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

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Thesis submitted in fulfillment of the requirements.
for the award of the degree of
Bachelor of Engineering Technology (Energy & Environment)

Faculty of Civil Engineering Technology

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FEBRUARY 2022

ACKNOWLEDGEMENTS

My greatest wishes and thanks to Allah, The Great Almighty God who gave my bachelor’s degree thesis appropriateness.

I am grateful and would like to express my sincere gratitude to my supervisor, Dr. Abdul Syukor Bin Abd Razak for his ideas, guidance, continuous encouragement, and support in making this research project possible. I appreciate his consistent support from the first day of this project started till these concluding moments. I am truly grateful for his progressive vision during my project, his tolerance of my naïve mistakes, and commitment for my future career. I also sincerely thanks for the time spent proofreading and correcting my mistakes. I am very lucky to have him as my supervisor.

I acknowledge my sincere indebtedness and gratitude to my parents and family members for their incessantly prayers, love, dream, and sacrifice throughout my life. I cannot find the appropriate words that could properly describe my appreciation for the devotion, support, and faith in my ability to achieves my goals.

Special thanks should be given to my friends, lecturers and staff of Faculty of Civil Engineering, Universiti Malaysia Pahang, who helps me in many ways and made my stay at UMP pleasant and unforgettable. I also would like to acknowledge their comments and suggestions, which are crucial for the successful completion of this project.

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 memberi tumpuan kepada menganalisis ciri-ciri sisa minyak sawit dalam pembuatan makanan ayam yang dirumus. Oleh itu, kajian ini juga memberi tumpuan kepada makanan ayam yang dirumuskan dengan menggunakan minyak asid sawit (PAO) dan kek kernel sawit (PKC). Kajian ini juga untuk menyiasat kadar pertumbuhan ayam ke arah perumusan makanan ayam. Dalam eksperimen, ayam daging digunakan dan dibahagikan kepada 2 kumpulan 15 ekor ayam masing-masing 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 42 hari. 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 (jagung).

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 focus on analysing the palm oil waste characteristics in manufacturing formulated chicken feed. Therefore, this study also focuses formulated chicken feed by using palm acid oil (PAO) and palm kernel cake (PKC). This study also to investigate the growth rate of chicken towards the formulation of chicken feed. In experiment, broiler chicken was used and divided into 2 groups of 15 chickens each 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 42 days. 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 (corn).

TABLE OF CONTENT

DECLARATION		
TITLE PAGE		
ACKNOWLEDGEMENTS		**ii**
ABSTRAK		**iii**
ABSTRACT		**iv**
TABLE OF CONTENT		**v**
LIST OF TABLES		**viii**
LIST OF FIGURES		**ix**
LIST OF SYMBOLS		**x**
LIST OF ABBREVIATIONS		**xi**
LIST OF APPENDICES		**xii**
CHAPTER 1 INTRODUCTION		**1**
1.1	Background of Study	1
1.2	Problem Statement	3
1.3	Research Objectives	4
1.4	Scope of Study	4
1.5	Significant of Study	5
CHAPTER 2 LITERATURE REVIEW		**6**
2.1	Solid Waste Management	6
	2.1.1 Agro-Industrial Waste	6
2.2	Palm Oil Industry In Malaysia	9
	2.2.1 Effect of Palm Oil Industry to Environment	11
2.3	Palm Oil Mill Effluent (POME)	12

2.4 Palm Acid Oil (PAO) 13

2.4.1 PAO Characteristics 15

2.5 Palm Kernel Cake (PKC) 16

2.6 Broiler Chicken 19

2.6.1 Poultry Industry in Malaysia 20

2.7 Rice Bran 21

2.8 Limestones, Calcium Carbonate ($CACO_3$) 22

2.9 Corn 23

2.10 Soybean Meal 24

CHAPTER 3 METHODOLOGY 25

3.1 Introduction 25

3.2 Research Workplan 25

3.3 Project Site 26

3.4 Pellet Production 27

3.5 Conduct of Experiment 30

3.5.1 Animal Feed Composition 30

3.5.2 Chicken Monitoring 31

3.6 Measurement of Growth Performance 32

3.6.1 Body Weight Change (BWC) 32

CHAPTER 4 RESULTS AND DISCUSSION 33

4.1 Introduction 33

4.2 Nutrient Intake Value in Diet 33

4.2.1 Crude Protein Requirements 34

4.2.2 Free Fatty Acid (FFA) 35

4.2.3 Crude Fibre Requirements 35

4.2.4 Water Requirements 36

4.2.5 Energy Requirements 36

4.2.6 Vitamin Requirements 37

4.3 Animal Feed Composition 38

4.4 Growth Performance 39

4.5 Body Weight Change (BWC) 43

4.6 Reduction of Waste 44

4.7 Promotes Local Economic Growth 46

CHAPTER 5 CONCLUSION 47

5.1 Introduction 47

5.2 Conclusion 47

5.3 Recommendation 48

REFERENCES 49

APPENDICES 55

LIST OF TABLES

Table 2.1	Characteristics of Palm Oil Mill Effluent (POME)	13
Table 2.2	Quality and Oxidative Parameters of Palm Acid Oils	16
Table 2.3	The nutrient content in the palm kernel and its by-products PKC.	17
Table 2.4	Difference between PKC and OPF Composition, Advantage and Disadvantage	18
Table 3.1	Composition of animal feed.	31
Table 4.1	Nutrient content in PKC and PAO.	33
Table 4.2	Composition for Each Diet.	38
Table 4.3	Weight of chicken D1 and D2.	39
Table 4.4	The comparison of body weight change for chicken.	43

LIST OF FIGURES

Figure 2.1	Percentage share by kind of economic activity.	7
Figure 2.2	Agro-industrial wastes and their types.	8
Figure 2.3	Agricultural waste management functions.	9
Figure 2.4	Amount of palm oil produces in selected countries in 2019.	10
Figure 2.5	Oil palm planted area from 2017 to 2020.	11
Figure 2.6	Palm oil processing flow chart.	14
Figure 2.7	Palm acid oil.	15
Figure 2.8	Broiler Chicken.	19
Figure 2.9	Poultry consumption per capita in Malaysia from 2006 to 2020, with a forecast for 2025.	20
Figure 2.10	Rice bran.	21
Figure 2.11	Limestone.	22
Figure 2.12	Corn.	23
Figure 2.13	Soybean meal.	24
Figure 3.1	Flowchart illustrating the overall outline of work for this study.	25
Figure 3.2	Location of farm where project were conducted.	26
Figure 3.3	Process of pellet manufacturing.	27
Figure 3.4	Feed intake.	28
Figure 3.5	Material silo.	28
Figure 3.6	Mixer.	28
Figure 3.7	Pelletizer.	29
Figure 3.8	Cooler.	29
Figure 3.9	Packaging silo.	29
Figure 3.10	Chicken coop.	30
Figure 3.11	Classification of the chicken by type of diet being fed.	31
Figure 3.12	Flowchart of chicken monitoring.	32
Figure 4.1	Comparison of Nutritive Content in Each Diet. **Error! Bookmark not defined.**	
Figure 4.2	Growth performance curve of D1 and D2 chicken.	41
Figure 4.3	Food and water intake for each broiler per day.	44
Figure 4.4	Percentage of components in FFB.	45

LIST OF SYMBOLS

±	Plus Minus

LIST OF ABBREVIATIONS

BOD	Biochemical Oxygen Demand
BW	Body Weight
BWC	Body Weight Change
CaCO3	Calcium Carbonate
CF	Crude Fibre
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
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

LIST OF APPENDICES

Appendix A:	Formal Letter	56
Appendix B:	Project Timeline Senior Design Project 1&2	57
Appendix C:	Cost Analysis	49

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Each year, agricultural-based industries produce a substantial amount of residue. If these residues are not properly disposed of, they can contaminate the environment and harm human and animal health. Due to the untreated and underutilised nature of the majority of agro-industrial wastes, they are typically disposed of through burning, dumping, or unintentional landfilling. By increasing the amount of greenhouse gases produced, these untreated wastes contribute to climate change (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).

Palm oil industrial waste is among the most major agricultural wastes. Palm oil is commonly used as a food ingredient or feedstock for the pharmaceutical, biodiesel and oleochemical 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 mesocarp fibres, palm sludge cake, 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 producers, contributing significantly to Malaysia 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 countryside is extremely significant in developing countries as a major source of animal protein (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 integrate cheaper and more readily available alternative ingredients 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, local chickens develop at a slower rate than commercial breeds, which can contribute significantly to the distinction of their meat's chemical and physical qualities (Zidane et al., 2018). Although adjusting management systems and increasing the amount and quality of food offered might increase scavenging birds' efficiency, (Zidane et al., 2018) discovered that these chickens are likely to behave differently when exposed to diverse management and feeding systems. Therefore, one of the alternatives to solve waste management problem regarding palm oil industry waste are by converting palm oil industry waste into value added product such as chicken feed. As a result, the availability of nutritious, balanced, and suitable complementary feeds that can increase meat growth and quality (Zidane et al., 2018) and also solve waste management problem in palm oil industry.

1.2 Problem Statement

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. This problem can be solved by utilized the waste from palm oil industry into chicken feed. The wastes that are used in this study from palm oil industry are palm kernel cake (PKC) and palm acid oil (PAO). PKC one of the region's most abundant and potentially low-cost agricultural products. In chicken feeding, PKC is a suitable partial substitute for soybean meal and corn since it contains high crude protein (CP) and varying amounts of various minerals. PAO contains low free fatty acid (FFA), reasonable amount of unsaturated fatty acid and low peroxide value (Azizi et al., 2021). By utilizing the PKC and PAO as one on the ingredient in animal feeds, this could lead to solution in waste management in palm oil industry.

Malaysians consumed roughly 49.3 kg of poultry per capita in 2020. Malaysia was forecasted to consumed around 51.28 kg per capita in 2025 (R. Hirschmann, 2021). This show that poultry consumption in Malaysia will be continue increasing by years. So, to meet the increasing in poultry production in Malaysia, there is a need of using alternative ingredients in local industry. By replacing the imported ingredient in chicken feed such as corn to PKC, this could lead in reducing the dependency to the imported ingredients in chicken feed. Since PKC are a by-product of palm oil extraction in palm oil industry which contribute to 37.7% in agriculture sector from 7.1% (RM101.15 billion) to Gross Domestic Product (GDP) (Vinet & Zhedanov, 2011), this could increase more our country GDP in agriculture sector.

1.3 Research Objectives

In general, this study aims:

i. To analyse palm oil waste characteristics in manufacturing formulated chicken feed.
ii. To prepare formulated chicken feed by using palm acid oil (PAO) and palm kernel cake (PKC).
iii. To investigate the growth rate of chicken towards the formulation of chicken feed.

1.4 Scope of Study

For this research, the parameter that will be analysed in the palm oil waste are free fatty acid, moisture content, and peroxide value. All this parameter is important to be analysed to ensure that the palm oil waste can be used as chicken feed and safe for them. Optimum value of the parameter will ensure that the chicken can grow healthily without any side effects.

