UNIVERSITI PUTRA MALAYSIA

UTILIZATION OF FOOD WASTE AND KITCHEN WASTE AS POULTRY FEED

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181777

PROJECT REPORT SUBMITTED IN PARTIALLY FULFILLMENT OF THE REQUIREMENT FOR THE

BACHELOR OF ENGINEERING (PROCESS AND FOOD)

DEPARTMENT OF PROCESS AND FOOD ENGINEERING

FACULTY OF ENGINEEERING

UNIVERSITI PUTRA MALAYSIA

2019

ACKNOWLEDGEMENT

In the name of ALLAH, the most gracious and the most merciful with Selawat and Salam to Prophet Muhammad S.A.W. Alhamdulillah, thanks to ALLAH S.W.T for blessing me with His mercifulness for my health, strength and life all this time. With the help and permission of ALLAH, a lot of efforts and self-confidence in doing this research, I was granted the opportunity to accomplish this final year project.

Firstly, I would like to take this opportunity to express my gratitude to my supervisor, Assoc. Prof Dr Rosnah binti Shamsudin for her guidance, advice, valuable suggestion, encouragement and moral support throughout the completion of this project. A million thanks to her for being so nice, patient and kind in dealing with my queries and problems during this semester and for gave me lots of information during providing the implementation of this final year project.

Then, I would like to convey my gratitude to beloved parents, Encik Mahazer bin Yaacob and Puan Nazroh binti Ismail, family members, coursemates and friends for their encouragement. Thank you for being so supportive, may ALLAH bless all of you always. Finally, I would like to thank to the Lab Assistant and also master students who always willing to help me during conducting the analysis. Last but not least, to Faculty of Engineering UPM and for those who have directly or indirectly contributed in this research whom I am not mentioned. Thank you.

ABSTRACT

Food service defines those businesses, institutions, and companies responsible for any meal prepared outside the home. This industry includes restaurants, school and hospital cafeterias, food court and catering operation. Two types of waste generated from food service are kitchen waste (KW) and food waste (FW). Food waste is foods that are discarded and lost uneaten. Kitchen waste is foods that are left over from cooking. Nowadays, food wasted has been increasing among Malaysians about 55% of solid waste disposed at landfills comprise of food. Malaysia also needs to produce its own feed ingredients for the poultry industry to remain self-sufficient while reducing dependency on imported agricultural products. In order to overcome this problem, an alternative has been developed to reduce this excessive of food waste and kitchen waste and to minimize the imported ingredients which are utilized these wastes as poultry feed. The study of this project is to determine daily kitchen waste and food waste generation at three different locations which are the cafeteria, food court and restaurant in Serdang, Malaysia. In addition to analyzing the proximate composition of food waste and kitchen waste and also produce a pelleting using the compaction process. Analysis of food waste and kitchen were determined by collecting all the waste, separated it into organic and inorganic waste. The sample of organic waste were boiled at 100^{O} C for 30 minutes, dried in the oven at 55 ^{O} C for 3 days and grinded into powder form. Then, the sample were analyzed to determine the moisture content, protein, fiber, ash, fat and carbohydrate. The result shows that the food waste contains 56% of organic waste and 44% of inorganic waste while the kitchen waste contains 76% of organic waste and 24% of inorganic waste from three different locations. The food waste from the cafeteria is the most suitable to be utilized as poultry feed as their proximate composition similarly to bran. Finally, the pelleting process was done by the compaction process as well as the determination for physical properties of the pellets with different moisture content which are 40%, 50% and 60%. However, food waste pellets at 60% moisture content was better to utilize as poultry feed compared to kitchen waste pellets which are easily break into small pieces. Food waste pellets at 60% of moisture content give friability, bulk density, true density, porosity and tensile strength of 5.57%, 1447.53 kg/m^3, 289.85 kg/m^3, 79.03% and 3.06 kg.s respectively.

ABSTRAK

Industri perkhidmatan makanan merupakan perniagaan, institusi, dan syarikat-syarikat yang bertanggungjawab dalam menyediakan makanan di luar rumah. Industri ini termasuk restoran, sekolah dan kafeteria di hospital, pengendalian makanan dan katering. Dua jenis sisa yang dijana daripada industri perkhidmatan makanan ialah sisa makanan dan sisa dapur. Sisa makanan adalah makanan yang dibuang dan hilang tanpa dimakan. Sisa dapur adalah makanan yang tersisa daripada memasak. Pada masa kini, makanan yang terbuang semakin meningkat di kalangan rakyat Malaysia kira-kira 55% sisa pepejal yang dilupuskan di tapak pelupusan terdiri daripada makanan. Selain itu, Malaysia juga perlu menghasilkan ramuan makanan sendiri untuk industri ayam supaya kekal berdaya saing serta mengurangkan pergantungan ke atas produk pertanian yang diimport. Untuk mengatasi masalah ini, satu alternatif telah dibangunkan untuk mengurangkan sisa makanan dan sisa dapur yang berlebihan untuk meminimumkan bahan-bahan yang diimport dengan menggunakan sisa ini sebagai makanan ternakan ayam. Kajian projek ini adalah untuk menentukan penjanaan harian sisa dapur sisa makanan di tiga lokasi yang berbeza iaitu kafeteria, medan selera dan restoran di Serdang, Selangor Darul Ehsan, Malaysia. Di samping menganalisis komposisi sampingan sisa makanan dan sisa dapur, pelet juga dapat dihasilkan menggunakan proses pemadatan. Analisis sisa makanan dan dapur ditentukan dengan mengumpul semua sisa, memisahkannya menjadi sisa organik dan sisa bukan organik. Sampel sisa organik direbus pada 100 °C selama 30 minit, dikeringkan dalam ketuhar pada 55 °C selama 3 hari dan dikisar ke dalam bentuk serbuk. Kemudian, sampel dianalisis untuk menentukan kandungan lembapan, protein, serat, abu, lemak dan karbohidrat. Keputusan menunjukkan bahawa sisa makanan mengandungi

56% sisa organik dan 44% sisa tidak organik manakala sisa dapur mengandungi 76% sisa organik dan 24% sisa tidak organik dari tiga lokasi berbeza. Sisa makanan dari kafeteria adalah yang paling sesuai digunakan sebagai makanan ternakan kerana komposisi sama dengan dedak. Akhirnya, proses mempelletkan dilakukan oleh proses pemadatan serta penentuan sifat-sifat fizikal pelet dengan kandungan lembapan yang berbeza iaitu 40%, 50% dan 60%. Ciri-ciri fizikal pelet yang ditentukan adalah kerapuhan (%), ketumpatan pukal (kg/m^3), kepadatan sebenar (kg/m^3), keliangan (%) dan kekuatan tegangan (kg.s). Sebagai kesimpulan, sisa makanan dan sisa dapur boleh digunakan sebagai makanan ternakan dalam bentuk pelet. Walau bagaimanapun, pelet sisa makanan pada kandungan kelembapan sebanyak 60% lebih baik digunakan sebagai makanan ternakan berbanding pelet sisa dapur kerana ianya yang mudah hancur kepada bentuk yang kecil. Pelet sisa makanan pada 60% kandungan kelembapan memberikan kebolehlaburan, ketumpatan pukal, kepadatan sebenar, keliangan dan kekuatan pada 5.57%, 1447.53 kg/m^3, 289.85 kg/m^3, 79.03% dan 3.06 kg.s.

