kernel shell as by-products (Sharmila et al., 2014). The nutrient content of Malaysian palm kernel and its by-products PKC is shown in the table below.

Table 2.3 The nutrient content in the palm kernel and its by-products PKC.

| Chemical contents | Palm Kernel | PKC |
|---|---|---|
| Oil content | 49.0 | 7.9 |
| Protein | 8.3 | 14.8 |
| Crude Fibre | 8.1 | 16.7 |
| Moisture | 6.5 | 6.4 |
| Ash | 2.0 | 3.9 |
| Carbohydrate | 26.1 | 50.3 |

Source: Nuzul Amri, 2013; (Sharmila et al., 2014).

Since it has no competition from humans or farm animals, PKC is an alternative feed resource that can be used in poultry feeds. Agro-industrial by-products like PKC can be used to replace conventional feed ingredients like maize and soyabeans in poultry diets due to their low cost and availability. There have been several studies on the nutritional benefits of PKC in monogastric animal feeding, with more than two-thirds of them focusing on various types of poultry. PKC's use in poultry feed is limited due to its high fibre content, and the optimal amount of PKC to include in poultry rations varies widely. PKC inclusion in poultry can differ depending on the types of poultry, age, and sex due to the origin and variation in the oil and shell content of the PKC used (Sharmila et al., 2014).

The digestion of non-starch polysaccharides (NSPs) of the cell wall of PKC in poultry is variable due to low digestive enzymic activity and their propensity to create a viscous environment in the intestinal lumen. It can, however, be broken down with the help of enzymes generated by the caecal microflora or by supplementing poultry diets with specific enzymes. PKC cannot be used in monogastric animal diets due to its high CF, coarse texture, and gritty appearance. In the past, PKC was not widely used in pig and poultry diets. Its astringency and high fibre content (150 g/kg DM) contribute to this. As a result, the digestibility of these animals is limited. PKC has a high CF content, ranging between 16 and 18 percent, which is high for non-ruminants (Azizi et al., 2021). At high concentrations, it may not be suitable for use in poultry or pig diets. PKC is not widely used in poultry diets due to its high concentration of NSPs. As a result, NSPs are reduced using SSF. Anti-nutritional factors in PKC include 0.40 percent tannic acid, 6.62 mg/g phytin phosphorus, 23.49 mg/g phytic acid, and 5.13 mg/g oxalate, all of which detract from the nutritional value of the product. PKC should be kept to a maximum of 20% in poultry diets (Azizi et al., 2021). Broiler birds could eat a PKC-based diet up to 20% of the time without affecting their production quality, according to Anaeto et al. (2009).

Table 2.4 Difference between PKC and OPF Composition, Advantage and Disadvantage

| | Composition | Advantages | Disadvantages |
|---|---|---|---|
| PKC | Dry matter – 91.2%<br>Crude Protein - 16.7%<br>Crude Fibre - 19.8%<br>Lignin- 13.4%<br>Ash - 4.7% | -High energy source<br>-High quality protein<br>-Balanced material content<br>-Good palatability<br>-Availability<br>-Cost effectiveness<br>-No toxin (Feed, n.d.) | -May content substantial residual oil. |
| OPF | Dry matter – 88.9%<br>Crude Protein - 5.6%<br>Lignin- 19.9%<br>Ash - 6.0% | -Solving problem of feed shortage<br>-Reduction of feeding, operation and management cost (Ishida & Abu Hassan, 1997). | -Need to be process first before it can be utilized.<br>-70% of the palm oil mill process effluent comes from OPF. |

## 2.6 Rice Bran

Rice bran is a by-product of the rice milling process that accounts for 10% of global rice output of 48 million tonnes per year. Rice bran is typically utilised as animal feed or dumped as garbage (Alauddin et al., 2017). Rice bran is attracting researchers' attention since it is high in nutrients like protein, fat, carbs, bioactive chemicals, and dietary fibre, and it is readily available and inexpensive. The content of rice bran varies according to rice variety, geographical conditions, and processing processes (Alauddin et al., 2017). Rice bran, the outer layer of the rice grain, accounts for 8–10% of the overall weight of the grain, but it contains the majority of the nutrients: carbs (34–62%), lipids (15–20%), protein (11–15%), crude fibre (7–11%), and ash (7–10%).

Rice bran aids in the digestion of poultry food. Dietary fibres help animals absorb nutrients more quickly and effectively, boosting their overall health and appearance. Rice bran helps to strengthen their immune systems, minimising their chances of getting sick (WestGrains Trading, 2019).

Figure 2.8 Rice bran.
Source: (McDougall, 2013)

## 2.7 Limestones, Calcium Carbonate ($CACO_3$)

Calcium carbonate (CaCO3), sometimes known as limestone, is a nutritional supplement for animals. Limestone is mostly used in livestock feed as a calcium source (Son Ha Minerals Co., 2018). Limestone is available in a wide range of compositions. Calcium is the most abundant chemical in the body. The skeleton and teeth hold 98 percent of the calcium in the body, which makes up about 2% of the animal's weight. Calcium is necessary for tooth and bone development, nerve transmission, muscle excitability, heart regulation, blood coagulation, and enzyme activation in animals (Son Ha Minerals Co., 2018).

Limestone can be beneficial to pigs, beef and dairy cattle, poultry, horses, and sheep. All forms of livestock require calcium, however the amount required varies depending on age and habitat, notably in young growing animals. A calcium deficiency in young animals can induce irregular bone formation and slow overall growth. There is no withholding time for limestone, however it should be kept dry and out of direct sunlight (Son Ha Minerals Co., 2018).

Figure 2.9 Limestone.
Source: (Son Ha Mineral Co.Ltd, 2020)

## 2.8 Corn

Corn, commonly known as maize, is a common energy feed element in poultry diets all over the world (Dei, 2017). Corn is usually always a major component of processed animal feed. It is a favoured ingredient for animal food producers because of the energy contribution, as well as the content level (60-80%) and the minimal variability of its chemical makeup (Dacsa Group, 2019). Corn is fed to chickens either straight or thoroughly blended with other foods. The mixture is subsequently fed to or changed into the forms that certain animals prefer (Dei, 2017). Corn is the easiest grain to digest for animals and is low in fibre (Jacquie Jacob, 2020).

Figure 2.10 Corn.
Source: (123RF, 2020)

## 2.9 Soybean Meal

Soybean meal is a waste product from the production of soybean oil. For poultry, cattle, and ruminant animals, soybean meal is the most important protein source. The amount of protein, fibre, and fat in the oil varies depending on how it is extracted. Soybean meal is an excellent source of extra protein in poultry diets because it is abundant in highly digested protein (Cromwell, 2017). Soybean meal has a high protein content (44 percent to 49 percent), is easily digestible, and the amino acids produced from the protein after digestion are appropriate for nonruminants (Cromwell, 2017).