In this research, the parameter for preparation of chicken feed is temperature, duration of mixing the ingredients and cooling the chicken feed. The temperature of steam used are 160°C which are optimum temperature to ensure palatability of chicken feed. The duration of mixing the ingredients in the mixer are 10-15 minutes. And lastly, to ensure the chicken feed has no moisture, the chicken feed will go through the cooler using conveyer belt before transfer to final step which is packaging silo.

In this research, thirty broiler chicks are used and divided into two groups (A and B) which are being fed with different feeds; A will be fed with chicken feed which are already sold in market and B will be fed with 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 8th 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. Thirty chicks were fed with the feed (fifteen 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 significant of this study is the reduction of the agro-industrial waste by utilizing the wastes to produce animal feed because waste like palm kernel cake and palm acid oil are abundance after being process by the mills. Because of its availability and cost-effectiveness compared to conventional feedstuffs, the inclusion of oil palm industry products and co-products as a non-traditional alternative food source for poultry is of paramount importance in tropical countries (Saminathan et al., 2020). As the meat demand from poultry industry increasing, the alternative for the chicken feed is needed to meet the demands. This also will help to reduce our dependency on imported chicken feed ingredients. From this study, the significant can be contribute to the public, which will create a job opportunity in our country especially in palm oil industry and chicken feed manufacturing industry. From economic point of view, this will helps increase Malaysia’s income because the utilisation uses of waste in palm oil industry to chicken feed. The utilization of PKC and PAO can produce a chicken feed that nearly exact with nutrients chicken feed with corn and rice bran. From palm oil industry perspective, the utilization of agro-industrial waste into chicken feed will helps reduce the cost of disposal of waste, reducing negative impact to the environment and most important a best solution for waste disposal is created.

CHAPTER 2

LITERATURE REVIEW

2.1 Solid Waste Management

Solid waste management (SWM) is becoming a major challenge in global development plans, especially in increasingly growing cities. Malaysia is one of the most successful transition countries. Malaysia's most important environmental concern is solid waste management, with landfilling serving as the principal disposal technique for the country's annual increase in solid waste generation (Moh & Abd Manaf, 2017). Due to advancements in living standards, it is unavoidable that solid waste generation would increase over time if Malaysians' attitudes and behaviours toward waste management do not change. Even though other methods of handling and reducing solid waste exist, the future of solid waste management remains unclear. Unsurprisingly, the amount of available land is becoming scarce, considering the world's increasing population increasing every year. Improper collection services (such as low collection coverage, irregular schedule for collection services), illegal dumping, and scavenging activities are typical solid waste management companies had to deal with (Moh & Abd Manaf, 2017).

2.1.1 Agro-Industrial Waste

Every year, agricultural-based industries generated a massive amount of residues (Sadh et al., 2018). If these wastes are not properly disposed of, they may lead to pollution and have a negative effect on human and animal health. Although the residues are numerous, they have such a high nutritional potential that they are taken into account during quality control and classified as agro-industrial by-products (Sadh et al., 2018). Due to its proximity to the equator and proximity to the sea, Malaysia's climate is classified as hot, wet, and rainy throughout the year. Malaysia is ideal for agricultural activities such as plantation, fruits, vegetables, and other crops due to its high temperature and humidity combined with rain (Neh & Ali, 2020).

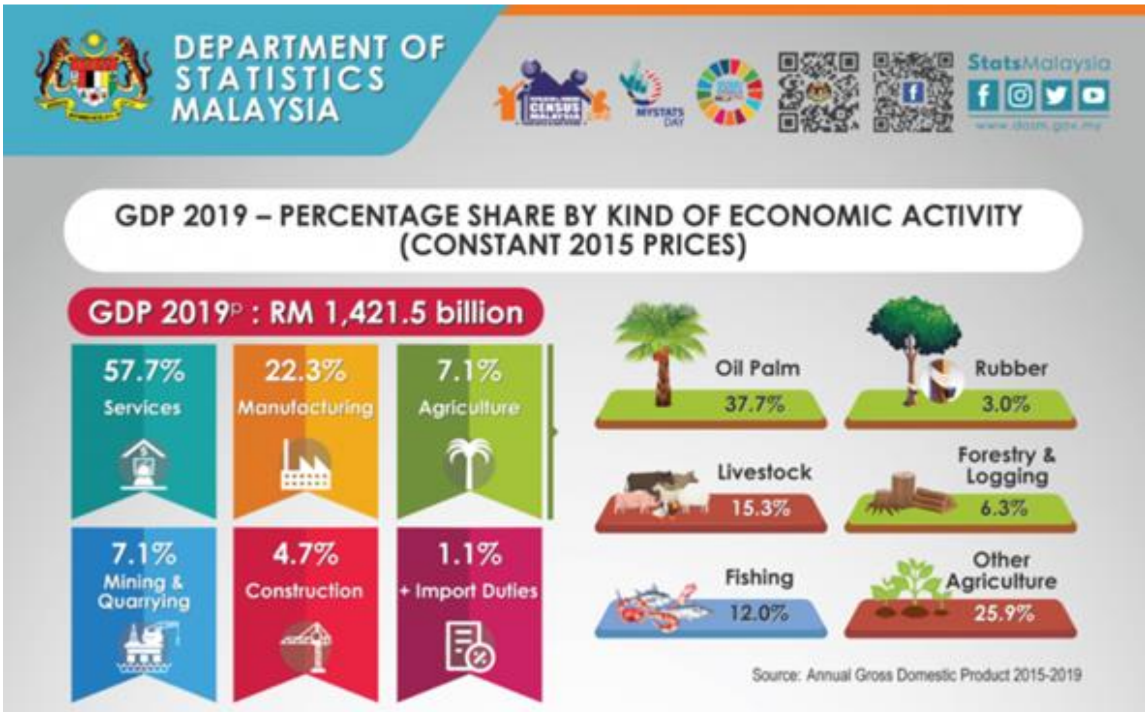

Figure 2.1 Percentage share by kind of economic activity.
Sources: Department of Statistics Malaysia (2020).

Agriculture is a significant industry in Malaysia. For many years, this sector has served as the backbone of the Malaysian economy, producing agricultural products for domestic consumption and earning foreign exchange (Neh & Ali, 2020). According to data from the Department of Statistics Malaysia, agriculture contributed 7.1% (RM101.5 billion) to Malaysia's Gross Domestic Product in 2019. (GDP). Oil palm accounted for 37.7% of agricultural value added, followed by other agriculture (25.9 %), cattle (15.3%), fisheries (12.0%), forestry and logging (6.3%), and rubber (3.0%) (Vinet & Zhedanov, 2011). Agriculture exports increased by 0.9% to RM115.5 billion in 2019, up from RM114.5 billion in 2018.

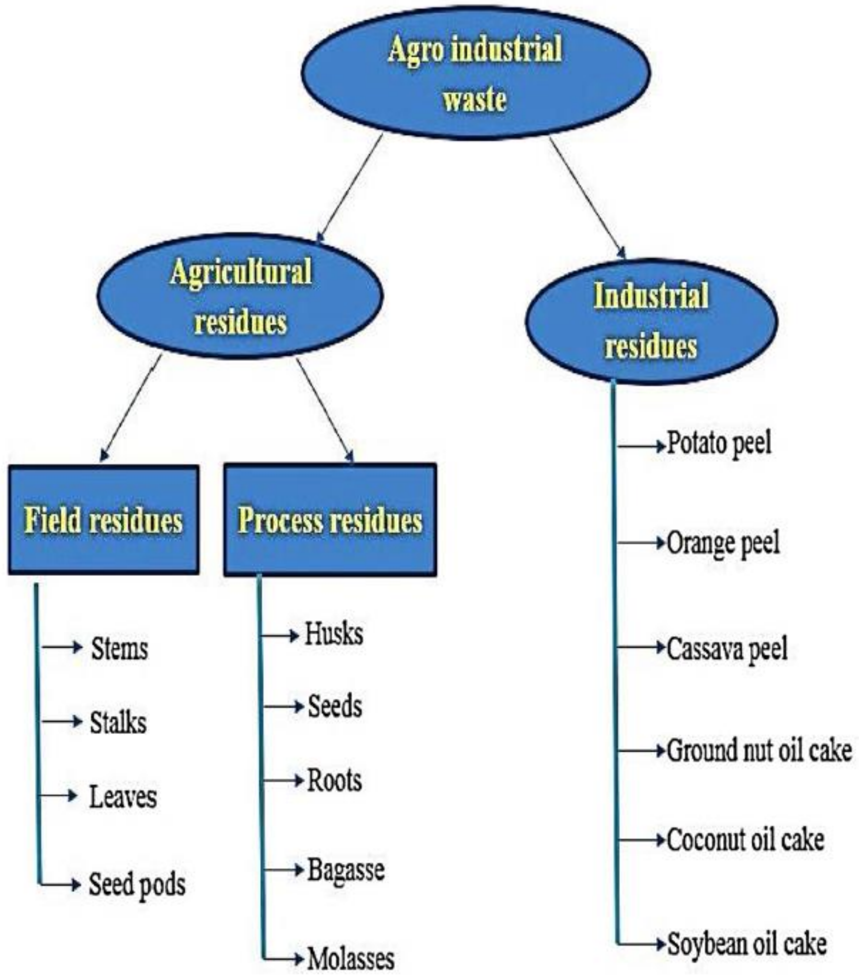

Figure 2.2 Agro-industrial wastes and their types.
Source: (Sadh et al., 2018)

Agriculture residues and industrial residues are two distinct categories of agro-industrial wastes, as illustrated in Figure 2.2. Agriculture residues are classified into two types: field residues and process residues. Field residues are crop harvesting by-products that remain in the field (Sadh et al., 2018). Field residues include leaves, stalks, seed pods, and stems, whereas process residues are those that remain after the crop has been processed into another useful resource. Molasses, seeds, stems, stalks, shells, pulp, peel, and roots, among other leftovers, are used in animal feed, soil development, fertilisers, and manufacturing, among other applications (Sadh et al., 2018). Field wastes are created in vast quantities, the majority of which are discarded.

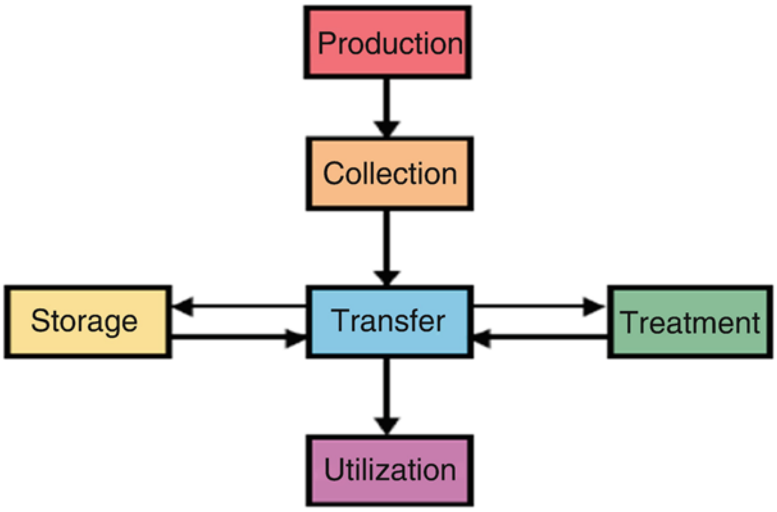

Figure 2.3 Agricultural waste management functions.
Sources: (Obi et al., 2016)

Figure 2.3 illustrates the concept of waste minimization, which aims to reduce the amount and adverse effects of waste generation by reducing waste generation, reusing waste products with simple treatments, and recycling wastes by reusing them as resources to manufacture the same or modified products (Obi et al., 2016). Certain waste items can be recycled or repurposed as raw materials for the creation of other commodities or the same product. The waste reduction concept strives to accomplish effective waste generation minimization by the careful use of goods to minimise trash creation, repeated use of items or portions of items that retain useable characteristics, and the utilisation of waste as a resource (Obi et al., 2016).