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FW	Food Waste
KW	Kitchen Waste
OW	Organic Waste
IOW	Inorganic Waste

CHAPTER 1

INTRODUCTION

1.1. Waste from Food Services

Food waste is an ecological, economic and social problem. Every year some 1.3 billion tons of food are lost or wasted globally (FAO, 2013), representing a considerable share of the overall food produced (Lundqvist et al., 2008). Food wastage appears to be highest in developed countries (Buzby and Hyman, 2012). Global food service industry, which is implicated in food consumption and waste generation (Betz et al., 2015).

Based on USDA Economic Research Service (2015), food service or catering industry defines those businesses, institutions, and companies responsible for any meal prepared outside the home. This industry includes restaurants, school and hospital cafeterias and catering operations and others.

Wastes are substances or objects which are disposed of or are intended to be disposed of or are required to be disposed of by the provisions of national law according to the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal of 1989, Art. 2(1). The examples of waste include municipal solid waste, hazardous waste, wastewater, radioactive waste, and also food waste.

Based on Food and Agriculture Organization of the United States (2019), food waste is any food substance that is discarded. It can be raw or cooked, solid or liquid. It is generated by the processing, handling, storage, sale, preparation, cooking and serving of foods. Hence, it can happen anywhere along the supply chain, from the farm to the manufacturer to the retailer or restaurant, and in our homes or at work.

In this study report, there are two types of waste from food services industry which are food waste and kitchen waste. Food waste is food that is discarded or lost uneaten while kitchen waste is food that are left over from cooking, such as vegetable and fruits peelings. All the samples of waste were collected at three different sources with three examples for each source in Serdang, Selangor Darul Ehsan.

Based on the observations while conducting this study, there were the differences between the contents on the physical composition of the waste. For KW, the physical composition were fruits and vegetables peeling, by products of fish, chicken and meat, rotten fruits and vegetables and also spoiled food. Next, the physical composition of food waste were excessive rice and meal, vegetables and fruits, processed fruits and also bone from meat, chicken and fish.

The similarity between the FW and KW were the types of food but their chemical composition of the waste were different due to the FW have been cooked for certain time while KW was the fresh waste from animals and plants for cooking.

1.2. Poultry Feed

Poultry are domesticated birds kept by humans for their eggs, their meat or their feathers including chickens, turkeys, geese and ducks (Anonymous, 2019). Feed ingredients for poultry diets are selected for the nutrients they can provide, the absence of anti-nutritional or toxic factors, their palatability or effect on voluntary feed intake, and their cost. The key nutrients that need to be supplied by the dietary ingredients are amino acids contained in proteins, vitamins and minerals. All life functions also require energy, obtained from starches, lipids and proteins (Jacquie,2018).

Feed ingredients are broadly classified into cereal grains, protein meals, fats and oils, minerals, feed additives, and miscellaneous raw materials, such as roots and tubers (Jacquie,2018). Poultry diets must be formulated to provide all of the bird's nutrient requirements to achieve optimum growth and production of poultry. Table 1.1.1 below shows six classes of nutrients for the poultry feed.

Table 1.2.1 Six Classes of Nutrients For The Poultry Feed

Nutrient Component	Functions
Carbohydrates	The major source of energy for poultry. Most of the carbohydrate in poultry diets is provided by cereal grains.
Fats	Provide energy and essential fatty acids that are required for some bodily processes.
Proteins	Required for the synthesis of body tissue (particularly muscle), feathers and for egg production. Proteins also provide a small amount of energy.
Vitamins	Organic chemicals (chemicals containing carbon) which help control body processes and are required in small amounts for normal health and growth.
Minerals	Inorganic chemicals (chemicals not containing carbon) which help control body processes and are required for normal health and growth.
Water	Water plays an important role in the body of an animal. Water softens feed and carries it through the digestive tract. It also

	carries nutrients from the digestive tract to cells and carries away waste products.

(Source : Nutrient Requirements, Poultry Hub, 2019)

Other than that, based on SAHS Lifesciences Pvt Ltd which is a fast growing integrated company and a leading poultry feed manufacturer and supplier in India, poultry feed refers to the food, concentrates, premixes, additives and chemicals used in the commercial farming of chickens, ducks, geese, turkey, quails and other birds. Generally, a feed is prepared by mixing nutritional supplements in the grains to maintain the health of poultry and quality of their meat and eggs. It comes in several forms as in Figure 1 such as mash, pellets, crumbles and scratch grain to provide best food to broilers, layers, baby chicks and hatchlings.

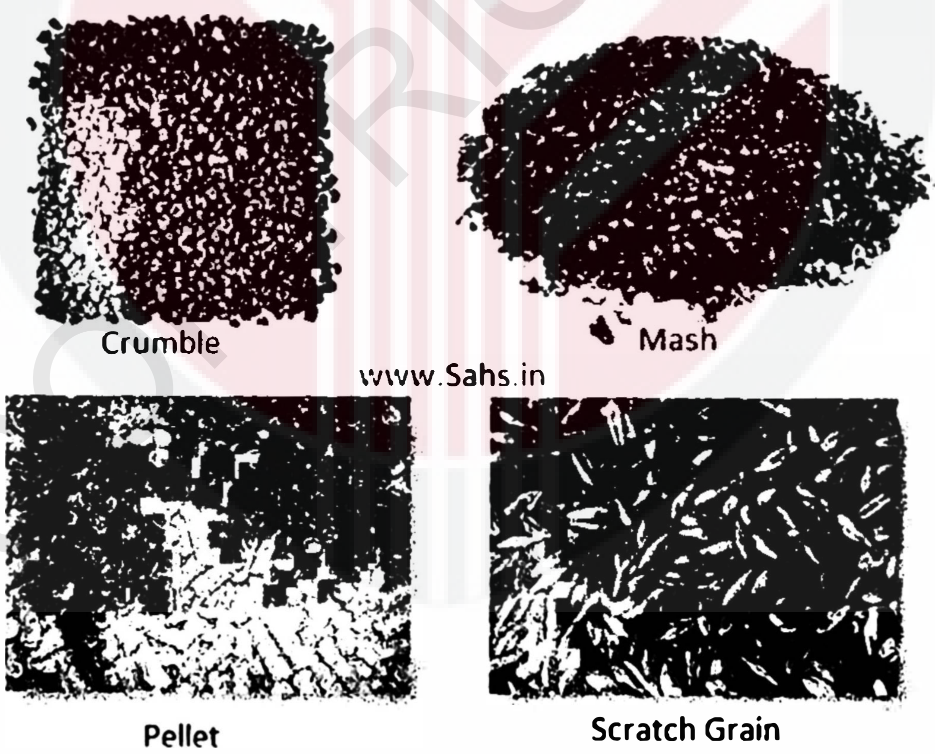

Figure 1.2.1. Forms of Poultry Feeds

(Source : SAHS Lifesciences Pvt Ltd, 2019)

A healthy broiler chicken or any other bird requires a 22% protein for the starter feed and 19% for the finisher feed in their daily diet (Anonymous, 2016). Feed quantity and nutrition value depends on many factors such as weather, age, weight, body growth rate and egg production rate (Poultry Hub,2019). Therefore, different feed formulations were created for better health and proper poultry nutrition.

1.3. Market Prospect of Poultry Feed in Malaysia

The Former of Ministry of Agriculture and Agro-based Industry Malaysia, Datuk Ahmad Shabery Cheek has speaking at the Opening of Livestock Asia 2018, Malaysia need to produce its own feed ingredients for the livestock industry to remain self-sufficient while reducing self-dependency on imported agricultural products. He also said that domestic poultry industry was heavily reliant on imported feed (Jane, 2018).