Figure 2.11 Soybean Meal.
Source: (Ryan, 2019)

## 2.10 Free Range Chicken

Free range chicken is term for method by enabling animal to roams freely outdoors rather than being confined by an enclosure for 24 hours. These chickens can roam far from their habitat that considered being free (Watson, 2020).

Ayam kampung is a chicken breed found in south east Asia which simply named free range chicken or village chicken. In Indonesia, this term ayam kampung are for indigenous chickens raised using traditional method production by every house in the village. Its population are cross-breed of the red jungle-fowl, southeast Asian chickens and exotic chickens of several types of imported in the late 1800s by European settlers. Gallus domesticus is the scientific term for the first generation of chickens. Gallus gallus is the scientific name for the first generation of chickens. When the Chinese Traders arrived in our country, the second generation of village chicken was born, which was a cross between the first generation of village chicken and the Canton village chicken. The third generation of village chickens resulted from a hybrid between the second generation and a few breeds imported from other countries by European colonial powers (Nu'man, 2011).

Figure 2.12 Free Range Chicken.
Source: (Nu'man, 2011)

# CHAPTER 3

# METHODOLOGY

## 3.1 Introduction

This chapter presenting the methodology in testing the growth rate, in which procedure are directly influence the experimental conclusion. Observation in every step must be done carefully to summarise the relationship of factors and levels of data analysis.

## 3.2 Research Workplan

For this research project, a series of task will be carried on. Firstly, the manufacturing of the chicken pellet is carried out in Bukit Sagu Factory. The process of pellet manufacturing is based on the industrial standard. Then, the flow chart of analysing growth rate of the chicken until the chicken are achieve adult age for selling. The diagram below was shown below:

## 3.3 Study Site

This study was carried out at a farm (3° 45’ N latitude and 103° 10’ E longitude), located at Kampung Seri Mahkota Kuantan, Pahang, Malaysia. PKC, PAO, were supplied by the local palm oil mill (Kilang Sawit Lepar Hilir 3). For the limestone, soy bean meal, rice bran, and corn were supplied by Kilang OPF Bukit Sagu.

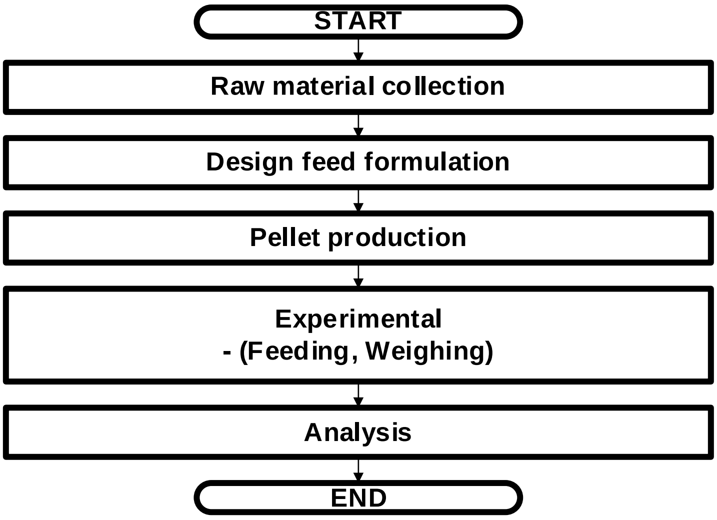



Figure 3.1 General Flow Chart of the Study.

### 3.4 Pellet Production

The raw materials were taken and weighed according to the composition that was formulated with the help of Kilang OPF Bukit Sagu management before the pellet production began. The bucket elevator was used to transport all of the materials to the silo storage. Each material was weighed and fed into the mixer according to the desired ratio. The PAO was applied when the material was carried by the conveyer. The materials are combined for 5 to 7 minutes in the mixer to ensure that they are evenly blended.

The mixture is then transferred to a pelletizer, where steam is supplied and mixed uniformly for 15 to 20 minutes to soften the mixture and assure pelletability. The mixture is then transferred to a pelletizer, where it is transformed into a pellet and cut into the desired size using a mould. The pellet is placed in the cooler for 15 minutes to cool. The cooler serves as an exhaust fan, releasing heat while also removing dirt from the pellet.

The pellet is then transported to a packaging silo to begin the packaging process. **Figure 3.2** depicts the pellet production equipment used in this study.

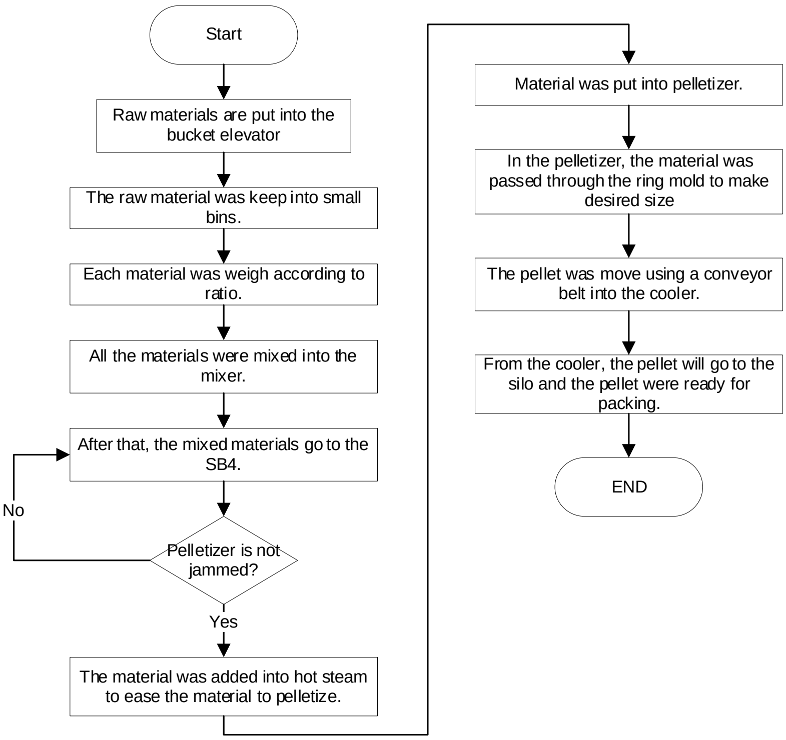



Figure 3.2 Process of Pellet Manufacturing.


Figure 3.3 Feed Intake.


Figure 3.4 Material Silo.

Figure 3.5 Mixer.

Figure 3.6 Pelletizer.

Figure 3.7 Cooler.

Figure 3.8 Packaging Silo.

## 3.5 Conduct of Experiment

Each type of feed was fed to 15 chickens aged 1 week with the average weight 40 ± 0.5g. The chicken was divided into two groups and individually weighed. All chicken is housed in separated section in chicken coop based on type of diets that will be given and the chicken had free access to fresh water.