2.2 Palm Oil Industry In Malaysia

Palm oil is the world's most traded vegetable oil. Demand for palm oil is increasing due to growing domestic oilseed supplies in India's biggest consumer, as well as increased demand in Europe and China (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).

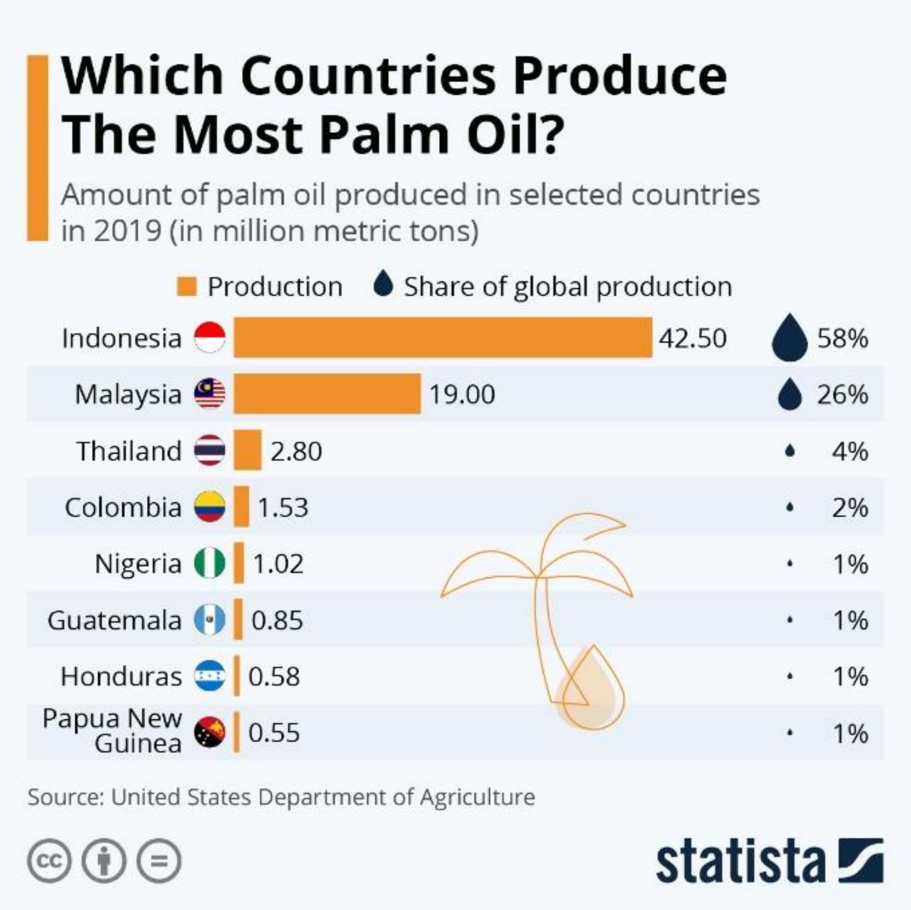

Figure 2.4 Amount of palm oil produces in selected countries in 2019.
Source: (McCarthy, 2020)

Malaysia produces over a quarter of the world's palm oil, making it the world's second largest producer and exporter of palm oil behind 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 unregulated deforestation, obliterating the habitats of several endangered species, including the orangutan, Sumatran tiger, and Sumatran rhino (McCarthy, 2020).

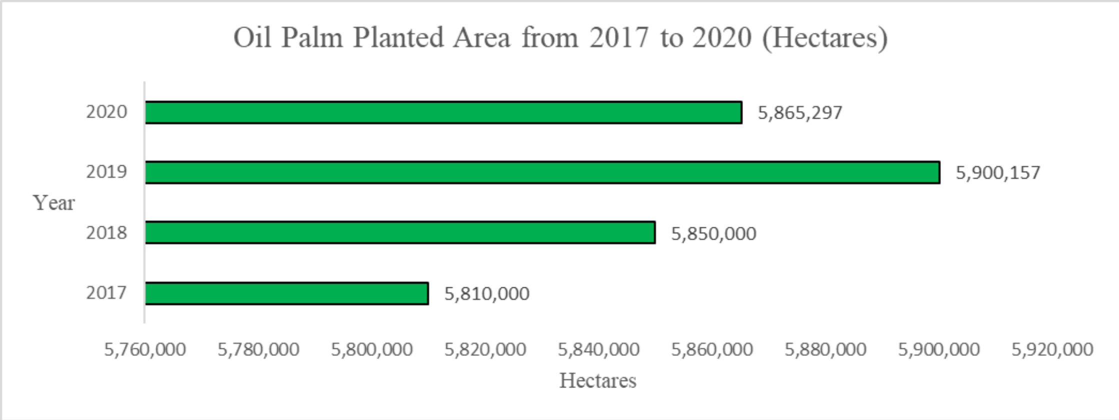

Figure 2.5 Oil palm planted area from 2017 to 2020.
Source: (MPOB, 2020)

To meet demand, the plantation area for palm oil trees is growing year after year. According to data, the oil palm area in 2020 decreased by 0.6% to 5.865 million hectares, down from 5.900 million hectares in 2019 due to global outbreak of COVID-19 pandemic (MPOB, 2020). The decline in palm oil tree area is a result of migrant workers being denied the right to return and continue work in local plantations, which resulted in lower productivity due to the restriction on air travel (BERNAMA, 2020). The palm oil industry expanded as a result of the processing of palm oil fresh fruit brunch (FFB), 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

Due to the land-intensive nature of the oil palm business, it is closely related to the environment. To make space for huge monoculture oil palm plantations, vast areas of tropical forest and other high-value ecosystems have been removed. Numerous endangered animals, including rhinoceroses, elephants, and tigers, have suffered habitat loss as a result of this clearance (World Wide Life, 2020). Forest fires used to clear land for the crop also contribute significantly to greenhouse gas emissions. Intensive g techniques degrade the soil, contribute to erosion, and contaminate the water (World

Wide Life, 2020). Each year, palm oil mills keep increasing, resulting in increased capacity for solid waste or effluent discharge. However, in order to generate 1 tonne of crude palm oil, roughly 5–7 tonnes of water were necessary to disinfect the palm fruit bunches and clarify the extracted oil, resulting in 50% of the water being converted into palm oil mill effluent (POME) (Hesam Kamyab et al., 2018). Due to its high chemical oxygen demand (COD) and biological oxygen demand (BOD), POME is 100 times more contaminated than municipal sewage (COD). Furthermore, the effluent has higher levels of organic nitrogen, phosphorus, and other chemicals (Hesam Kamyab et al., 2018). If adequate management is not applied in palm oil mills, this massive amount of POME will harm the water courses surrounding the mills (Amalina Ishak et al., 2019).

2.3 Palm Oil Mill Effluent (POME)

Raw palm oil mill effluent (POME) contains a lot of organic compounds and residual oil, so it has a lot of biological oxygen demand (BOD) and chemical oxygen demand (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 extracted 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). By-product of palm oil alkaline refinery will be produced palm acid oil (PAO). It is used in the production of animal feed formulations (calcium soap) and also laundry soaps (Amalina Ishak et al., 2019). The properties and composition of PAO can vary depending on the palm oil feedstock and the alkaline refining process.

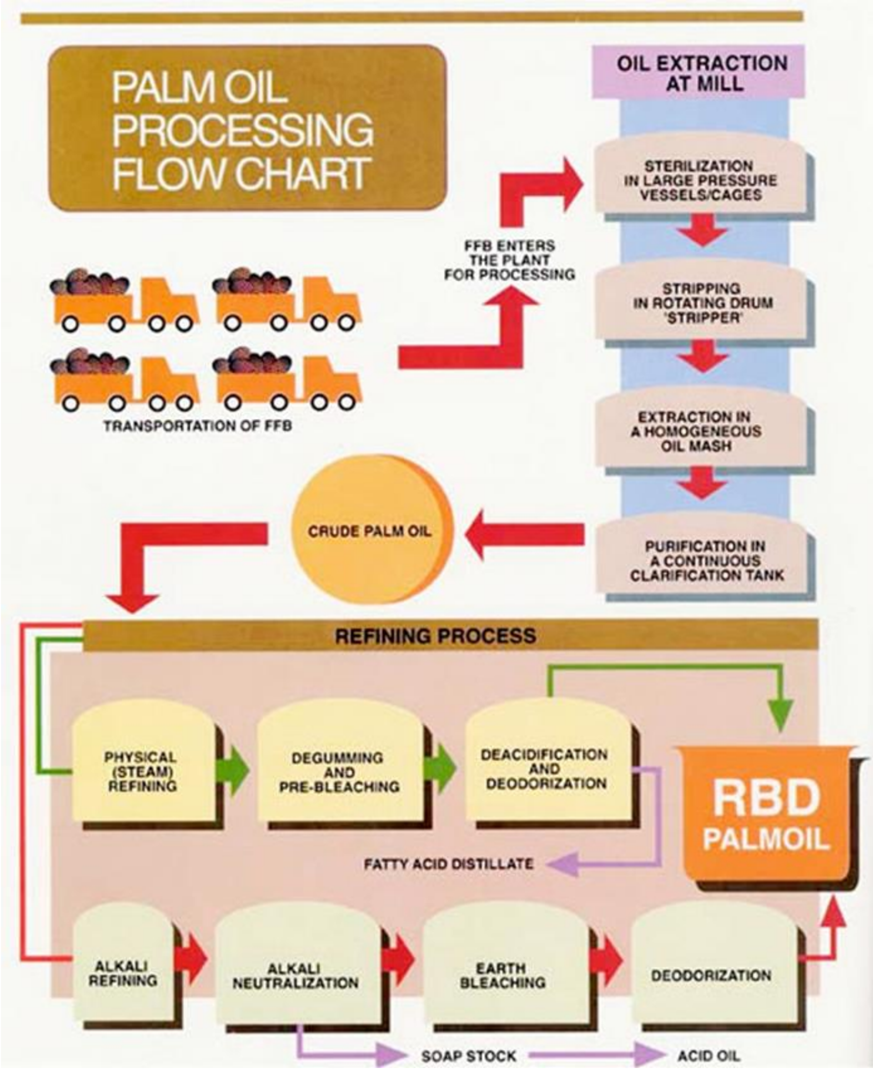

Figure 2.6 Palm oil processing flow chart.
Source: (MPOC, 2019)

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.
Source: (PrimRose, 2018)

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 using expeller presses or solvent extraction, is one of the region's most numerous and potentially low-cost agricultural products. PKC is a viable partial replacement for soybean meal (SBM) and maize in chicken feeding since it provides 14–18% crude protein (CP), 12–20% crude fibre (CF), 3–9% ether extract (EE), and varied levels of various minerals (Azizi et al., 2021). Due to the high fibre content, chicken digestion has been observed to be reduced, making PKC potentially unsuitable for poultry feeding. However, solid-state fermentation (SSF) can be employed to improve the nutritional efficiency of PKC by boosting CP and decreasing CF. PKC has been granted a licence to be used as a component in animal diets. PKC is more competitive in the international meal market due to its nutritious features, competitive pricing in comparison to other meals, and long-term availability (Azizi et al., 2021).