The main ingredient of animal feed in Malaysia is maize, which is imported from abroad. In 2015, Malaysia imported maize from Argentina and Brazil to the tune of US$415m and US$321m respectively to support the livestock feed manufacturing sector. The volume of such imports will continue to increase unless we reduce the maize component in feedstock production.

There is no commercial production for feed in Malaysia, according to the latest USDA (2017) gain report on country's feed and grain sectors. Most corn produced in-country is sweet corn for human consumption. Maize is planted in rotation with other plants such as banana, sweet potatoes, pineapple and watermelon to complement farmer income (Jaine, 2018).

Based on data by the Malaysian Agricultural Research and Development Institute (MARDI), cost of production was US$225.00 per tonne in 2016. With strengthening corn prices, appreciation of Malaysian currency relative to the US dollar, improved standards of living and greater popularity of poultry meat among different races in Malaysia, demand for corn are forecast to slightly increase in line with demand for poultry.

1.4. Problem Statement

Nowadays, food is wasted has been increasing among Malaysians. The star on October 16, 2018 have reported that food waste in this country has reached a critical level as data by Solid Waste Management and Public Cleansing Corporation (SWCorp) shows that 55 percent of solid waste disposed at landfills comprise food. In order to overcome this wastage of food which can give negative impact to environmental issues, many alternatives have been developed to reduce this excessive of food waste. Based on the research studies, food waste can be utilized as animal feed.

Other than that, domestic poultry industry in Malaysia was heavily reliant on imported and need to produce our own feed ingredients for the livestock industry to remain self-sufficient while reducing self-dependency on imported agricultural products said Minister of Agriculture at the opening of Livestocks Asia 2018.

Therefore, the objective of this research is to determine food waste (FW) and kitchen waste (KW) generation in order to produce poultry feed as the utilization method for the excessive waste from food service industry.

1.5. Objectives

1. To determine the amount of daily food waste and kitchen waste generation at three different location such as cafetaria, food court and restaurant.

2. To analysis the proximate composition of food waste and kitchen waste.

3. **To develop pelleting process of food waste and kitchen waste at different moisture levels (40%, 50% and 60%) using compaction process.**

CHAPTER 2

LITERATURE REVIEW

2.1. Excessive Waste

According to the US Department of Agriculture, it is estimated 133 billion pounds of food from stores, restaurants and homes was wasted in 2010. The amount of uneaten food from homes and restaurants in 2008 was valued at $390 per consumer. Most food that is thrown away ends up in landfills, where it can have negative environmental impacts. The Star Online on October 2018 reported that food waste in our country has reached a critical level as data by Solid Waste Management and Public Cleansing Corporation (SWCorp) shows that 55 percent of solid waste disposed at landfills comprise food. MySaveFood Secretariat head Dr Ainu Husna had said the food waste not only refers to the edibles disposed of by consumers but also the post-harvest loss at farms and plantations (Jaine,2018). MySafeFood is a project that was started in 2016 by the Malaysian Agricultural Research and Development Institute (MARDI), in collaboration with Food and Agriculture Organisation (FAO) of the United Nations, under the latter's global SaveFood initiative to reduce food waste.

2.2. Utilization of Food Waste and Kitchen Waste

Food waste (FW) used to be well utilized as animal feed in Japan. The use of food waste, however, declined due to the introduction of commercial concentrate feed and high performances exotic breeds, accompanied by a change of producer's strategy in pursuing more efficient production (Tomoyuki, 2011).

As alternatives to landfill, food waste can be composted to produce soil and fertilizer, feed to animals, or used to produce energy or fuel. Large quantities of fish, meat, dairy and grain are discarded at a global scale annually, when they can be used for things other than human consumption. The feeding of food scraps to domesticated animals is, historically, the most common way of dealing with household food waste. The animals turn roughly two thirds of their ingested food into gas or fecal waste, while the last third is digested and repurposed as meat or dairy products. There are also different ways of growing produce and feeding livestock that could ultimately reduce waste.

Food waste can be biodegraded by composting and reused to fertilize soil. Composting is the aerobic process completed by microorganisms in which the bacteria break down the food waste into simpler organic materials that can then be used in soil. By redistributing nutrients and high microbial populations, compost reduces water runoff and soil erosion by enhancing rainfall penetration, which has been shown to reduce the loss of sediment, nutrients, and pesticide losses to streams by 75–95% (Roy & Ken,2011).

Food waste collected in the City of San Francisco, California, was characterized for its potential for use as a feedstock for anaerobic digestion processes. The results of this study indicate that the food waste is a highly desirable substrate for anaerobic digesters to its high biodegradability and methane yield (Ruihong et al., 2016).

2.3. Method to Analysis Food Waste and Kitchen Waste

Based on Article about Potential reuse of Kitchen Food Waste (2016), the sample of restaurant food waste were collected at girl's hostel in National Institute of Technology, India. It was selected as raw materials for its huge food waste generation and their dumping problem. In each sampling, 2.5 kg of food waste were collected during peaks hours during lunch and dinner. All the samples were collected in airtight plastic containers and weighing for further analysis of restaurant food waste (Sipra & Kakoli, 2016).

2.4. Method Processing of Animal Feed

Table 2.5.1. Method Processing of Animal Feed

References	Preparation Method Of Animal Feed
Katsuaki S. et al. (2009). Ecofeed, Animal Feed Produced from Recycled Food Waste. Veterinaria Italania, page 397-404.	For the collection of raw materials, mouldy food waste should be rejected for the production of ecofeed. Next the raw materials were cooked at 70°C for 30 minutes or 80°C for 3 minutes before used to prevent microbial contamination. Then, ecofeed must be dried so that moisture content is 13.5% or less.
Tomoyuki K. (2004). The Use of Food Waste as A Protein Source for Animal Feed. National Institute of Livestock and Grassland Science Japan, page 303-309.	After the enforcement of the food recycling law, several kinds of model plant were built up to manufacture feed from food waste using dehydration. The methods involved in dehydration are conventional dehydration by heat, fermentation-dehydration and fry cooking. The dry matter of products processed by these methods ranged from 70 to 97 percent. Farmers can feed it to swine without any modification of their feeding system if feed composition is appropriate, or the products can be used as ingredients for commercial concentrate feeds.
Sipra and Kokoli (2016). Potential Reuse of Food Waste. Journal of Enviromental Chemical Engineering, page 196-204.	The collected food waste from kitchen outlet have been dried by various method, such as oven drying at 55°C for 3 days, 70°C for 3 days and 105°C for 2 days, freeze drying method at -4°C for 2 days. Different drying techniques have been followed to obtain the best techniques as dewatering is a vital stage for in lipid analysis. Hence, the oven drying method at 105°C was the best method and give less moisture content of food waste.

2.5. Proximate Analysis

2.5.1. Moisture Content

Optimising moisture levels is crucial from an economic as well as a feed quality point of view. For commercial reasons it is important to control moisture content in order to compensate for losses that occur during grinding and cooling processes. Moreover, a sufficient moisture level is important as it reduces the energy usage during the pelleting process, and it ensures that production runs more smoothly by lowering the risk of blockages. This is important for preventing nutrient losses as a result of excessive heat production. Furthermore, it guarantees good pellets quality as an optimal moisture level is known to positively affect pellet shardness. The downside of increasing moisture levels, however, is that free and 'unprotected' water poses a significant threat to feed quality, as ideal conditions are created for rapid mould growth and the development of mycotoxins (Anonymous,2010). Table 2.5.1.1 show the moisture content of two different types of poultry feed.