### 3.5.1 Animal Feed Composition

The animal feed for the chickens is set into 3 categories. First category is a conventional animal feed that being sold in the market which is corn. The second category is the factory formulated feed with addition of palm acid oil to improve the nutritional content in the animal feed. The third category is the factory formulated feed with palm kernel cake only. Table 3.1 shows the three types of diet for the chicken to be fed. Diet 1 and Diet 2 were chosen in this project to feed the chickens because Diet 2 were needed to compared the nutritional content of the combination between PKC and PAO and Diet 1 was a control diet.

Table 3.1 Three types of diet that being fed to the chicken

| Diet 1 (D1)<br>(Conventional feed) | Diet 2 (D2)<br>(Factory formulation + PKC+ PAO) | Diet 3 (D3)<br>(Factory formulation + PKC) |
|---|---|---|
| -Corn 100 kg | -PKC 83.75 kg<br>-Rice bran 10.5 kg<br>-Corn 1.9 kg<br>-Limestone 0.95 kg<br>-Soybean Meal 2.86 kg<br>-PAO 0.04 kg | -PKC 83.75 kg<br>-Rice bran 10.5 kg<br>-Corn 1.9 kg<br>-Limestone 0.95 kg<br>-Soybean Meal 2.86 kg |

### 3.5.2 Chicken Monitoring

For the first 2 weeks the chicken feed is added once every 2 days. The following week, the chicken feed is added when needed. All chicks will have access to water since water are important to maintain their body temperature. The chickens are weighing and measured the size of chicken for their initial measurement. The chicken is put into two separated compartment which depends on their diets. Then, the chicken's condition was monitored weekly and their weight and size were recorded.

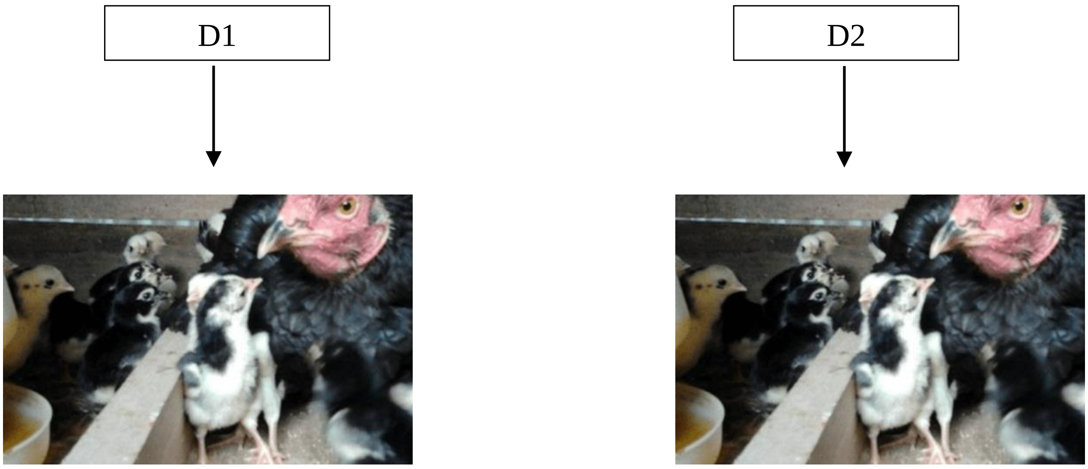



Figure 3.9 The Chicken divided into 2 groups.

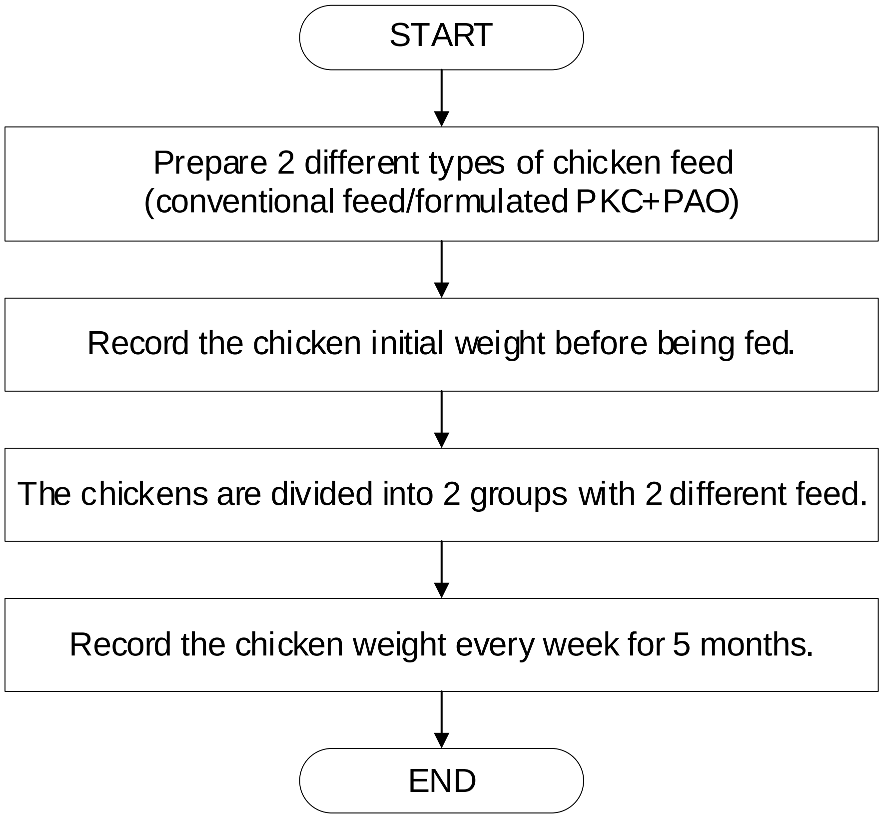



Figure 3.10 Flow Chart Process of Chicken Monitoring.

## 3.6 Measurement Of Growth Performance

A parameter is being use in this project associated with growth performance which consists of BWC.

### 3.6.1 Body Weight Change (BWC)

The parameter that being used is to analyse the growth performance is body weight change (BWC). The initial BW of the chickens were taken at the beginning of the project in the morning before feeding. BW gain of each chicken was recorded each 7 days for a total period of 5 months. Further illustration was shown in Figure 3.9. The chickens used in this project were weighed weekly using a weighing scale. The Body Weight Change were calculated by subtracting the final BW with the initial BW of the chickens.

Body weight change (kg) = Final body weight (kg) – Initial body weight (kg)

# CHAPTER 4

# RESULT AND DISCUSSION

## 4.1 Introduction

All of the data obtained is summarised in this chapter, and quantitative data is presented using tables, graphs, and brief explanations. As described in the previous chapter, the data will provide answers to the project methodology. The primary data collection will be discussed first in this chapter. Following that, there is a discussion of the findings and their implications for theory and practise. The outcome and discussion will address the project's goal and solve the challenge described in the problem description. Tables, graphs, and charts are used to analyse experimental data that includes current data in a significant way.