PKC is extracted from palm fruit in two stages: the first extraction of palm oil is from the pericarp portion of the fruit, and the second is the secondary extraction of oil from crushed kernels, which 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 a substitutes feed ingredient that could be used in poultry feeds. Due to the low cost and availability of agricultural by-products such as PKC, they can be utilised in place of standard feed items such as corn and soy beans in chicken diets. Numerous researches on the nutritive value of PKC in monogastric animal feeding have been conducted, with over two-thirds of them focusing on different species of chicken. 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% Crude Protein - 16.7% Crude Fibre - 19.8% Lignin- 13.4% Ash - 4.7%	-High energy source -High quality protein -Balanced material content -Good palatability -Availability -Cost effectiveness -No toxin (Feed, n.d.)	-May content substantial residual oil.
OPF	Dry matter – 88.9% Crude Protein - 5.6% Lignin- 19.9% Ash - 6.0%	-Solving problem of feed shortage -Reduction of feeding, operation and management cost (Ishida & Abu Hassan, 1997).	-Need to be process first before it can be utilized. -70% of the palm oil mill process effluent comes from OPF.

2.6 Broiler Chicken

Broiler chickens are chickens that are bred primarily for the purpose of producing meat. Broiler chickens, which are often a cross between two breeds developed for quick growth, are commonly utilised in factory farms worldwide. Broiler breeds are chosen for their high efficiency of conversion of feed to meat and quick maturation (Richards, 2017). These varieties are distinguished by their white or yellow skin and white feathers, which contribute to the clean finished appearance demanded by commercial markets.

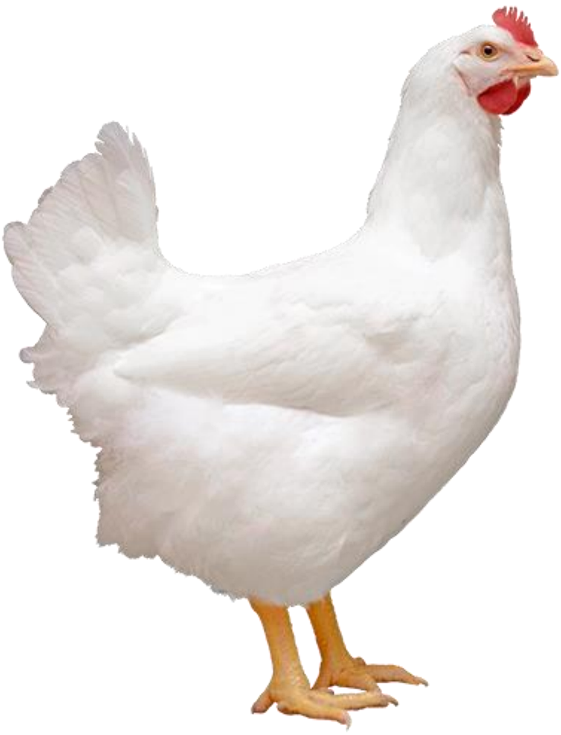

Figure 2.8 Broiler Chicken.
Source: (Cobb Vantress, 2022)

Broiler chickens begin their lives in hatcheries, which incubate and hatch thousands of eggs. Broiler chickens never see their mothers, as they are housed in separate breeding facilities (Richards, 2017). Broiler breeders are housed in facilities identical to those used to rear conventional broiler chickens, in mixed-sex flocks to facilitate natural mating and fertilisation. Eggs are gathered and sent to hatcheries, which is where broiler chicks begin their lives.

2.6.1 Poultry Industry in Malaysia

Broiler farming has grown to be the most important livestock industry in Malaysia, and the meat has become a staple food for Malaysians (Bahri et al., 2019). Additionally, broiler consumption per capita increased from 48.75 kg in 2019 to 49.3 kg in 2020 and it has been forecast to increase to 51.28 kg in 2025 (R. Hirschmann, 2021).

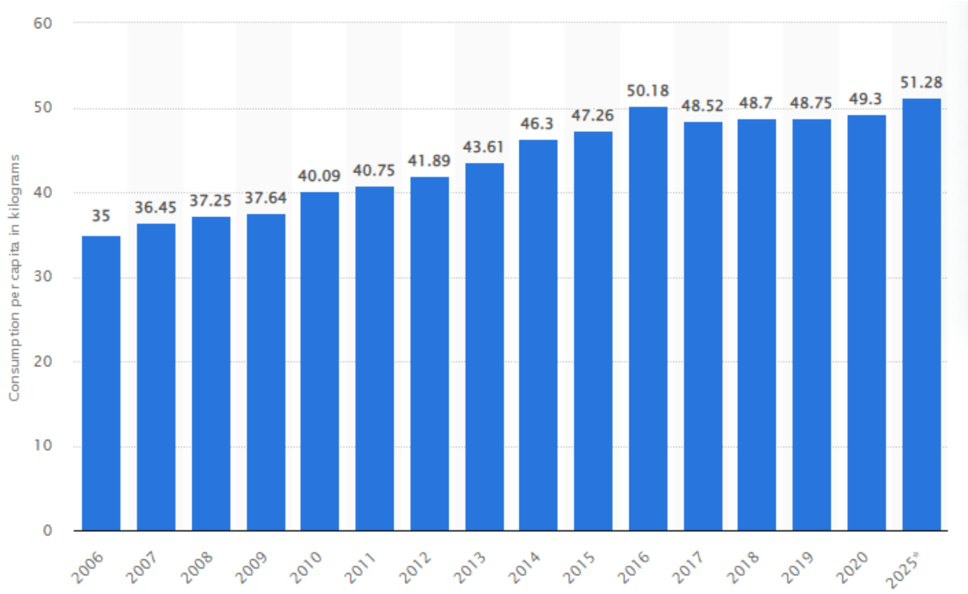

Figure 2.9 Poultry consumption per capita in Malaysia from 2006 to 2020, with a forecast for 2025.

Source: (R. Hirschmann, 2021)

The industry is exposed to various of factors that can have an effect on farmers' profit and loss accounts and viability, including a heavy reliance on imported raw materials for animal feed, the price of which is typically unstable (Bahri et al., 2019). This is because the broiler industry consumes approximately 4 million tonnes of imported soybean and corn on annual basis (Bahri et al., 2019). Both ingredients are imported from South America, and their prices are subject to fluctuation due to currency exchange rates, which affect the price of chicken.

Three factors contribute to the annual increase in broiler production costs. The first factor is an end to fuel subsidies (Bahri et al., 2019). With the rising cost of fuel, the cost of raw materials for chicken feed will rise as well. Additionally, the implementation of minimum wages for farmers will have an effect the production cost. Finally, the Ringgit Malaysia's depreciation contributed to the increase in production costs (Bahri et al., 2019). As a result, Malaysia needs to strengthen its capacity to produce chicken feed independently, utilising optimal technology and natural resources, rather than relying on other countries.

2.7 Rice Bran

Rice bran, a by-product of the rice milling process, accounts for 10% of global rice production of 48 million tonnes per year. Rice bran is often used as animal feed or is dumped as waste material (Alauddin et al., 2017). Rice bran is attracting researchers' attention because to its high nutritional content, which includes protein, fat, carbs, and bioactive substances and dietary fibre which are widely available and also cheap. Rice bran composition varies depending on rice variety, geographical conditions, and processing methods (Alauddin et al., 2017). Rice bran, the outer layer of the rice grain, accounts for 8–10% of the grain's overall weight but includes the majority of the grain's nutrients: carbs (34%–62%), lipids (15-20%), protein (11%–15%), crude fibre (7–11%), and ash (7–10%). Rice bran assists in poultry food digestion. Dietary fibres aid in the faster and more effective absorption of nutrients, improving the animal's general health and attractiveness. Rice bran aids in the improvement of their immune systems, thus lowering their risk of getting sickness (WestGrains Trading, 2019).

Figure 2.10 Rice bran.
Source: (WestGrains Trading, 2019)

2.8 Limestones, Calcium Carbonate ($CACO_3$)

Limestone, calcium carbonate ($CaCO_3$) is a dietary supplement for livestock. Limestone is largely utilised as a calcium source in livestock feed (Son Ha Minerals Co Ltd, 2018). Limestone comes in a variety of compositions. The most abundant chemical in the body is calcium. The skeleton and teeth contain 98% of the body's calcium, which accounts for around 2% of the animal's weight. Calcium is required by animals for tooth and bone production, nerve transmission, muscle excitability, heart control, blood coagulation, and enzyme activation (Son Ha Minerals Co Ltd, 2018).

Pigs, beef, poultry, and sheep can all benefit from limestone in their diets. Calcium is required by all types of livestock; however, the amount required varies according on age and also environment. For young animals, a calcium deficit can cause abnormal bone growth and retard general growth. Although limestone does not require a holding period, it should be stored in a dry location away from direct sunlight (Son Ha Minerals Co Ltd, 2018).

Figure 2.11 Limestone.
Source: (Son Ha Minerals Co Ltd, 2018)

2.9 Corn

Corn, also known as maize, is widely recognised around the world as a major energy feed ingredient in poultry diets (Dei, 2017). Corn is usually always a major component of processed animal feed. Due to the energy contribution, the content level (60-80%), and the minimal variability of its chemical composition, it is a desirable ingredient for animal food manufacturers (Dacsa Group, 2019). Corn are either fed directly to poultry or thoroughly mixed with other ingredients. The mixture is then fed to or converted into the forms preferred by specific animals (Dei, 2017). Corn is the easiest grain for animals to digest and low in fiber (Jacquie Jacob, 2020) .

Figure 2.12 Corn.
Source: (Dei, 2017)

2.10 Soybean Meal

Soybean meal is a by-product of soybean oil extraction. Soybean meal is the most important protein source for poultry, livestock, and ruminant animals. Protein, fibre, and fat levels all vary depending on how the oil is extracted. Soybean meal considered as outstanding source of supplemental protein in diets for poultry, it is rich in highly digestible protein (Cromwell, 2017). Soybean meal contains between 44% and 49% protein, is highly digested, and the amino acids produced from the protein are excellent for nonruminants (Cromwell, 2017).

Figure 2.13 Soybean meal.
Source: (Cromwell, 2017)

CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter presents the detailed description of materials, equipment, methods and data analysing of pellet production and chicken monitoring. Observation of every method must be done carefully to conclude the relationship of factors and levels in data analysis.