Table 2.5.1.1. Moisture Contents of Two Different Types of Poultry Feed

Type of Poultry Feed	Moisture Content (%)
Broken Rice	11.90
Maize Bran	10.50

Source: (Salome & Eliane, 2011)

2.5.2. Protein Content

Proteins are complex compounds made up of smaller units called amino acids. After a bird consumes protein, the digestive process breaks down the protein into amino acids. The amino acids are then absorbed by the blood and transported to cells that convert the individual amino acids into the specific proteins required by the animal. Proteins are used in the construction of body tissues such as muscles, nerves, cartilage, skin, feathers, beak, and others (Jacquie,2018). Table 2.5.2.1 shows the protein content of two different types of poultry feed.

Table 2.5.2.1 Protein Content of Two Different Types of Poultry Feed

Type of Poultry Feed	Protein Content (%)
Broken Rice	9.84
Maize Bran	15.36

Source: (Salome & Eliane, 2011)

2.5.3. Fiber Content

Dietary fiber is the part of plant material consisting mainly of cellulosic and non-cellulosic polysaccharides, and a non-carbohydrate component, lignin. These components are highly resistant to hydrolysis by alimentary enzymes and cannot. therefore, it can be digested or absorbed in the blood stream. Hence, fiber plays an important role in poultry diets, if applied properly (Salah,2012). Although fiber in poultry nutrition is often associated with reduced energy availability due to its minor role in energy supply. Low to moderate amounts of fiber might be beneficial for gastrointestinal development, function and health, thereby enhancing nutrient digestibility and growth performance (Sonja, 2015). Table 2.5.3.1 show the fiber content of two different types of poultry feed.

Table 2.5.3.1. Fiber Content of Two Different Types of Poultry Feed

Type of Poultry Feed	Fiber Content (%)
Broken Rice	2.04
Maize Bran	22.23

Source: (Salome & Eliane, 2011)

2.5.4. Fat Content

Fats are composed of smaller compounds called fatty acids. Fatty acids are responsible for cell-membrane integrity and hormone synthesis. Although there are many different fatty acids, poultry have a specific requirement for linoleic acid (it must be included in the diet). Linoleic acid is considered an essential fatty acid because poultry cannot generate it from other nutrients (for example, by converting one fatty acid to another).

Fat must be present in the diet for poultry to absorb the fat-soluble vitamins A, D, E, and K. In addition to its role in nutrition, fat is added to feed to reduce grain dust. Fat addition also improves the palatability of feed (Jacquie,2018). Table 2.5.4.1 shows the fat content of two different types of poultry feed.

Table 2.5.4.1. Fat Content of Two Different Types of Poultry Feed

Type of Poultry Feed	Fat Content (%)
Broken Rice	1.48
Maize Bran	12.29

Source: (Salome & Eliane, 2011)

2.5.5. Ash Content

Ash residue is composed of various types of minerals, often from animal sources such as bone and meat. It typically also contains the remains of any mineral additives the manufacturer uses to enhance the food. The main components of ash are usually phosphorous and calcium, but it also normally contains other minerals such as iron and zinc. Anything in the food that not burning ends up being counted as part of the ash. The amount of ash is of limited value, since the value represents the total ash and doesn't provide any insight into which specific minerals it represents. Reducing the amount of minerals in the diet can help to minimize certain growth and urinary tract problems (Cindy,2018). Table 2.5.5.1 show the ash content of two different types of poultry feed.

Table 2.5.5.1. Ash Content of Two Different Types of Poultry Feed

Type of Poultry Feed	Ash Content (%)
Broken Rice	1.57
Maize Bran	4.99

Source: (Salome & Eliane, 2011)

2.5.6. Carbohydrate Content

Carbohydrates (compounds with carbon, hydrogen and oxygen) are an energy source for animals and make up the largest portion of a poultry diet. Carbohydrates are typically eaten in the form of starch, sugar, cellulose, and other nonstarch compounds. Poultry typically do not digest cellulose and the nonstarch compounds, referred to as crude fiber, well. However, poultry are able to use most starches and sugars well. Important sources of carbohydrates in poultry diets include corn, wheat, barley, and other grains (Jacquie, 2018). Table 2.5.6.1 show the carbohydrates content of two different types of poultry feed.

Table 2.5.6.1. Carbohydrates Content of Two Different Types of Poultry Feed

Type of Poultry Feed	Carbohydrate Content (%)
Broken Rice	75.21
Maize Bran	69.15

Source: (Salome & Eliane, 2011)

2.5.7. Pelleting of Animal Feed

Pelleted feeds have been defined as "agglomerated feeds formed by extruding individual ingredients or mixtures by compacting and forcing through die openings by any mechanical process" (Behnke & Gilpin,2014). Basically, the purpose of pelleting is to take a finely divided, sometimes dusty, unpalatable and difficult-to-handle feed material and, by using heat, moisture and pressure, form it into larger particles. These larger particles are easier to handle, more palatable and usually result in improved feeding results when compared to the unpelleted feed (Zainuddin et al., 2014).

Almost all livestock feeders agree that animals make better gains on pelleted feed than a meal ration. The most logical reasons are that (a) the heat generated in conditioning and pelleting make the feedstuffs more digestible by breaking down the starches, (b) the pellets simply put the feed in a concentrated form, and (c) pelleting minimizes waste during the eating process. When pelleted feed is fed, each animal receives a well-balanced diet by preventing the animal from picking and choosing between ingredients. Tests have shown that most animals, if given the choice between the same feed in pellets or mash form will prefer the pellets (Reddy,2011).

By combining moisture, heat and pressure on feed ingredients, a degree of gelatinization is produced which allows animals and poultry to better utilize the nutrients in these ingredients. Feed conversion will be improved. These advantages are particularly noticeable in the broiler industry (Reddy,2011).

Pelleting prevents the segregation of ingredients in a mixing, handling or feeding process. By feeding a pelleted feed, the animal is more apt to receive a totally mixed ration than one that has separated through these processes. It also prevents waste. Bulk density is increased, which enhances storage capabilities of most bulk facilities. Shipping facilities are also increased, thereby reducing transportation costs (Kaliyan & Morey, 2009). This is particularly evident in such fibrous ingredients as alfalfa, gluten feed, oat hulls, rice and bran. A better flow and handling characteristic of pellets were one of the least mentioned advantages but probably the most important, particularly as it relates to dairy farmers (Reddy,2011).

The process of producing feed pellets can roughly be described as a plastic molding operation of the extrusion type. Feed ingredients are made up of various compounds such as proteins, acids, sugars, fibers, and minerals. These products can be softened (conditioned) by the addition of heat and water. When sufficiently controlled compression is applied to the "conditioned" feed ingredients, they will form a dense mass, shaped to conform to the die against which they are pressed. When the heat and moisture is again withdrawn (dried and cooled) as to withstand moderately rough handling without excessive breakage and has retained or enhanced its nutritive value (Supriya et al., 2012).

CHAPTER 3

METHODOLOGY

3.1. Overall Flow Diagram

Figure 3.1.1 below shows the overall flow diagram of utilization of food waste and kitchen waste as poultry feed. Firstly, the sample was divided into two types which are food waste (FW) and kitchen waste (KW). All the samples were collected from three different locations which are cafeteria, food court and restaurant in Serdang, Selangor Darul Ehsan.

For the first objective which is to determine the amount of daily food waste and kitchen waste generation at three different location, all the samples were weighed using balance scale for three days in order to get uniform results. Then, the sample were analysed to get their profile analysis and comparison between KW and FW from three different locations.

Second objective is to analysis the proximate composition of food waste and kitchen waste, the sample of organic FW and KW undergoes several processing methods until the powder were formed. Then, the samples of FW and KW powder were analysed their proximate composition such as protein content, moisture content, fat content, ash content, fiber content and carbohydrate content.