## 4.2 Nutrient Intake Value In Diet

Table 4.1 The nutritive value for corn and PKC

| NUTRIENT | TYPE OF INGREDIENT | | | |
|---|---|---|---|---|
| (%) | CORN (D1) | PKC + PAO (D2) | PKC (D3) | Commercial PKC |
| Dry matter | 53.71 | 87.3 | 90 | 85 |
| Crude Protein | 8.64 | 16.1 | 17 | 15.1 |
| Crude Fibre | 9.86 | 21.3 | 20 | 19.3 |

The table 4.1 shows the nutritive content of each diet in the chicken feed. The dry matter content in D2 was 87.3% as compared to D1 which only 53.71%, D3 was 90% and commercial PKC was 85%. Dry matter was essential for the chicken’s health and production. When it comes to crude fibre, PKC has a greater amount than corn, with 21.3 percent and 9.86 percent, respectively. Crude fibre is necessary in poultry diets because it aids in the maintaining of a healthy digestive system. Crude protein found in D2 was higher than D1 which shows value of 16.1% as for D1 8.64% but lower than D3 which is 17%. The figure 4.1 shows the comparison of the nutritive content in different diet.

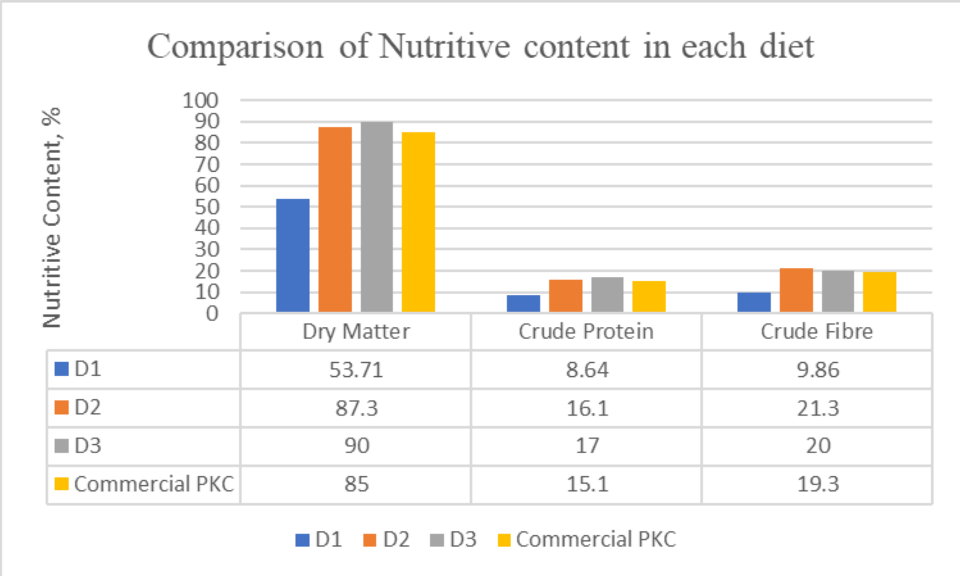



Figure 4.1 Comparison of nutritive content in each diet.

### 4.2.1 Crude Protein Requirements

Crude protein plays an important role for the chicken's growth, egg production and immunity. Crude protein found in D2 was higher than D1 which shows value of 16.1% as for D1 8.64% but lower than D3 which is 17%. This are supported by Yeong (1983) report that the crude protein in chicken diet can be used but only 10-20% for PKC. Amino acid from the crude protein in utilization of PKC are important because of its digestibility and quality. Yeong (1983) also report the crude protein content in PKC is the same percentage with the crude protein content in diet 2. Essential amino acids (e.g., DL-methionine and L-lysine) are frequently supplied to the diet in purified form to reduce total protein levels and diet costs. This also has the added benefit of reducing nitrogen excretion. The dietary methionine requirement of growing birds must be met in order to promote appropriate tissue growth (Fagundes et al., 2020).

### 4.2.2 Free Fatty Acid

For the FFA content in PAO ranges between 50% - 62.5%. It was determined that unsaturated diets containing a moderate amount of dietary FFA (up to 15%) could be utilised in broiler-chicken starting diets because they produced equivalent FA absorption and performance results as diets containing the least amount of dietary FFA (Rodriguez-Sanchez et al., 2019). Despite their high energy content, supplementary fats are commonly employed to meet energy requirements in poultry diets. Different fat sources are available and can be utilised in poultry diets. Food fat by-products from the edible oil refining sector, for example, are a cost-effective alternative to conventional fats that can be revalued as a feed fat element (Rodriguez-Sanchez et al., 2019). From the statement of Rodriguez-Sanchez et al. (2019), the PAO is ideal ingredient or source for poultry feed additives.

### 4.2.3 Crude Fibre Requirements

For Crude fibre content, Jha & Mishra (2021) reported that because of its negative effects on feed intake and nutrient digestion, dietary fibre (DF) was once thought to be an antinutritional component. Scientists have discovered that DF has significant effects on the development of the gastrointestinal tract (GIT), digestive physiology, including nutrient digestion, fermentation, and absorption processes in poultry, based on mounting data. By enhancing mucosal structure and functions and boosting the population and diversity of commensal bacteria in the GIT, it may help maintain the integrity of the small and large intestines. Increasing the amount of DF in the diet improves digestive physiology by boosting gastrointestinal trac (GIT) growth and enzyme production Inclusion of moderate amounts of fibre in poultry diets also affects growth performance. It boosts immune function and promotes gut health by modifying beneficial bacteria in the large intestine. So, CF is important ingredient that should be included in poultry diet because of the reasons stated by Jha & Mishra (2021).

### 4.2.4 Water Requirements

The chickens are getting unlimited access to water to maintain their body temperature during the period of experiment. The chicken also needs the water to have a smooth digestive system. Water is essential for all living things. Water makes up half to two-thirds of an adult animal's body mass, and more than 90% of a new born animal's body mass. Water is a necessary component of practically all bodily secretions. Water is a universal solvent throughout the body that aids cellular biological reactions such as digestion, absorption, and transport of nutrients (Cherian, 2020). Water helps different digestive juices and meal components interact, increasing digestion, and aids in the expulsion of waste products from the animal body in the form of urine, faeces, and perspiration, sweat. Water's high specific heat aids in the regulation of body temperature by absorbing the heat generated by various metabolic reactions. Water regulates body temperature by evaporating as sweat or transporting heat away from organs via the bloodstream. Body cells are shaped by water. Water aids in maintaining the body's acid-base balance. Water protects the many critical organs from shocks and accidents by acting as a cushion for tissue cells and the nervous system (Cherian, 2020).