3.2 Research Workplan

For the preliminary stage, the project is focusing on the objective of the studies where preparation of formulated chicken feed by using agro-industrial waste from palm oil industry that can reduce the negative impact towards environment by utilizing selected potential wastes. To ensure this objective is successful, project planning that need to be done are selection of where to take the agro-industrial waste, method used to generate chicken feed formulations and identify best method to conduct the experiment.

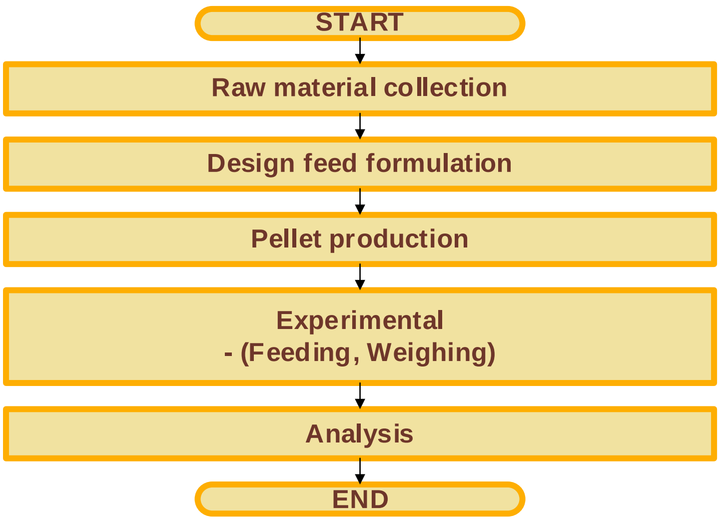

Figure 3.1 Flowchart illustrating the overall outline of work for this study.

This second stage is also stage where the type of chicken is determined. The type of chicken that is chosen are Broiler (Ross breed). This type of breed is chosen due to high Food to Meat Conversion Ratio. The weight of broiler can be found around 1.5 kg until 3.0 kg for matured broiler.

For the collection and analysis part, all the chickens are weighed before fed with chicken feed. One type of group is fed using formulated chicken feed. Meanwhile, the other one is fed with regular chicken feed which is corn. The data was collected for 42 days equal to 1 month and 12 days. The weight and condition were observed.

Moving on to the last stage which is result and discussion. This is the stage where the objective of this project will be discussed based in the data gathered. The effectiveness of the formulated chicken feed is determined and discussed.

3.3 Project Site

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

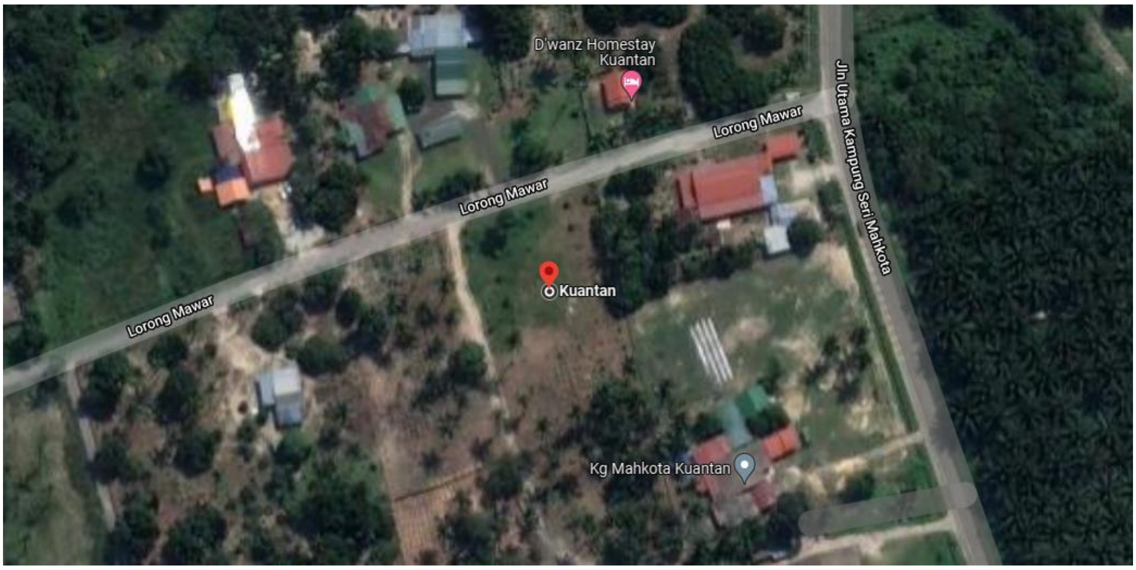

Figure 3.2 Location of farm where project were conducted.
Source: (Google Maps, 2021)

3.4 Pellet Production

Before the pellet production began, the raw materials were collected and weighted according to the composition that has been formulated with guidance of Kilang OPF Bukit Sagu manager. All the material was placed into the silo storage via bucket elevator. Each material was weight according to desired ratio and moved the material into the mixer. When the material is moved by the conveyer, the PAO was added. In the mixer, the material is mixed together for 5 to 7 minutes to ensure the material are mix evenly.

Next, the mixture is moved into pelletizer where steam was added and mix evenly for 15 to 20 minutes to soften the mixture and ensure pelletability between materials. After that, the mixture moved to pelletizer where the mixture is turn into pellet and cuts into the desired size by using mould. The pellet is sent to the cooler and let cool for 15 minutes. The cooler acts as exhaust fan to release heat and remove the dirt from the pellet. The pellet then sent to packaging silo for packaging process. The pellet production setup used in this project is shown in Figure 3.3.

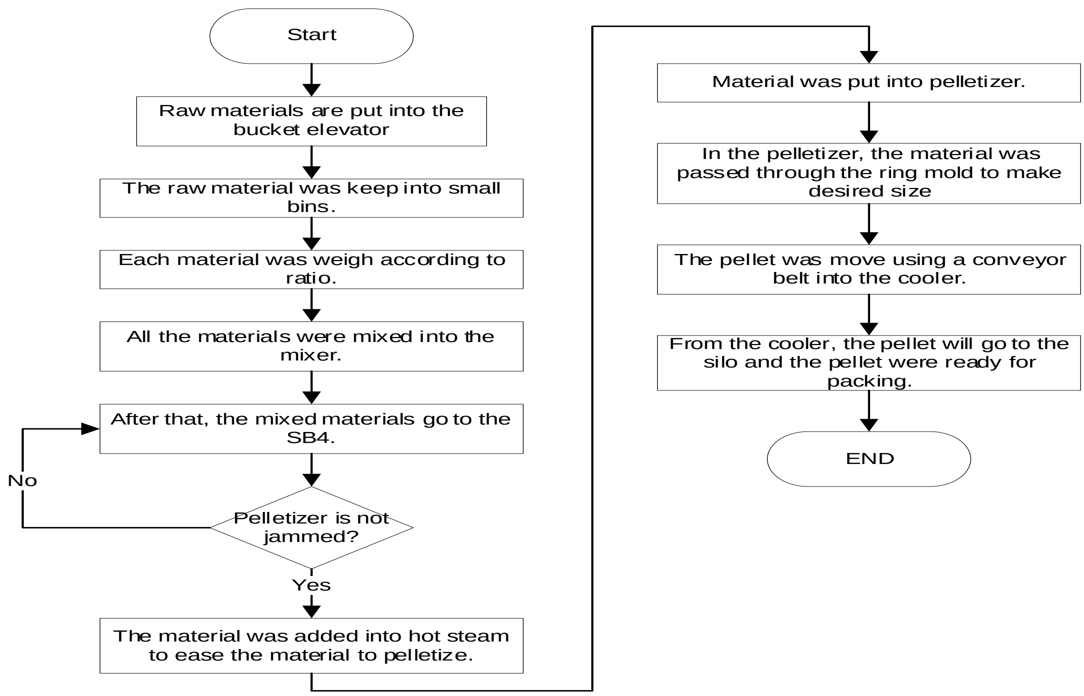

Figure 3.3 Process of pellet manufacturing.

Figure 3.4 Feed intake.

Figure 3.5 Material silo.

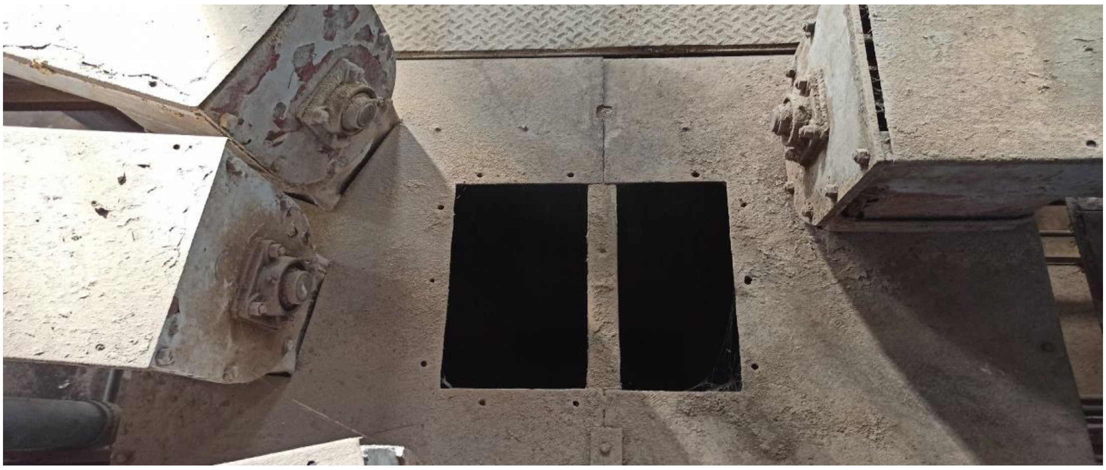

Figure 3.6 Mixer.

Figure 3.7 Pelletizer.

Figure 3.8 Cooler.

Figure 3.9 Packaging silo.

3.5 Conduct of Experiment

Each type of feed was fed to 15 chickens aged 2 days with the average weight 49 ± 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. The chicken coop covered with sun shade netting to prevent from direct sunlight because it may increase body temperature that will hinder their growth. Figure 3.10 shows the chicken coop with separated section.

Figure 3.10 Chicken coop.

3.5.1 Animal Feed Composition

The animal feed for the chickens is set into 3 categories. First category is the conventional chicken feed which are corn that are being sold in the market. The second category is the factory formulated of palm kernel cake with addition of palm acid oil to improve the nutritional content in the animal feed. The third category is the factory formulated of palm kernel cake only. Table 3.1 show three different type of diet for the chicken. Diet 1 and Diet 2 were chosen to be the experimental feed for the chicken. The

Diet 2 were selected to be used as an animal feed compared to the Diet 3 because the project was to identify the nutritional value of PKC and PAO and its effects towards the performance of chicken growth within stipulated time. Diet 1 was used as a control diet for the chicken.

Table 3.1 Composition of animal feed.