Lastly, the objective of this study is to develop pelleting process of food waste and kitchen waste at different moisture levels (40%, 50% and 60%) using compaction process. The powder of FW from all three locations were mixed together and undergoes compaction process to form pellets and as well as for powder of KW. Then, physical properties of FW and KW pellets were analysed such as friability (%), true density (kg/m^3), bulk density (kg/m^3), porosity (%) and tensile strength (kg.s).

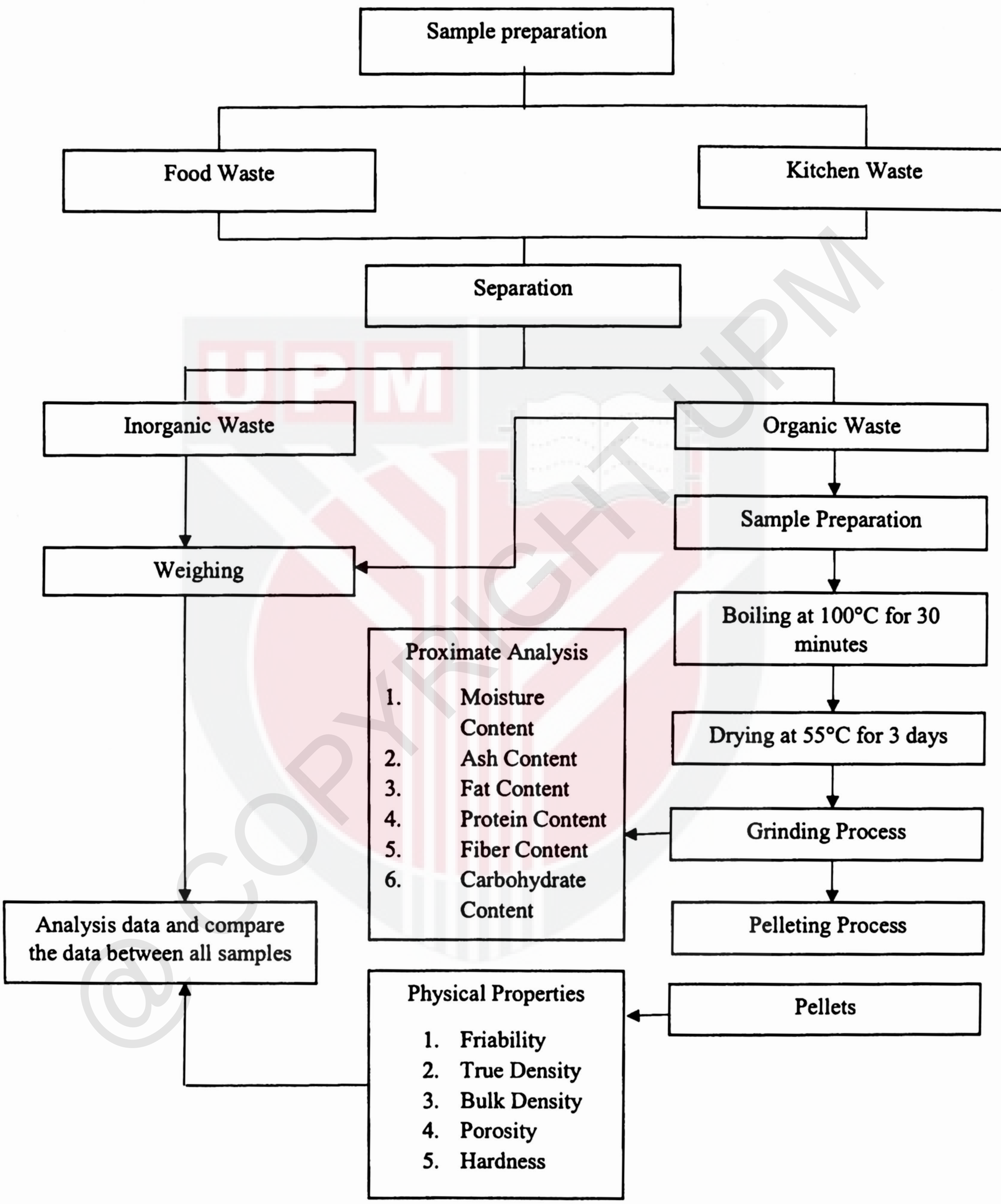

Figure 3.1.1. Overall Flow Diagram of Utilization of Food Waste and Kitchen Waste as Poultry Feed

3.2. Sample Preparation

3.2.1. Profile Analysis of Food Waste and Kitchen Waste

Sample of waste from three different types of sources which are cafeteria, food court and restaurant with three examples of each sources have been collected for 3 days. All of the sample were separated according to organic waste, inorganic waste. Then, all the samples were weighed using measuring balance in Figure 3.2.1.1 below. The data were collected in the table in Appendix 1 and 2. Then, the data were analysed in the bar graph and pie chart in order to get the profile of food waste and kitchen waste at three different location in Serdang, Selangor Darul Ehsan.

Figure 3.2.1.1 The Sample of Restaurant Waste Were Weighed Using Weighing Balance

3.2.2. Utilization of Food Waste and Kitchen Waste as Poultry Feed

200g of organic sample was used to produce as poultry feed as the utilization of food waste and kitchen waste. Firstly, 200g of sample were selected from overall of organic waste from food waste. Then, the sample was boiled for 30 minutes at 100°C to remove the layer of fat in the waste (Sipra & Kokoli, 2016). Hence, the sample was dried using oven at 105°C for 3 days (Sipra & Kokoli, 2016). Finally, the samples were grinded using a grinder. The powder formed will analysed using several methods to determine the moisture content, protein content, fiber content, fat content and ash content. The composition of utilized poultry feed formed will be compared with the bran in the market. The flow of the processes were shown in the Figure 3.2.2.1.

200g of food waste were selected from overall waste collected

The sample were boiled at 100°C for 30 minutes

The sample were oven dried at 105°C for 3 days

The sample after dried in the oven

The sample were grinded until it turns into powder form

Figure 3.2.2.1 Method for Preparing Poultry Feed

3.2.3. Production of Pellets

For compaction process, all the powder of FW from three different location were mixed together at ratio 1:1 for FW pellets while for KW pellets, all the powder of KW was mixed together. The sample were moisturized with water at different moisture content levels (40%, 50% and 60%). The moisture content can affect the physicochemical and stability of the pellets (Mahapatra et al., 2010). The chosen range of moisture content (40%-60%) used is because of the equipment used which is manual noodle maker only operated well for the sample that exceed 40% moisture content. The moisture content of the sample is measured based on wet basis. The samples with the desired moisture content area prepared by adding an amount of distilled water as calculated below (Coşkun, Yalçin, & Özarslan, 2006):

$$Q = Wi\,(Mf - Mi) / (100 - Mf) \qquad \text{..........(3.1)}$$

Where; Q: Mass of distilled water added in kg

Wi: Initial mass of the sample in g

Mi: Initial moisture content mass of the sample in %

Mf: Final moisture content of the sample in %

After compaction process, the pellets are obtained with different moisture content. The length of each of the pellets is 1.4 to 3 cm. Based on the Bureau Research and Development (2012) who has developed standards for pelleting biomass that stated by Zainudin M.F., et al., (2014), first class pellets must have a size less than 8.0mm in diameter and less than 3.2 cm in length.