### 4.2.5 Energy Requirements

**Nutrient Requirements of Broilers [a]**

| Age[b] | 0–3 wk | 3–6 wk | 6–8 wk |
|---|---|---|---|
| kcal $AME_n$/kg diet[c] | 3,200 | 3,200 | 3,200 |
| Crude protein[d] | 23.00 | 20.00 | 18.00 |
| Arginine | 1.25 | 1.10 | 1.00 |
| Glycine + serine | 1.25 | 1.14 | 0.97 |
| Histidine | 0.35 | 0.32 | 0.27 |
| Isoleucine | 0.80 | 0.73 | 0.62 |
| Leucine | 1.20 | 1.09 | 0.93 |
| Lysine[e] | 1.10 | 1.00 | 0.85 |

Figure 4.2 The nutrient requirement for the broiler.

Source: (Klasing, 2015)

Kilocalories are used to indicate the energy requirements of chickens and the energy composition of feedstuffs (1 kcal equals 4.1868 kilojoules). The metabolizable energy (AMEn) and the true metabolizable energy (TME) are two different metrics of bioavailable energy in feedstuffs (TMEn). After an adjustment for nitrogen retained in the body, AMEn is the gross energy of the feed minus the gross energy of the excreta. TMEn calculations include an additional correction to account for endogenous energy losses not directly related to the feedstock, making it a more meaningful metric. For many substances, AMEn and TMEn are interchangeable. However, some ingredients, such as feather meal, rice, wheat middlings, and corn distiller's grains with solubles, have significantly different values.

Poultry may adapt their feed intake to suit their daily energy needs over a wide range of feed energy levels. Energy requirements and, as a result, feed intake, vary greatly depending on the temperature of the surroundings and the level of physical activity. The daily requirements for amino acids, vitamins, and minerals in birds are mostly unaffected by these circumstances. The nutritional requirements are based on average rates of intake of birds in a thermoneutral environment eating a feed with a certain energy content (e.g., 3,200 kcal/kg for broilers). When a bird consumes a diet with a higher energy level, it consumes less food; as a result, the diet must contain a higher proportion of amino acids, vitamins, and minerals. The PKC contain high amount of crude protein (amino acid) which are 16.1% which suitable as a chicken feed for the chicken to get daily nutrient requirement.

### 4.2.6 Vitamin Requirements

Because of the immune system's critical role in illness prevention and good growth, producing hens with strong immune systems is a key goal in poultry production. (Shojadoost et al., 2021). Vitamins A, D, E, and C, among all vitamins, have been shown to have the largest impact on immune system function through a variety of ways. In chickens and mice, vitamin A helps with a variety of immunological activities, including mucosal immunity and free radical reduction. Vitamin D also has anti-inflammatory properties, as it lowers the levels of proinflammatory cytokines.

Vitamin E has potent antioxidant and anti-inflammatory properties, as well as increasing the quantity and activity of immune cells and stimulating antibody production in response to chicken immunisation. Vitamin C is especially useful in cases of oxidative stress, infection, and inflammation in hens because of its antioxidant and anti-inflammatory properties (Shojadoost et al., 2021). Moisture, oxygen, trace minerals, heat, and light all contribute to vitamin deterioration over time (Klasing, 2015). To accommodate for these losses, stabilised vitamin formulations and large margins of safety are frequently used. This is especially true if the diet is pelleted, extruded, or kept for an extended period of time (Klasing, 2015).

In this project the diet that will be use are diet 1 and diet 2 to compare the differences in nutrient intake for the chickens. These 2 diets will be fed to the chicken and the chicken growth rate will be monitored. Based on the points that been stated above, the objective to analyse palm oil waste characteristics in making of the formulated chicken feed has been achieved since PKC and PAO are suitable to be included as alternative ingredients in poultry feed rather by-product that will pollute the environment.

## 4.3 Animal Feed Composition

Table 4.2 Composition for each diet

| Diet 1 (D1)<br>(Conventional feed) | Diet 2 (D2)<br>(Factory formulation + PKC+ PAO) | Diet 3 (D3)<br>(Factory formulation + PKC) |
|---|---|---|
| -Corn 100 kg | -PKC 83.75 kg<br>-Rice bran 10.5 kg<br>-Corn 1.9 kg<br>-Limestone 0.95 kg<br>-Soybean Meal 2.86 kg<br>-PAO 0.04 kg | -PKC 83.75 kg<br>-Rice bran 10.5 kg<br>-Corn 1.9 kg<br>-Limestone 0.95 kg<br>-Soybean Meal 2.86 kg |

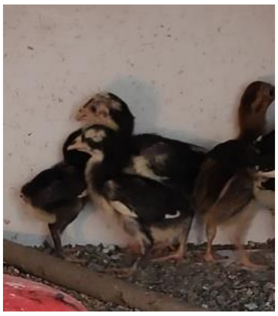
Based on table 4.2, D1 feed is for the control chicken which consist of 100% of corn only. D2 is for the chicken fed with a mixture of PKC, rice bran, corn, limestone, soybean meal and PAO while D3 is for the chicken fed with the mixture of PKC rice brain, corn, limestone, and soybean meal. The formulation of D2 and D3 are the optimum formulation for the pelletability of the chicken feed that have been established by Kilang OPF Bukit Sagu. Since the project is focus on the mixing of solid waste from PAO and PKC, diet 2 have been selected compared to diet 3 because absence of PAO in diet 3. From the discussion above, the objective to produce chicken feed formulation by the mixture of palm acid oil and palm kernel cake has been achieved as stated in D2.

From the article wrote by Bryne (2018), Datuk Seri Ahmad Shabery Cheek suggested that increased use of palm kernel cake in chicken diets, combined with increased local maize planting for feed consumption, might reduce the country's reliance on imported feed by 30 to 40 percent, putting a cap on rising feed costs.

## 4.4 Growth Performance

For the growth performance, the weight for all chickens were obtained and then the weight difference in each week is tabulated and shown in the Table 4.3. The free-range chicken growth between 6 to 7 months but in this project the chickens are monitored until 5 months which faster due to the additional formulated chicken feed. Continuous advancements in feeding methods and management systems may lead to an even higher rate of growth in the future.