Diet 1 (D1) **(Control feed)**	**Diet 2 (D2)** **(Factory formulation + PKC + PAO)**	**Diet 3 (D3)** **(Factory formulation + PKC)**
- Corn 100 kg	- PKC 83.75 kg - Rice bran 10.50 kg - Soybean meal 2.80 kg - Corn 1.90 kg - Limestone 0.95 kg - PAO 0.04 kg	- PKC 83.75 kg - Rice bran 10.50 kg - Soybean meal 2.80 kg - Corn 1.90 kg - Limestone 0.95 kg

3.5.2 Chicken Monitoring

The chicken will be fed throughout a day. All chicks will have easy access to water since water is important to maintain their body temperature. The chicken weight is taken and size of chicken are recorded for their initial measurement. Then, the chickens are put in a two separate partition depends on their type of diets. After that, the chicken's condition will be monitor weekly and their weight and size are recorded.

D1

D2

Figure 3.11 Classification of the chicken by type of diet being fed.

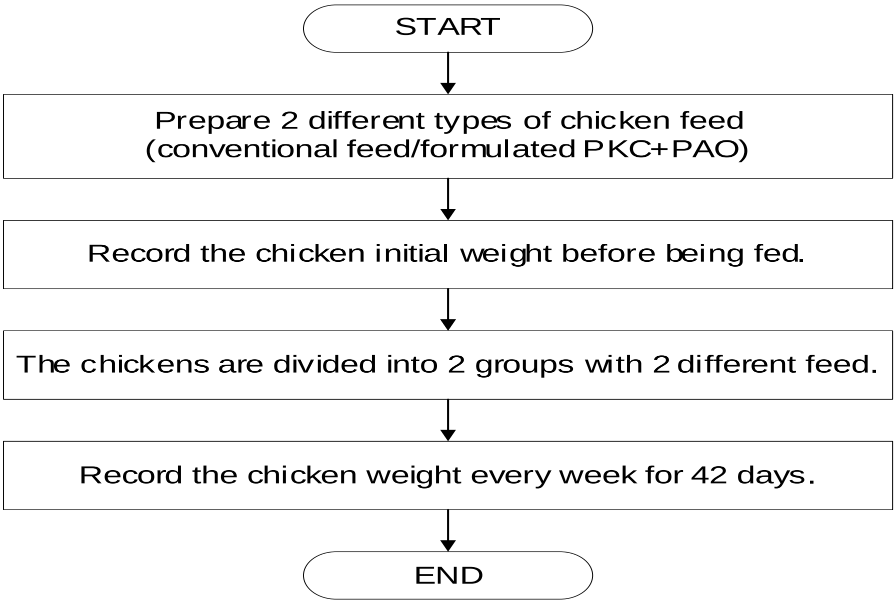

Figure 3.12 Flowchart of chicken monitoring.

3.6 Measurement of Growth Performance

One parameter associated with growth performance were determined in this project which consists of body weight change (BWC).

3.6.1 Body Weight Change (BWC)

The parameter to assess the growth performance is BWC. Initial body weight of the chicken was taken at the beginning of the project before feeding process. BW gain of each animal was recorded at 5 days interval and was continued for 42 days. The value recorded was compared between chicken that applied with D1 and D2. Further illustration was shown in Figure 3.11. The chicken was weighed for every 5 days by using a weighing scale. The BWC gain was calculated by difference between the final BW and initial BW of the individual's chickens.

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

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Introduction

In this chapter, all data collected is summarized where quantitative data is presented with the help of tables, graphs and brief explanation. The data will answer the project methodology as discussed in the previous chapter. This chapter will begin with the discussion of primary data collection. After that, discussion and implication of findings to the theory and practices are also discussed. The result and discussion will answer the objective of this project and solve the problem from the problem statement. Analysis of experimental data involving present data in a significant way by the uses of tables, graphs or charts.

4.2 Nutrient Intake Value in Diet

Table 4.1 Nutrient content in PKC and PAO.

Nutrient	**Type of Material**			
(%)	**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

Table 4.1 shows the nutrient content of each diet in the chicken feed. PKC and corn nutrient content were compared because these two contents are the main ingredients that will be used in the production of chicken feed. Dry matter content in D2 was 87.3%, D3 was 90% and commercial PKC was 85% compared to corn only 53.71%. Chicken need to consume dry matter to maintain health and production. Crude protein in D2 was

higher than corn which show 16.1% and 8.64% respectively but still lower from D3 which was 17%. Figure 4.1 shows the comparison of the nutritive content in each diet.

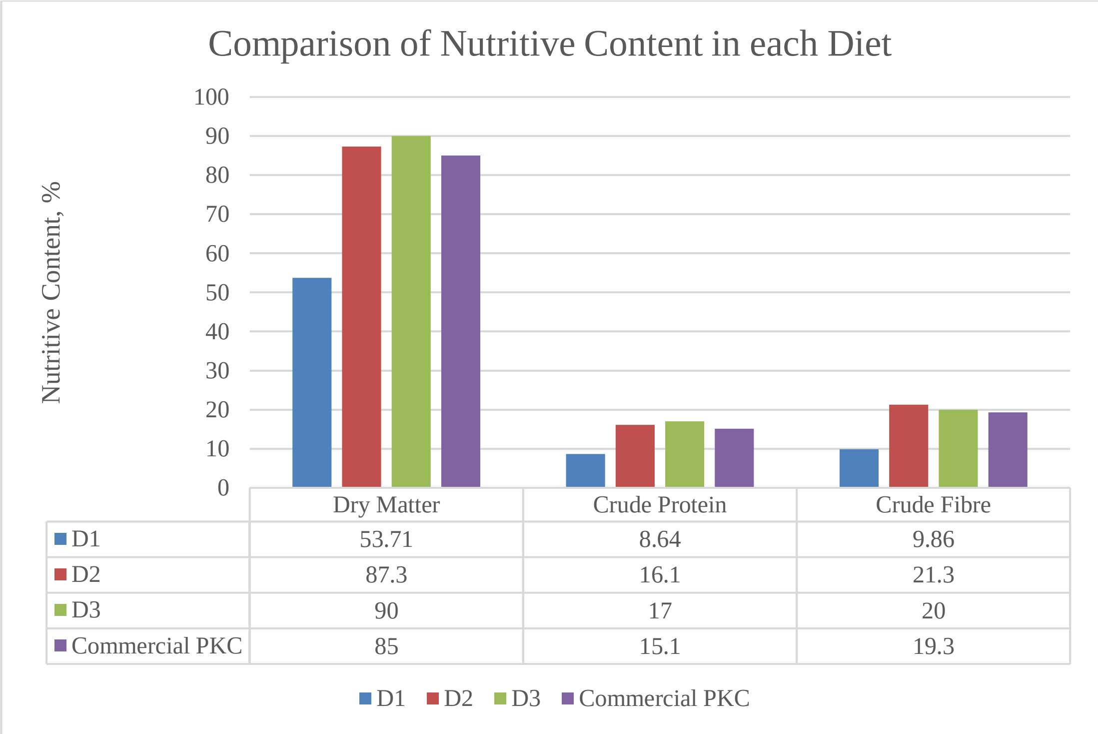

Figure 4.1 Comparison of Nutritive Content in Each Diet.

4.2.1 Crude Protein Requirements

Crude protein in D2 was higher than corn which show 16.1% and 8.64% respectively but still lower from D3 which was 17%. Crude protein is important ingredient in poultry diet because it is essential for chicken growth, egg production and immunity. For the crude fibre, the content in PKC are relatively higher compared to corn which show 21.3% and 9.86% respectively. Crude fibre is needed in poultry diet because it helps to preserve healthy digestive system. This are supported by Yeong (1983) stated that crude protein content in PKC can be used in chicken diets but only to low levels which is 10-20%. Crude protein which is composed of amino acid play an important role in utilization of PKC as animal feed due to its quality and digestibility (Yeong, 1983). Yeong (1983) also report the crude protein content in PKC is 16.06% which are similar to crude protein content in D2. Additionally, the diet must include adequate nitrogen to enable for the synthesis of non-essential amino acids. Purified essential amino acids (e.g., DL-methionine and L-lysine) are often added to the diet to reduce the overall protein content of the diet (Fagundes et al., 2020). Methionine is an important amino acid that is required for appropriate tissue development, as well as optimal cellular and molecular activities and immune system regulation.

4.2.2 Free Fatty Acid (FFA)

Free fatty acid (FFA) content in PAO ranges between 50-65%. FFA in chicken diets could be used up to 15% as it will led to fatty acid (FA) absorption and shown good performance results to the diets (Rodriguez-Sanchez et al., 2019). Due to high energy content needed in animal feed, supplementary fats are commonly used to meets energy requirements in poultry diets. Different fat sources are available and can be utilised in poultry diets (Rodriguez-Sanchez et al., 2019). Food fat by-products from the edible oil refining industry are a cost-effective alternative to conventional fats that may be used as a feed fat addition. From this statement of Rodriguez-Sanchez et al. (2019), the PAO are suitable as an additive ingredients or sources of animal feed.

4.2.3 Crude Fibre Requirements

Due to its negative effects on nutrient digestion, crude fibre (CF) was regarded an antinutritional component. However, scientists have discovered that CF has significant effects on the development of the gastrointestinal tract (GIT), digestive physiology comprises nutrient digestion, fermentation, and absorption processes in poultry (Jha & Mishra, 2021). It may aid in the preservation of the large and small intestines by enhancing mucosal structure and functions and boosting the number and variety of commensal bacteria in the GIT (Jha & Mishra, 2021). Increasing CF content can escalate digestive physiology by increasing GIT development and also enzyme production. Addition of fibre at a moderate amount in chicken diets also affects poultry growth performance. It assists gut health by increasing immune activities and regulating beneficial bacteria in the large intestine. From Jha & Mishra (2021) statement, CF in PKC are important nutritive content needed in poultry diet.

4.2.4 Water Requirements

Figure 4.1 show the comparison of nutritive content in each diet. To maintain chicken body temperature and smooth digestion of the chicken feed, the chickens will have unlimited access to fresh water. Water accounts for two-thirds of adult animal body mass and more than 90% of new born (Cherian, 2020). Water is a universal solvent inside the body, facilitating cellular biological activities such as digestion, absorption, and nutrient transfer (Cherian, 2020). The aqueous medium of water allows different digestive fluids and food components to interact, increasing digestion, and helps in the expulsion of waste products in the form of urine, faeces, and sweat from the animal body (Cherian, 2020). Because of water's high specific heat, it aids in body temperature regulation by absorbing heat generated by various metabolic reactions. Water also controls body temperature by evaporating as perspiration or transporting heat away from organs via blood (Cherian, 2020). Water gives bodily cells form. Water aids in the maintenance of the body's acid-base balance. Water functions as a cushion for tissue cells and the nervous system, protecting them from shocks and accidents.

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 Nutrient Requirement for Broiler.

Source: (Klasing, 2015)

Dietary energy is essential for producing feed for animals because it is required for all elements of the animal's life. For feed formulation in poultry, apparent metabolise energy (AME) and true metabolise energy (TME) values have been applied (Wu et al., 2020). Poultry may alter their feed intake across a wide variety of feed energy levels to suit their daily energy requirements. Energy requirements and, as a result, feed intake change greatly depending on external temperature and level of physical activity. Figure 4.2 show energy requirement for broiler which is 3200kcal/kg. Klasing (2015) state that high amount of amino acids, vitamins and minerals in chicken feed are needed to ensure daily energy requirements for poultry is met. Since, PKC has high value of amino acid (CP) which are 16.1%, so it suitable to be used as main ingredient in chicken feed.