3.3. Proximate Analysis of Food Waste and Kitchen Waste

3.3.1. Determination of Moisture Content

Moisture content is the amount of water content that dependent on the any plant, soil and food. The moisture content was determined using the Standard Official Analysis Method (AOAC, 1990). This involves drying to a constant weight of 105 °C and calculating the moisture as a dry weight loss sample. The powder is washed and dried with oven at 100 °C for 30 minutes and left cool in the desiccator. After cooling, they are weighed against the weight balance and the range of weight they have been recorded as W1. Then, 2.0 g of samples were put into crucibles and weighed to determine W2. After that, the sample and crucible are placed in the oven and dried at 100 °C for 4 hours, then cooled and weighed at the same temperature for 30 minutes until the constant weight is obtained to obtain the W3. Then, the moisture content of the sample is calculated from equation below:

$$\frac{(Initial\ weight\ of\ filled\ crucible) - (Final\ weight\ of\ filled\ crucible)}{(Initial\ weight\ of\ filled\ crucible) - (Initial\ weight\ of\ empty\ crucible)} \times 100\% \quad \text{..........(3.2)}$$

3.3.2. Determination of Protein Content

Sample protein content was determined using the Kjeldahl method (AOAC, 1990), which involved digestion and distillation of proteins. For protein digestion, approximately 2.0 g of the sample was weighed into the Kjeldahl flask, and 2 Kjeldahl Catalyst tablets added. This is followed by adding 25 ml of concentrated sulfuric acid. The whole mixture has to be heated inside the fume cupboard. The heating is done slowly at first and increases shacking once the solution gets green. The digester temperature remains above 420 °C for about 60 minutes. The solution was cooled, and the black particles found in the neck of the bottle are washed with distilled water. The solution is reheated slowly initially until the green color disappears. Then, it is allowed to cool down. To prepare protein distillation, Kjeltec distillers were steamed for 15 minutes, after which a 100 ml conical flask containing 5 ml of the boric acid / indicator was placed under the condenser so that the condenser tip was under the liquid. About 5.0 ml of the digest was pipetted into the body of the apparatus via a small funnel aperture. Digestion was washed with distilled water, followed by an addition of 50 ml of NaOH 60% solution. Digestion in the condenser was steamed for about 1 to 5 minutes, after which sufficient ammonium sulfate was collected. The receiving flask was removed, and the tip of the condenser was washed down into the flask, after which the condensed water was removed. The solution in the receiving flask was treated with 0.01 M hydrochloric acid. Also, a blank was run through along with the sample (Zainuddin et.al, 2014). After the titration, the percentage of nitrogen was calculated using equation below:

$$\% N_2 = (V1 - V2)\ X\ (molarity\ of\ acid)\ X\ 0.01410\ X\ (W)\ X\ 100\% \qquad \text{……….(3.3)}$$

Where V1 is the volume of acid used in the titration, V2 is the corresponding amount of acid for the blank titration, and W is the weight of the sample. On average all biological proteins contain 16% N; therefore, protein content is estimated by multiplying N% by 6.25 (6.25 is the reciprocal of 0.16). Thus, crude protein does not differentiate between N in feed samples coming from true protein or other nonprotein nitrogen (NPN) compounds, nor does it differentiate between available and unavailable protein.

$$\% Nitrogen \times 6.25 = \% Crude\ Protein \qquad \text{……….(3.4)}$$

3.3.3. Determination of Fiber Content

Fiber is made up of cellulose, hemicellulose, pectic substances and also contains some lignin. The raw fiber content is determined using the method described by AOAC (1990). Dry the powder in the oven for about 1 hour at 105 °C, then cooled to the desiccator. The hammer weight has been calculated. A 1.0 g sample and 1.0 g filter agent using Celci 545 diatomaceous earth was dissolved in 200 ml boiling 0.25 N sulfuric acid using fibertec analysis and boiled for 30 minutes. The hydrolysis mixture was filtered through the solution and the residue was cleaned with boiled distilled water to remove the acid from the filtrate in the pan. Again, 200 ml of boiled 0.313 N of sodium hydroxide (NaOH) is added to boiled and boiled for 30 minutes. The hydrolysis sample has been refined again, and the residue is rinsed with boiled distilled water so that the solution is alkaline-free. The rest was rinsed back with a little bit of acetone and then dried. The remains in the pan have been dried in the oven at 105 °C until the weight is reached. The puncture was placed inside the muffle furnace at 550 °C and burned finished (Meloan and Pomeranz 1980). The cliff is then placed in the desiccator so that the weight is reached and calculated as:

$$\%\ Crude\ Fiber = \frac{Weight\ of\ Residue\ Without\ Ash}{Weight\ of\ Sample} x\ 100\% \quad \text{………(3.5)}$$

3.3.4. Determination of Fat Content

The amount of fat in the sample is determined according to the Soxhlet extraction method using Soxtec Extraction. First, 250 ml of aluminum cup dried in the oven at 105 to 110 °C for about 30 minutes and refrigerated in the desiccator. Approximately 1.0 g of sample weighed into labeled thimbles. Aluminum cups are weighed to match and filled with about 80 ml of petroleum ether (boiling point of 40 to 60 °C). Extraction thimbles are firmly fitted with cotton wool. Soxtec equipment is installed and allowed for reflux for 75 minutes. The thimble has been carefully removed, and the petroleum ether is collected from the top container and drained into another container for reuse. After that, the flask was dried at 105 to 110 °C for 1 hour, when it was almost free from petroleum ether. After drying, it is cooled in the desiccator and weighed (Zainuddin, Shamsudin, Mokhtar, & Ismail, 2014). Then, the percentage fat of the sample is calculated using equation:

$$\% \ Fat = \frac{Weight\ of\ Fat}{Weight\ of\ Sample} x\ 100\% \qquad \text{.........(3.6)}$$

3.3.5. Determination of Ash Content

Ash is the inorganic residue which remains after the burning process of organic compound in the plant at a temperature of 500 to 700 °C. The ash content of the sample is determined by using the furnace combustion, as described by (AOAC, 1990), based on evaporation of water and volatile by combustion of organic matter in the presence of oxygen in air to carbon dioxide at 550 °C (dry ashing). Approximately 1.0 g of fine dry sample is placed in a porcelain pan and burned at 525 °C for 6 hours in a foreign muffle furnace until the ash is obtained. The ash is cooled in the desiccator and weighed. The percentage of ash content in the sample is calculated as:

$$\% \ Ash = \frac{Weight\ of Ash}{Weight\ of\ Sample} x\ 100\% \qquad \text{.........(3.7)}$$

3.3.6. Determination of Carbohydrate Content

Total carbohydrate content of foods has been calculated by difference, rather than analysed directly. Under this approach, the other constituents in the food (protein, fat, water, alcohol, ash) are determined individually, summed and subtracted from the total weight of the food (FAO, 1998). It should be clear that carbohydrate estimated in this fashion includes fibre, as well as some components that are not strictly speaking carbohydrate for example organic acids (Merrill and Watt, 1973). This is referred to as total carbohydrate by difference and is calculated by the following formula:

$$\% \, Carbohydrate = 100\% - \%moisture\ content - \%protein - \%fat - mineral\ 100\% \quad \text{........(3.8)}$$

3.4. Physical Properties of Kitchen Waste Pellets and Food Waste Pellets

3.4.1. Friabilty

20 pellets are randomly selected and then weighed using electronic balance (ER-120A, A&D, Japan). Next, by using the electronic riabilitor (DF-3, Distek, USA), the pellet are rotated at 25 rpm and let the pellets to roll and fall for 20 times by means of drum rotation and removal of any loose dust generated from ther= pellets during the test. Then, the pellets are desusted and weighed. The percentage of weight loss is calculated using the formula below. (Deveswaran et al., 2009):

$$Friability\ (\%) = \frac{Initial\ weight\ (g) - Final\ weight\ (g)}{Initial\ weight\ (g)}\ x\ 100\% \quad \text{.........(3.9)}$$

3.4.2. True Density

True density measures the weight per unit volume of powder material, excluding the voids (Zainuddin et al., 2014). The true density of single-components and binary mixtures were measured using a helium gas pycnometer (AccuPyc II 1340) Pycnometer Micromimetics, U.S.A.). The pressure difference between the known reference volume and total cell sample was taken as the measurement (Zainuddin et al., 2014). The test was carried out by measuring 1.0 g for each sample. The results of the true densities of the pellets were reported in triplicate.