Table 4.3 Weight of chicken D1 and D2

<table>
<tr><th rowspan="2">Age (week)</th><th colspan="2">Weight in grams (g)</th><th rowspan="2">Photo</th></tr>
<tr><th>D1</th><th>D2</th></tr>
<tr><td>1</td><td>40</td><td>40</td><td rowspan="4"><br>Chick’s weight 150 g</td></tr>
<tr><td>2</td><td>53</td><td>69</td></tr>
<tr><td>3</td><td>85</td><td>99</td></tr>
<tr><td>4</td><td>132</td><td>150</td></tr>
<tr><td>5</td><td>169</td><td>200</td><td rowspan="4"><br>Chick’s weight 500 g</td></tr>
<tr><td>6</td><td>265</td><td>330</td></tr>
<tr><td>7</td><td>301</td><td>405</td></tr>
<tr><td>8</td><td>368</td><td>500</td></tr>
<tr><td>9</td><td>443</td><td>650</td><td rowspan="4"><br>Chicken’s weight 1 kg</td></tr>
<tr><td>10</td><td>490</td><td>779</td></tr>
<tr><td>11</td><td>650</td><td>890</td></tr>
<tr><td>12</td><td>748</td><td>1000</td></tr>
</table>

| | | | |
|---|---|---|---|
| 13 | 831 | 1320 |  |
| 14 | 964 | 1480 | |
| 15 | 1250 | 1840 | |
| 16 | 1500 | 2500 | Chicken weight 2.5 kg |
| 17 | 1750 | 2850 |  |
| 18 | 1900 | 3050 | |
| 19 | 2100 | 3400 | Chicken weight 3.4 kg and above |
| 20 | 2300 | 3800 | |

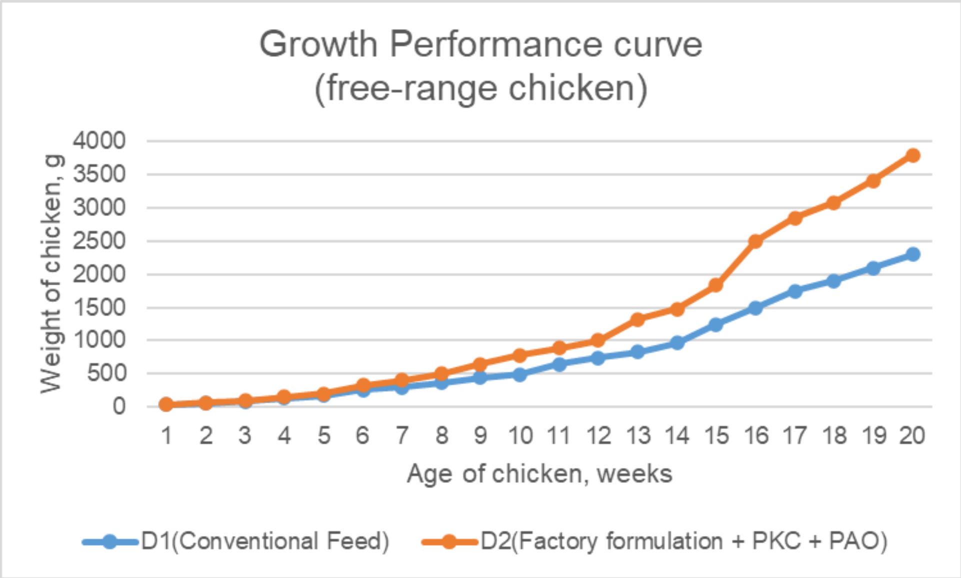



Figure 4.3 Growth Performance for the both types of diet.

Based on Figure 4.3, it shows the growth performance for the both types of diet chickens during the study period. All chicken has shown a good growth performance. Even so, this study is to determine the effectiveness of formulated PKC feed in the chicken feed comparing corn feed. To do that, the chicken fed with D1 need to be compared with the chickens fed with D2. Mohd Shahmi Hakimi et al. (2019) reported that the weight of chicken on week 8 is 784.5 g/bird compared to the data collected which is 500 g. The significant difference of the weight is due to the environment that Mohd Shahmi Hakimi et al. (2019) have provided in his project. Mohd Shahmi Hakimi et al. (2019) reported in week 12 weight is 1532.5 g/bird more than data collected which is 1000 g. Mohd Shahmi Hakimi et al. (2019) chickens were placed in an aluminium brooder with 100 watts of bulb compared to our project chicken which roam freely within stipulated area. When the livestock did not get enough feed, the chicken will have slower growth rate and good nutrient intake will give best effect to the growth performance of chickens. By feeding chickens with PKC from palm oil industry can significantly provide to the improvement of the growth performance of chickens by utilizing the abundant resource of solid waste from palm oil industry. Due to the cheaper cost of formulated feed food compared to commercial feed diet, free-range hens fed with it can build a viable company. According to this study, as the chicken gets older, the profit and expense of both diets would rise (Mohd Shahmi Hakimi et al., 2019). It is suggested that the most ideal weight for the free-range chicken market is 1.5 kg, so that farmers may make more money. The computation was based on the amount of feed consumed and the cost of feed per kilogramme.

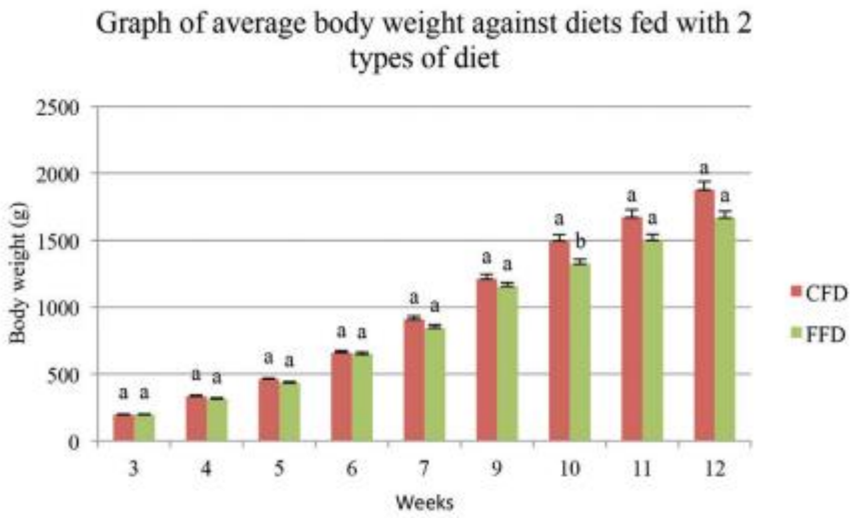



Figure 4.4 Impact of age and diet on growth performance of free-range chickens. Source: (Mohd Shahmi Hakimi et al., 2019)

Figure 4.4 shows that there were no significant changes in growth performance between the two diets until Week 12, with the exception of Week 10. The large difference in Week 10 could be owing to the weight increment factor being more prominent for CFD males compared to FFD males (Mohd Shahmi Hakimi et al., 2019). Mohd Shahmi Hakimi et al. (2019) also stated that using observation during this period, the size and weight of male birds was greatly enhanced due to factors such as feather and bone weight. This could be due to environmental factors as well as cross-breeding of free-range chicken strains. From the data of from this project in comparison with the data with Mohd Shahmi Hakimi et al. (2019), this shows that the capabilities of the PKC as the animal feed were no longer be denied which can substitutes the commercial feed to produce a similar product or similar chicken weight within the experimental period.