4.2.6 Vitamin Requirements

Vitamins are dietary substances that are required for vital cellular functions such as development, growth, and metabolism. Apart from these typical duties, vitamins A, D, E, and C are critical for the proper functionality of the immune system, since their shortage has been shown to affect both innate and adaptive host responses (Shojadoost et al., 2021). Given the immune system's critical role in illness prevention and good development, a critical goal in poultry production is to breed chickens with competent immune systems. This aids in pathogen protection.

The antioxidant vitamins A, D, E, and C have been shown to have the greatest influence on immune system function through a variety of ways. Vitamin A is involved in a variety of immune-related actions in chickens and mice, including the strengthening of mucosal immunity and the decrease of free radicals. Vitamin D is also well-known for its anti-inflammatory properties, since it lowers proinflammatory cytokines. Vitamin E exerts significant antioxidant and anti-inflammatory properties, as well as increasing the quantity and activity of immune system cells and stimulating antibody production in response to chicken vaccination (Shojadoost et al., 2021). Vitamin C is also well-known for its antioxidant and anti-inflammatory properties, making it advantageous in hens suffering from oxidative stress or infection (Shojadoost et al., 2021).

In this project, D1 and D2 will be used to show the differences in nutritive content will affect the performance of chicken growth. The chicken that was fed by both diets will be monitored. From this discussion, the objective to analyse palm oil waste characteristics in manufacturing formulated chicken feed has been achieved since PKC and PAO are proven beneficial by-product that can utilized as alternative ingredients for poultry feed due to its higher nutritive contents.

4.3 Animal Feed Composition

Table 4.2 Composition for Each Diet.

Diet 1 (D1) (Control feed)	**Diet 2 (D2) (Factory formulation + PKC + PAO)**	**Diet 3 (D3) (Factory formulation + PKC)**
- Corn 100 kg	- PKC 83.75 kg - Rice bran 10.50 kg - Soybean meal 2.80 kg - Corn 1.90 kg - Limestone 0.95 kg - PAO 0.04 kg	- PKC 83.75 kg - Rice bran 10.50 kg - Soybean meal 2.80 kg - Corn 1.90 kg - Limestone 0.95 kg

From the Table 4.2, D1 chicken will be fed with 100% of corn only which are control diet, D2 chicken will be fed with a mixture of PKC, rice bran, soybean meal, corn, limestone and PAO while D3 chicken will be fed with a mixture of PKC, rice bran, soybean meal, corn and limestone. The formulation of D2 and D3 mixture are the optimum amount of ingredients that has been developed by the Kilang OPF Bukit Sagu manager after several times of trial to get maximum nutrient content and ensure pelletability of the chicken feed. Since the project, focused on mixing of PKC and PAO as a source of animal feed, D2 has been chosen compared to D3 due to unpresented of PAO in D3. From this discussion, the objective to prepare formulated chicken feed by using palm acid oil (PAO) and palm kernel cake (PKC) has been achieved.

There were no issues by feeding 100% of corn for livestock however availability of corn is limited in the market. Datuk Seri Ahmad Shabery Cheek said at Livestock Asia 2018, “Mostly corn that used in Malaysia for poultry feed are imported from South America countries and usage of PKC in chicken feed can reduced country’s dependency on imported corn by 30-40%” (Byrne, 2018). The imported corn has no fixed price due to foreign exchange transaction which could affect the price of the chicken to be increasing.

4.4 Growth Performance

Among all the chicken breeds used for meat production, poultry chickens have the highest body weight and the fastest growth rate. A faster growth rate suggests that the chicken may reach market weight sooner. Continuous refinement of the feeding method and management system may eventually result in an even quicker growth rate. After the weight of each chicken was obtained, the different weight in each 5 days was calculated and shown in to compare the body weight for chicken that fed with D1 and D2 until chicken reach matured age which are 42 days. The difference weight is use to tabulate the growth performance curve that indicate the growth of the chicken. Table 4.3 show the weight of poultry chicken, weight in grams and tabulated for every 5 days until its reached 42 days.

Table 4.3 Weight of chicken D1 and D2.

Age (Days)	Weight in grams (g)		Photo
	D1	D2	
2	49	49.5	
5	57.5	60.7	

10	100	173.7	
15	335.9	367	
20	706.7	727.4	
25	907	1100	
30	1000	1500	
35	1300	1900	
42	1580	2000	

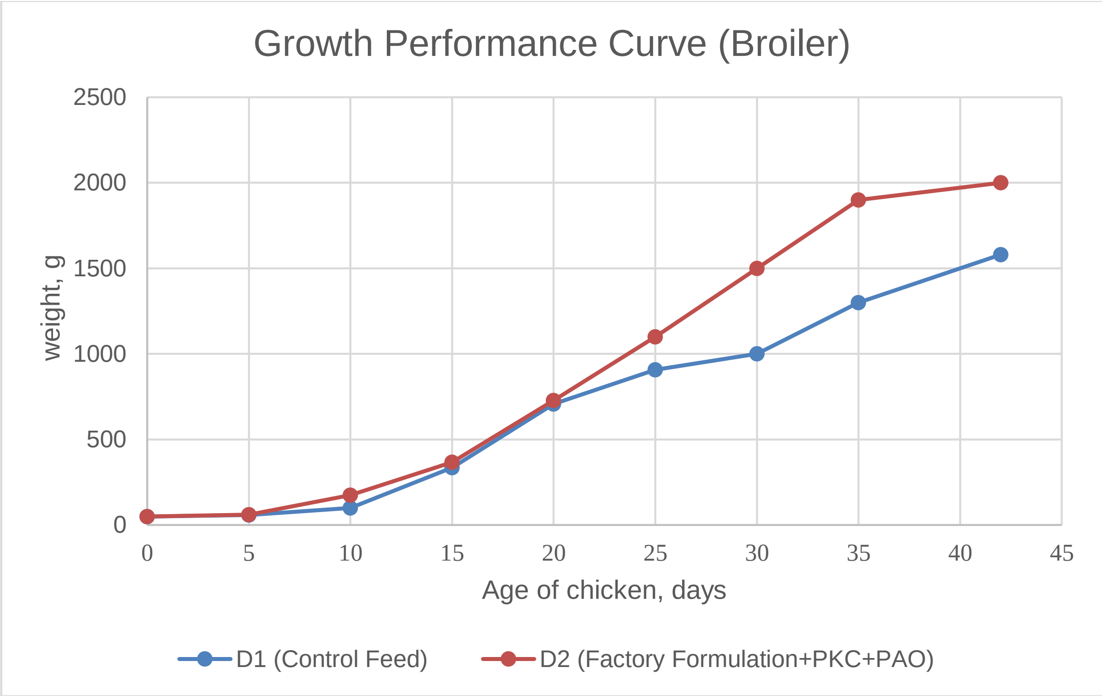

Figure 4.3 Growth performance curve of D1 and D2 chicken.

From the figure 4.2, it shows the effect of both type of diet on the growth performance of chickens during the experiment period. All chicken has a good growth performance. However, in this project is to investigate the growth rate of the chicken towards formulated chicken feed by comparing with control feed which are corn. When a livestock did not get an effective feed, the growth would be slower and good nutrient intake proves to give best effect towards growth of the chicken. At day 20, the weight of the chicken that fed with D2 show a weight of 727.4 g, while data from Rohaya et al. (2017) at day 21 of chicken being fed with premium grade PKC show a weight of 785-800 g which are almost similar to the weight of chicken being fed with D2. This proves that the uses of solid waste PKC are suitable to substitute imported ingredients from other countries and also increase utilisation of local agro-industrial waste (Rohaya et al., 2017).

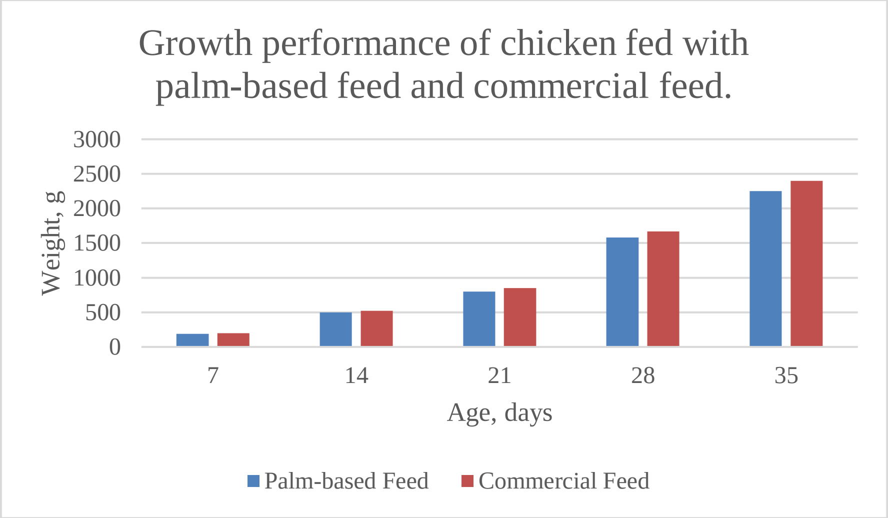

Figure 4.4 Growth performance of chicken fed with palm-based feed and commercial feed.

Source: (Rohaya et al., 2017)

Figure 4.3 shows that there were no significant changes in growth performance between the two diets until Day 21. The large difference in Day 21 could be owing to the weight increment factor being more prominent for commercial feed compared to palm-based feed. Rohaya et al. (2017) also stated that using observation during this period, the size and weight of male birds was greatly enhanced due to environmental factors as well as cross-breeding of free-range chicken strains. From the data of this project in comparison with the data with Rohaya et al. (2017), 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.

Economically, poultry chicken fed with D2 can develop a profitable business due to the lower cost of the diet compared to D1. According to this analysis, the profit and cost of both diets would increase as the chicken ages. The use of local agro-industrial by-products such as PKC demonstrated potential as a substitute for commercial feed and can be viewed as an economic advantage not only due to their availability and lower cost but also due to their nutritional value. From this discussion, the objective to investigate the growth rate of chicken towards the formulation of chicken feed has been achieved.

Feeding chickens with agro-industrial waste in this project can contributes significantly to the improvement of the growth performance of chicken by utilizing the most abundant and low-cost waste in palm oil industry in Malaysia.

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 during the beginning of the project. This then followed by individual weighing every 5 days for 42 days. The readings were recorded and tabulated for comparison. Table 4.3 shows the measurement of body weight in control diet and formulation diet groups throughout the feeding period. For the results of BWC, at the beginning of project before feeding begins, the initial BWC in D1 and D2 groups are almost similar which are 49 g and 49.5 g, respectively. Then after 42 days of project ends, the final BWC in formulated diet groups (2000 g) shown a significant improvement compared to with control group (1580 g).

Table 4.4 The comparison of body weight change for chicken.