3.4.3. Bulk Density

Bulk density is measured by filling a 25 ml measuring cylinder with sample from a set height, then, tapping twice in order to get uniform packing and minimise wall effect. Next, the contents are weighed by using digital balance. The bulk density is calculated as the ratio of the sample mass to the measuring cylinder volume (Liu et al., 2013).

$$\rho b = \frac{mb}{Vb} \qquad \text{.........(3.10)}$$

Where; ρb: Bulk density (kg/m3) mb: Total mass of pellets (kg) Vb: Volume of cylinder (m^3)

3.4.4. Porosity

The porosity is calculated by the true density and bulk density (Stelte et al., 2011). Porosity or void fraction a measurement of the void spaces in a material. It is a fraction of the volume of voids over total volume lies between 0 - 1.

$$Porosity = 1 - (\rho b/\rho t) \times 100\% \qquad \text{.........(3.11)}$$

Where; b: Bulk density (kg/m^3), ρt: True density (kg/m^3)

3.4.5. Tensile Strength

The tensile strength of pellets is measured by using texture analyser (TA-XT plus, Stable Micro Systems, Surrey, UK) to test the hardness that the samples can endure before started to fracture. Two selected pellets with length about 0.5 cm and diameter about 0.1

cm. The length and diameter are chosen based on the probe used which is 35 mm Cylinder Probe using 5 kg load. Then, the two pellets are positioned centrally under the probe, and the compression test are commenced. The results are recorded for analysis of data.

3.4.6. Statistical Analysis

One-way ANOVA was used to analysis of variance is applied in determination of statistically significant differences between the means of triplicate raw data of samples. Significance is accepted at $P < 0.05$ using IBM SPSS Statistic Software Version 25.

CHAPTER 4

RESULTS AND DISCUSSION

4.1. Profile Analysis of Food Waste and Kitchen Waste

Waste were collected from three different types of location which are from cafeteria, food court and restaurant in Serdang, Selangor Darul Ehsan. Three places were chosen for each type of location for the food service industry in order to get uniform samples. In this study, waste was divided into two types which are food waste (FW) and kitchen waste (KW). All of the samples were separated into inorganic waste (IOW) and organic waste (OW) while for food waste, it was separated for others in category of organic waste which are containing animal's bone such as fish, chicken and cow. Then, all the samples were weighed using weighing balance. The result for the average weight of kitchen waste and food waste collected in Serdang, Selangor were shown in the Table and Figure 4.1.1 and 4.1.2 below.

Table 4.1.1 shows the results for the average weight of FW for three different types of location which are cafeteria, food court and restaurant. At cafeteria the range for average weight of FW were in between of 3.72 kg and 13.67). For Cafeteria A, the average weight of OW, others and IOW were 11.75 kg, 3.48 kg and 3.68 kg, respectively. Meanwhile, for Cafeteria B, the average weight of OW was 13.67 kg, others category was 5.18 kg and

IOW was 3.68 kg. Cafeteria C have the average weight for OW, others category and IOW where the values were 8.74 kg, 3.72 kg and 4.16 kg, respectively. Based on Figure 4.1.1, the average weight of OW at Cafeteria A was the highest which was 11.75 kg while for IOW, it was the lowest which was 3.68 kg compared to Cafeteria B and C. The results for OW shows that there were significant ($P<0.05$) for Cafeteria A, B and C while for others category there was significant ($P<0.05$) only at cafeteria B. Meanwhile, the results for IOW, there were found that Cafeteria A, B and C were not significant ($P>0.05$). The average weight of IOW at three different cafeterias were varied because of there were cafeteria had classified their garbage dump were for the waste from their cafeteria only without mixing the IOW from other sources. Hence, the value of IOW was different at the location.

At food court the range for average weight of FW were in between of 4.36 kg and 25.77 kg. For Food Court A, the average weight of OW, others and IOW were 15.62 kg, 4.36 kg and 7.39 kg respectively. Meanwhile, for Food Court B, the average weight of OW was 25.77 kg, others category was 10.82 kg and IOW was 14.24 kg. Food Court C have the average weight for OW, others category and IOW where the values were 21.62 kg, 11.30 kg and 16.81 kg respectively.

Based on Figure 4.1.1, the average weight of OW at Food Court B was the highest which was 25.77 kg compared to Food Court A and C while Food Court C have the highest value which were 11.30 kg and 16.81 kg respectively for IOW and others category. The results for OW and IOW show that there were significant ($P<0.05$) for Food Court A, B and C while for others category there was significant ($P<0.05$) only at Food Court A. The average weight for others category at Food Court B and C were varied because of the huge difference in the weight of bones at the locations. Hence the value for others category were not significant ($P>0.5$) at Food Court B and C.

At restaurant the range for average weight of FW were in between of 3.89 kg and 25.22 kg. For Restaurant A, the average weight of OW, others and IOW were 25.22 kg, 6.56 kg and 21.72 kg respectively. Meanwhile, for Restaurant B, the average weight of OW was 20.06 kg, others category was 4.87 kg and IOW was 16.55 kg. Restaurant C have the average weight for OW, others category and IOW where the values were 5.75 kg, 3.89 kg and 7.77 kg respectively. Based on Figure 4.1.1, the average weight of OW, others category and IOW at Restaurant A was the highest which were 25.22 kg, 6.56 kg and 21.72 kg respectively compared to Restaurant B and C. The results for OW, others category and IOW show that there were significant ($P<0.05$) for Restaurant A, B and C. This is because the restaurant sells same types of food with the same size and scale of restaurant business.

Table 4.1.1. Average Weight of Food Waste Collected for 3 Days at Three Different Types of Sources

Type of Locations	Organic Waste (kg)		Inorganic Waste (kg)
	Organic Waste	Others	
Cafeteria A	11.75 ± 1.36^{de}	3.48 ± 0.58^{c}	3.68 ± 0.67^{c}
Cafeteria B	13.67 ± 1.46^{bc}	5.18 ± 1.30^{bc}	4.61 ± 0.83^{c}
Cafeteria C	8.74 ± 0.51^{ef}	3.72 ± 1.15^{c}	4.16 ± 0.85^{c}
Food Court A	15.62 ± 1.87^{c}	4.36 ± 1.33^{bc}	7.39 ± 1.25^{c}
Food Court B	25.77 ± 1.80^{a}	10.82 ± 1.96^{a}	14.24 ± 1.45^{b}
Food Court C	21.62 ± 1.54^{b}	11.30 ± 2.22^{a}	16.81 ± 1.02^{ab}
Restaurant A	25.22 ± 3.05^{a}	6.56 ± 1.19^{b}	21.72 ± 8.34^{a}
Restaurant B	20.06 ± 2.09^{b}	4.87 ± 0.85^{bc}	16.55 ± 5.66^{ab}
Restaurant C	5.75 ± 1.01^{f}	3.89 ± 0.94^{c}	7.77 ± 0.73^{c}