The use of local agro-industrial by-product such as PKC as a substitute for commercial feed component has shown promise and can be considered a cost-effective alternative not only because of their availability in the local market and lower cost, but also because of their nutritional value (Mohd Shahmi Hakimi et al., 2019). From the points stated above, the objective to investigate the growth rate of chicken towards the formulation of the chicken feed has been achieved.

## 4.5 Body Weight Change (BWC)

The BW changes of chickens in response to the formulated chicken feed were measured by taking the BW of individual chickens at the start of the project. This followed by individual weighing per week for 5 months. The readings were recorded and tabulated for comparison in Table 4.3. For the result of the BWC, at the start of the project before feeding the chickens, the average of initial BWC in D1 and D2 chickens similar which are 40 g each. Then, after 5 months of feeding the average of final BW in D2 chicken which is 3800 g, are shown a significant improvement compared to D1 which is 2300 g.

Table 4.4 The comparison of body weight gain for chickens from D1 and D2

| Parameter (g) | Type of feed | |
|---|---|---|
| | D1 | D2 |
| Initial BW | 40 ± | 40 ± |
| Final BW | 2300 ± | 3800 ± |
| BW Change | 2260 ± | 3760 ± |

In this study, nutrition plays an important role in improving the BW to the chemical composition of PKC, which had high amount of protein and energy, which attracted the chickens to consume more feed. The BWG after being fed with D1 and D2 for 5 months was presented in Table 4.3. Based on the Table 4.4, chickens that fed with D2 has a higher BWG within the period with 3760 g compared to D1 with only 2260 g of BWG. The increased BWG obtained in chicken fed with PKC and few selected ingredients combination may attributed to the protein content of the waste product which would have influenced to the available for animal performance. The chicken fed with D2 shown a better performance could be due to increased energy intake.

## 4.6 Reduction of Waste

Agricultural wastes include fertiliser containers, agricultural chemicals, feed, harvest leftovers, and manure, among other items generated by agricultural and livestock activities. Because agrochemical containers are extremely dangerous, they are subject to special regulations (Boechat et al., 2017). Many of the by-product from the palm oil industries can be utilized as a source of animal feed and many other products. Further studies of these by-product need to be conduct to analyse the suitable composition to be turned into useable product. PKC is a high protein, high energy and cost-effective formulation in producing formulation for livestock feeds.

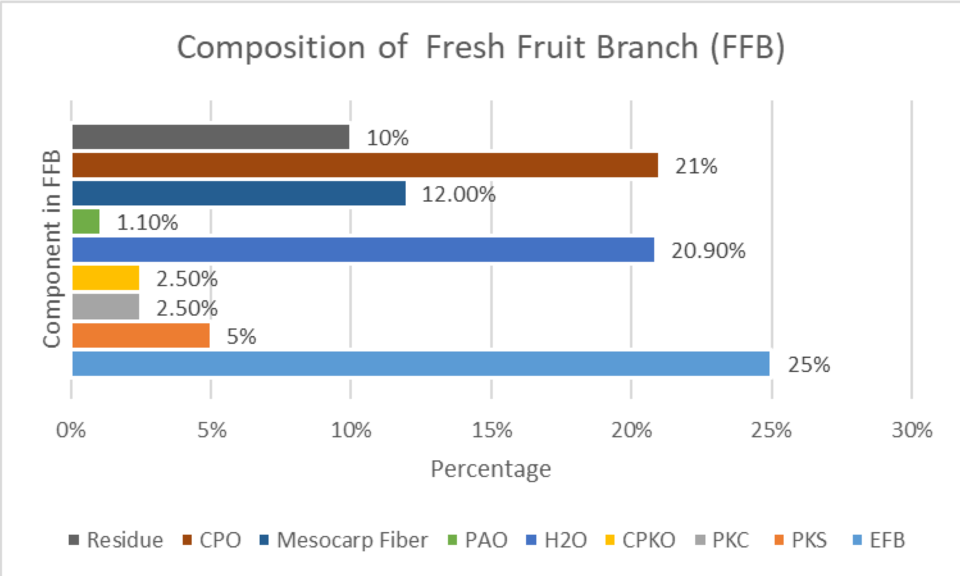



Figure 4.5 Percentage of component in FFB.

From the figure 4.5, shows percentage of the component that will be produce when processing fresh fruit branch. The amount of PKC and PAO that can be utilize is 2.5% and 1.1% respectively. For every 1000 tons of fresh fruit branch processed, it will produce 25 tons of PKC and 11 tons of PAO as a by-product that can be used for animal feed production. From this project, we can prove that by producing this animal feed, the waste from palm oil industry can be utilized as these two materials are economical for source of animal feed. As stated by Boechat et al. (2017), there is a lot of debate over the best ways to dispose of and use solid wastes has been deemed the most appealing alternative, both environmentally and economically. However, their usage in agriculture should be preceded by a thorough examination of the environmental and economic consequences, as haphazard waste disposal could result in contamination.

## 4.7 Promotes Local Economy Growth

The utilization of the agro-industrial waste can promote the local economic growth due creating job opportunities to the local citizen. Due to abundance of PKC and PAO in the palm oil industries, this can benefit both countries and local farmers as they can reduce the dependency of the imported ingredients for the animal feed production. These statements are supported by Mohd Shahmi Hakimi et al. (2019) in which due to the price and size perception of free-range chicken by local consumers, a designed feed diet can result in a profitable business in the free-range chicken market, where consumers choose younger and lower than average weights of typically slaughtered free-range chicken. Furthermore, additional study should be undertaken in the near future to improve the body weight of formulated feed diet fed chicken in order to increase profits in this agro-business. Finally, local feed resources like as PKC and CMC have the potential to substitute commercial additives in free-range chicken diets, particularly in terms of cost-benefit analysis.

# CHAPTER 5

# CONCLUSION

## 5.1 Introduction

For the objective of the project is to analyse the palm oil waste characteristics in manufacturing formulated chicken feed. Next, to formulated chicken feed by using palm acid oil (PAO) and palm kernel cake (PKC). Then, to investigate the growth rate of chicken towards the formulation of chicken feed.

## 5.2 Conclusion

Several conclusions can be drawn from the research. A good feed covers the quality of the feeds production, which is packed with a lot of nutrition and may be increased by feeding methods that are appropriate. The feed should have nutrients that meet the animal feed's nutrient requirements. If the prepared food contains a high nutrient content, it can aid in improving the livestock's growth performance. A feed that results in a high feed intake, on the other hand, will be helpful.