Parameter (g)	**D1** (Control Feed)	**D2** (Factory formulation + PKC + PAO)
Initial BW	49 ±	49.5 ±
Final BW	1580 ±	2000 ±
BW Change	1531 ±	1950.5 ±

As formulated chicken feed which main ingredient are PKC have higher DM, CF and CP content compared to the corn as shown in Table 4.1. This shows high level of nutrient content in chicken feed will improves BW of the chicken. The higher BWC in chicken fed formulated chicken feed might be linked to the waste product's nutritional content, which would have affected the chicken's growth performance. Moreover, DM intake of chicken fed with D2 diets which containing nutritious waste was significantly higher than those fed with D1 diets. Increased nutrient intake lead to better performance in chicken feed diets (Borreani et al., 2018).

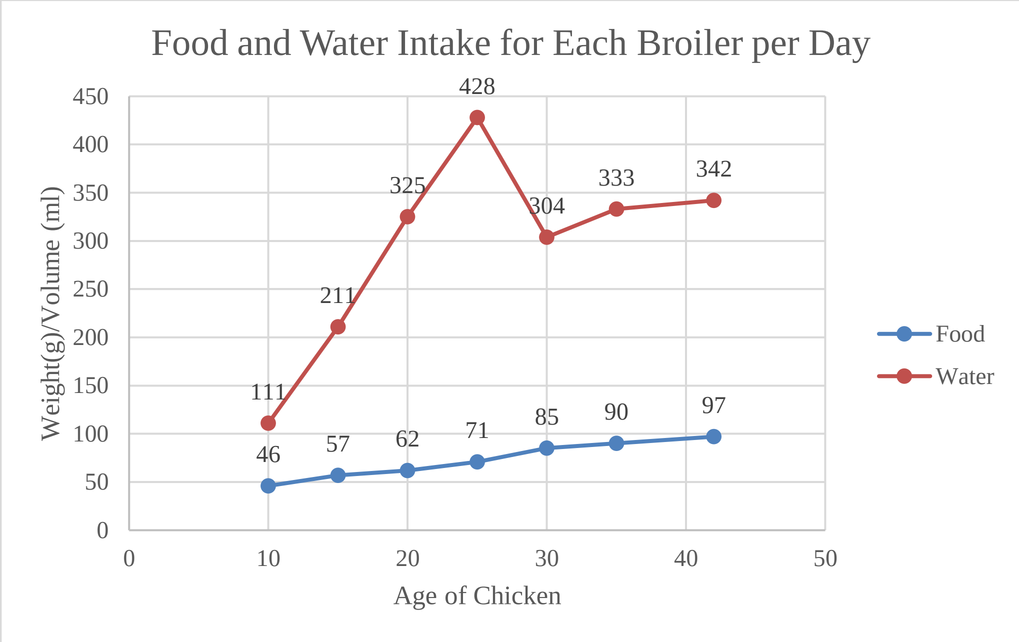

Figure 4.5 Food and water intake for each broiler per day.

Figure 4.3, show the amount of feed and water intake for each broiler per day. The feed and water intake significantly increase from day 0 until day 25 due to high metabolism of the chicken needed to growth. At day 25 the feed and water intake were 71g and 428ml respectively then dropped at day 30 which are 85g and 304ml due to the chicken are not fully covered with feather, so the chicken consumed more water to regulates their body temperature. The feed and water intake are calculated by amount of feed and water given to chicken divided with number of chickens in the coop. This project indicated that utilization of PKC as substitution of corn for chicken feed positively influences the performance of animals and providing excellent BWC. Using variety of techniques of processing and agro-industrial by-product or wastes may improve nutrient content due to optimum feed digestibility.

4.6 Reduction of Waste

Many agro-industrial wastes can be utilized as source of animal feed or other products rather than landfilling which could posed environmental issues. Utilization of solid wastes has been deemed the most appealing alternative, both environmentally and economically (Boechat et al., 2017). However, their usage should be preceded by an examination of the environmental and economic consequences, as wastes should not be used recklessly. Information on chemical composition, nutritive values, improvement methods and poultry feeding methods are widely documented. PKC is high in dry matter, crude protein, crude fibre and also abundant resources that can be used in animal feed for various livestock species.

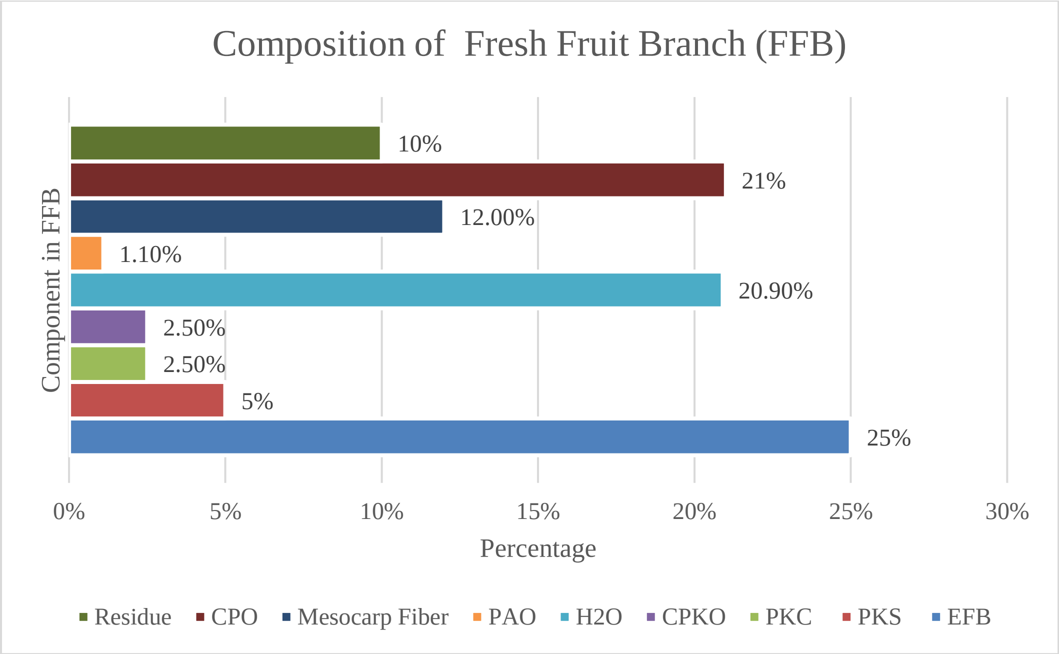

Figure 4.6 Percentage of components in FFB.

Figure 4.4 show a percentage of component that will be produced when processing fresh fruit brunch (FFB). PKC and PAO that will be produced from processing FFB is 2.5% and 1.1%, respectively. Although the percentage are small, every 1000 tonnes of FFB being processed, we can utilize 25 tonnes of PKC and 11 tonnes of PAO as source of animal feed. From this project, we can reduce solid waste in palm oil industry while benefitting from its abundant volume and inexpensive to be use as source of animal feed. So, proper and large-scale utilization of this solid waste could serve as practical approach to control solid-waste problem in agro-industrial sectors especially palm oil industry.

4.7 Promotes Local Economic Growth

Utilization of agro-industrial waste can create new job opportunities and promotes local economic growth due to the usage of PKC and PAO as substitute of commercial feed ingredients since PKC and PAO are abundant in palm oil industries. These will increase the utilisation of local raw material as main ingredients in chicken feed formulation and reduces cost of production, as cost for feed ingredients contributes nearly to 70% of production cost. PKC as chicken feed has huge potential to boost Malaysia's economic growth and reduce the country's dependency on imported feed material. Currently, the market imports more than 50% of raw materials (corn and soybean) used in the formulation of chicken feed (Rohaya et al., 2017).

The increased cost of chicken feed has affected the broiler industry, resulting in an increase in the price of chicken in the local market as chicken consumption in Malaysia forecasted to increase to 51.28 kg per capita in 2025 (R. Hirschmann, 2021). As a result, the moment has come to replace imported raw materials with more locally sourced feed ingredients in the feed blend. Substituting 30% – 45% PKC for the feed ingredient greatly reduces the amount of raw material imported. Therefore, agro-industrial wastes are should be considered as alternative feeds for poultry to overcome feed problems. The utilization of these waste can also reduce feed cost and environmental pollution.

CHAPTER 5

CONCLUSION

5.1 Introduction

The main objective of this project is to analyse the palm oil waste characteristics in manufacturing formulated chicken feed. Apart from that, this project is to formulated chicken feed by using palm acid oil (PAO) and palm kernel cake (PKC). Also, to investigate the growth rate of chicken towards the formulation of chicken feed. Recommendation for better chicken feed and future study also discussed in this chapter.

5.2 Conclusion

There are several conclusions that can be made. A good feed covers the quality of the feeds production, is densely packed with nutrition, and can increase feed intake through the use of an appropriate feeding system. The feed should contain nutrients that meet the animal feed's nutrient requirements. If the animal feed contains a sufficient amount of nutrients, it can aid in the livestock's growth performance.

This will answer the first objective which is to analyse the palm oil waste characteristics which is PKC and PAO in manufacturing formulated chicken feed. This is because PKC and PAO high in nutrient that are suitable for animal growth. This waste also can be obtained easily without any added charges from palm oil mill. A huge percentage of this waste can be prevented by utilising it as valuable products such as animal feed. The use of agro-industrial waste can help maintain the quality of landfill waste, reduce environmental pollution, and provide a safe and healthy environment for the public. On the other hand, the feedstock market in Malaysia relies heavily on raw materials imported from Brazil and Argentina, resulting in high production costs.

Followed by next objective, to formulated chicken feed by using palm acid oil (PAO) and palm kernel cake (PKC) from agro-industrial waste that have been proven contains nutrient needed for chicken growth. The nutrients that contains in the wastes are DM, CF and CP. PKC are suitable to be used as chicken feed since it contains high value in DM, CF and CP. DM are vital for chicken's health and production. CP in PKC also important in chicken growth and immunity system. PAO can be used as an additive to improve the nutrient content in the animal feed since PAO contains high number of FFA which acts as source of energy. Thus, the composition of formulated chicken feed is cheaper than conventional feed in the market if agro-industrial waste used in this project.

Finally, our last objective is to investigate the growth rate of chicken towards the formulation of chicken feed has been achieved. D2 shows the best results in growth performance of the chicken. All diets were consumed by chickens within 42 days. From the body weight change (BWC) result, chickens that take D2 as it feeding system achieved the highest BWC within the experiment period with 1950.5g. D2 has the highest total nutrient content compared to D1. By adding PAO in the formulation chicken feed can show better result in growth performance of chicken. Therefore, further research on PAO from POME and other agro-industrial wastes should be improved and new technology in chicken feed should be developed.

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.

- Further experiment should be carried out to reduces crude fibre content of PKC to meet the suitable levels for poultry feed.
- Detailed experiment regarding enzymes should be carried out to enhanced the nutritive content in the chicken feed.
- Further research should be carried out to enhanced the nutrient content of chicken feed by using another formulation.

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APPENDICES


Construction of chicken coop.


Weighing of the chicken.

Appendix A: Formal Letter

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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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Appendix B: Project Timeline Senior Design Project 1&2

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			■	■	■	■								
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														■

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														
Correction for thesis report														
Finalize thesis report														
Thesis report submission														

Appendix C: Project Timeline Senior Design Project

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