For the first objective is to analyse the palm oil waste characteristics in PAO and PKC for manufacturing formulated chicken feed. Both of these by-products are high in nutrient that can fulfil the animal feed requirement for chicken growth. This waste also can easily acquire from palm oil mills throughout the whole country. The utilisation of agro-industrial waste can help to control the quality of landfill waste disposal, reduce pollution, and give the community a clean and healthy environment. The feedstock used in the market is raw material imported from other nations such as Thailand, Argentina, and Brazil. This could make animal feed even more expensive.
Followed by the second objective which is to formulated chicken feed by using palm acid oil (PAO) and palm kernel cake (PKC) from agro-industrial waste have been proven that affect the growth rate of chickens. The nutrient content in the wastes that

useful for the chicken feed are crude protein, crude fibre and dry matter. PKC can be used to produce chicken feed to substitute corn because it is high in dry matter and rich in crude protein. Dry matter is important for the chicken production and chicken well-being while crude protein is essential for the chicken's growth, egg production and its immunity. The composition is less expensive than the conventional feed in the market and the resource could be saved if the agro-industrial waste used in this project as chicken feed.

Lastly, our final objective is to investigate the growth rate of chicken towards the formulation of chicken feed which shown by the health of chickens and its growth performances. D2 shows the best result in growth performance curve of chickens. D2 was consumed by chickens for 5 months. From the body weight change result, chickens that take D2 as its feed had achieved the highest BWG within the experimental period with 3760 g. D2 has the higher total nutrient content compared to D1. Further research on PKC needs to be conducted to improve and introduce new formulation for chicken feed.

## 5.3 Recommendation

The utilization of the agro-industrial waste is good as it can reduce the negative impact on the environment but several recommendations should be considered in achieved better result.

i. Further studies should be carried out to lowered the crude fibre content in PKC to meet the suitable nutrient requirement of chicken.
ii. Further experiment regarding enzymes should be carried out to improvise the nutrient content in the animal feed.
iii. More research should be done to improve the nutritious content of chicken feed by using another agro-industrial waste by-product.

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# APPENDICES

Appendix A: Formal Letter

Universiti Malaysia PAHANG

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Ruj.Kami (Our Ref.) : UMP.13.011/12.23/1
Tarikh : 22 April 2021

**MOHD FARID BIN ROZI**
**PENGURUS**
**KILANG MAKANAN TERNAKAN (OPF) BUKIT SAGU**
**26130 KUANTAN**
**PAHANG DARUL MAKMUR**

Tuan/Puan

**KEBENARAN UNTUK BELAJAR CARA MEMBUAT PELLET MAKANAN BINATANG**

Dengan segala hormatnya perkara di atas adalah dirujuk.

2. Adalah dimaklumkan, pelajar Ijazah Sarjana Muda dari Universiti Malaysia Pahang (UMP), ingin meminta kebenaran untuk belajar cara membuat pellet makanan binatang di kilang Tuan. Tujuan kami memohon untuk belajar adalah untuk membuat kajian bagi projek penyelidikan kami yang bertajuk "*The Mixing of Solid Waste from Palm Acid Oil (PAO) and Oil Palm Frond (OPF) as a Source of Animal Feed*". Penyelia projek ini ialah Dr. Abdul Syukor bin Abd. Razak dan boleh dihubungi di talian 016-921 1143. Nama pelajar-pelajar adalah seperti berikut:

i. Muhammad Amirul Syafiq bin Nasarudin (TC18024)
ii. Ali Zainal-Abidin bin Mohd.Termizi (TC18061)

3. Untuk makluman Tuan, tujuan pelajar kami memohon untuk belajar cara membuat pellet makanan binatang adalah untuk megetahui cara pemprosesan pellet makanan dari pelepah kelapa sawit yang terdapat di kilang Tuan.

4. Kerjasama dan pertimbangan daripada pihak Tuan adalah amat diharapkan dan diucapkan dengan jutaan terima kasih bagi melancarkan kajian penyelidikan ini.

Sekian, terima kasih

**"BERKHIDMAT UNTUK NEGARA"**

Saya yang menjalankan tugas,

**DR INTAN SUHANA BT MOHD RAZELAN**
Timbalan Dekan Akademik
Fakulti Teknologi Kejuruteraan Awam
Universiti Malaysia Pahang

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Formal Letter to OPF Bukit Sagu Factory

Appendix B: Project Timeline Senior Design Project 1

| ACTIVITY | Week | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
| Briefing Session | | | | | | | | | | | | | | |
| Submit FORM A1 and attend FYP/SDP seminar | | | | | | | | | | | | | | |
| Discussion with SV on the project and task distribution | | | | | | | | | | | | | | |
| Start preparing list of common materials | | | | | | | | | | | | | | |
| Find a journal that similar to title | | | | | | | | | | | | | | |
| Contact Person in Charge in Ministry of Veterinary for inquiry of formulation chicken feed | | | | | | | | | | | | | | |
| Discussion with SV and submit the procurement of common materials to the Head of Technical | | | | | | | | | | | | | | |
| Inquiry at OPF Bukit Sagu Factory regarding process | | | | | | | | | | | | | | |
| Submission of A2 form | | | | | | | | | | | | | | |
| Discussion with SV, prepare the slide presentation and A3 form | | | | | | | | | | | | | | |
| Submission of first draft | | | | | | | | | | | | | | |
| Presentation & evaluation from the panels | | | | | | | | | | | | | | |
| Improvisation of the proposal | | | | | | | | | | | | | | |
| Submission of the final proposal | | | | | | | | | | | | | | |

## Appendix C: Project Timeline Senior Project Design 2

| ACTIVITY | Week | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** |
| Material Purchasing | ■ | | | | | | | | | | | | | |
| Collect PAO from Lepar Hilir 3 Factory | | ■ | | | | | | | | | | | | |
| Set an appointment for manufacturing date | | ■ | | | | | | | | | | | | |
| Manufacturing animal feed at OPF Bukit Sagu Factory | | | ■ | | | | | | | | | | | |
| Chick purchasing (broiler and Kampung) | | | ■ | | | | | | | | | | | |
| Measure and record initial weight and size of chicks before feeding | | | ■ | | | | | | | | | | | |
| Measure, monitor and record weight and size of chicken. | | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | | | |
| Thesis report preparation | | | | | | ■ | ■ | ■ | ■ | ■ | ■ | | | |
| Poster presentation preparation | | | | | | | ■ | ■ | ■ | ■ | ■ | | | |
| SDP 2 presentation | | | | | | | | | | | | ■ | | |
| Final check with SV for thesis | | | | | | | | | | | | ■ | | |
| Correction for thesis report | | | | | | | | | | | | ■ | ■ | |
| Finalize thesis report | | | | | | | | | | | | | ■ | |
| Thesis report submission | | | | | | | | | | | | | | ■ |

Appendix D: Cost Analysis

| NO | Materials | Quantities | Cost (RM) | Total Cost |
|---|---|---|---|---|
| **1** | Conventional Animal Feed (kg) | 100 | RM3.3 | RM330.00 |
| **2** | Formulated Chicken Feed | 100 | RM1.2 | RM120.00 |
| **3** | Chick | 20 | RM 2.50 | RM 50.00 |
| **TOTAL** | | | | RM500.00 |