Means (± SD) with the same letter are not significantly different at p > 0.05 for each row

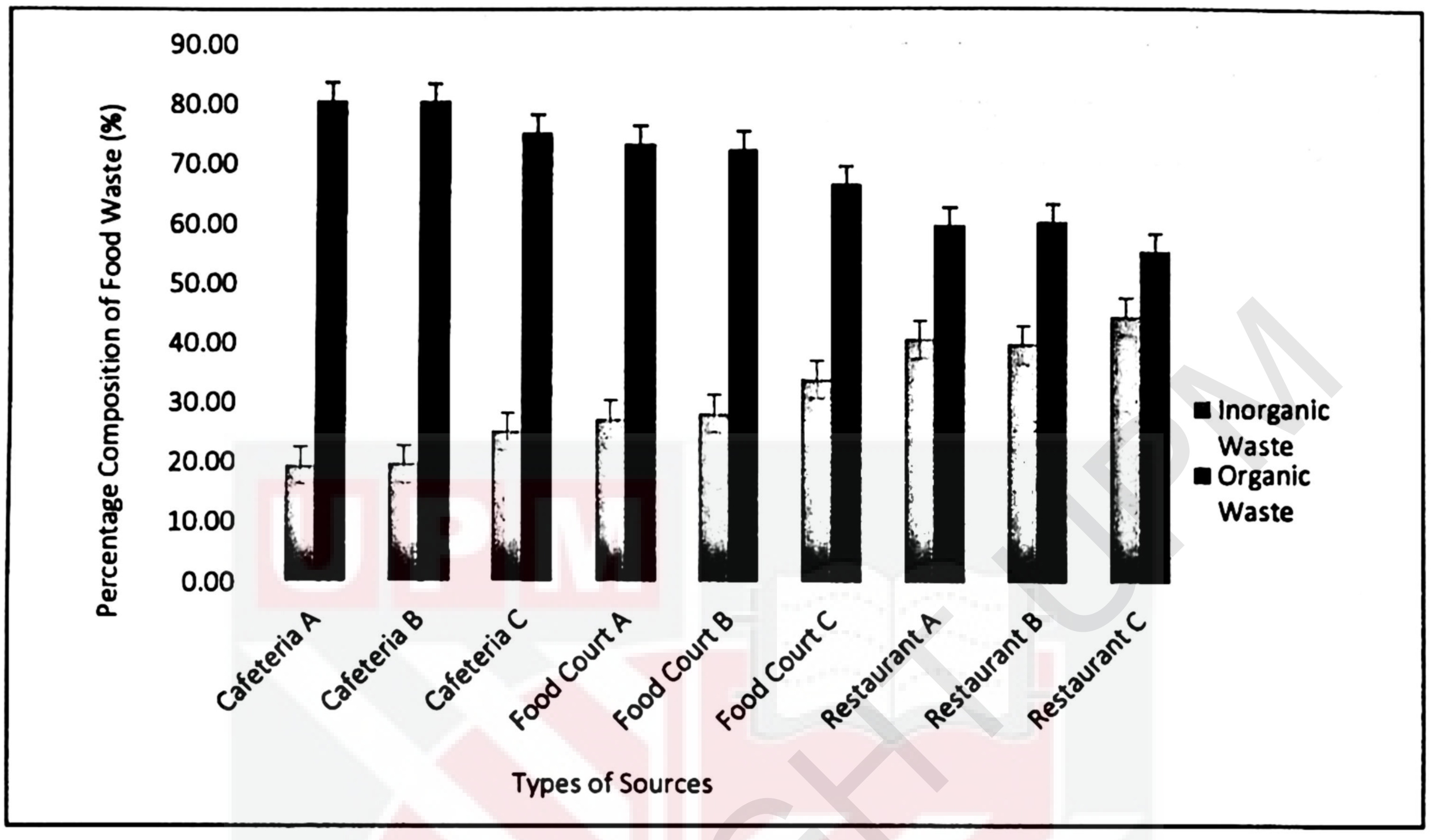

Figure 4.1.1 Composition of Food Waste at Three Different Types of Sources

Table 4.1.2 shows the results for the average weight of KW for three different types of location which are cafeteria, food court and restaurant. At cafeteria the range for average weight of KW were in between of 2.03 kg and 4.34 kg. For Cafeteria A, the average weight of OW and IOW were 3.26 kg and 2.21 kg respectively. Meanwhile, for Cafeteria B, the average weight of OW was 4.34 kg and IOW was 2.79 kg. Cafeteria C have the average weight for OW and IOW where the values were 2.06 kg and 2.03 kg respectively. Based on Figure 4.1.2, the average weight of OW and IOW at Cafeteria B was the highest which was 4.34 kg and 2.79 kg Cafeteria B and C. The results for OW shows that there were significant (P<0.05) for Cafeteria A, B and C while for IOW there was significant (P<0.05) only at cafeteria B. The average weight of IOW at Cafeteria A and C were varied because of the different size of food business at that cafeteria. Hence the value for IOW were not significant (P>0.5) at Cafeteria B and C.

At food court the range for average weight of KW were in between of 4.10 kg and 7.60 kg. For Food Court A, the average weight of OW and IOW were 6.26 kg and 4.10 kg respectively. Meanwhile, for Food Court B, the average weight of OW was 6.86 kg, and IOW was 5.60 kg. Food Court C have the average weight for OW and IOW where the values were 7.60 kg and 6.06 kg respectively. Based on Figure 4.1.2, the average weight of OW and IOW at Food Court C was the highest which were 7.60 kg and 6.06 kg compared to Food Court A and B. The results for OW shows that there were not significant (P>0.05) for Food Court B and C while for IOW there were significant (P<0.05) at Food Court A, B and C. The average weight for OW at Food Court B and C were varied because of the difference in the weight OW at the locations where the sellers have prepared their ingredients for cooking a day before. Hence the value for OW were not significant (P>0.5) at Food Court B and C.

At restaurant the range for average weight of KW were in between of 4.96 kg and 6.03 kg. For Restaurant A, the average weight of OW and IOW were 4.96 kg and 5.86 kg respectively. Meanwhile, for Restaurant B, the average weight of OW was 6.03 kg and IOW was 5.00 kg. Restaurant C have the average weight for OW and IOW where the values were 4.78 kg and 2.87 kg respectively. Based on Figure 4.1.2, the average weight of OW at Restaurant C was the highest which was 4.78 kg compared to Restaurant A and B while Restaurant A have the highest value which was 5.86 kg for IOW. The results for OW shows that there were significant (P<0.05) for Restaurant B and IOW shows that there were significant (P<0.05) for Restaurant A, B and C. Restaurant A and C have varied value for the weight of OW because the size of restaurant business were different where Restaurant A was more smaller scale than Restaurant C. Hence, there were not significant (P>0.05) for Restaurant A and C for OW.

Table 4.1.2. Average Weight of Kitchen Waste Collected for 3 Days at Three Different Types of Sources

Types of Location	Organic Waste (kg)	Inorganic Waste (kg)
Cafeteria A	3.26± 0.36 [de]	2.21± 0.57 [d]
Cafeteria B	4.34± 1.25 [cd]	2.79± 0.79 [cd]
Cafeteria C	2.06± 0.67 [e]	2.03± 0.75 [d]
Food Court A	6.26± 0.84 [ab]	4.10± 0.57 [bc]
Food Court B	6.86± 0.96 [a]	5.60± 0.57 [ab]
Food Court C	7.60± 1.56 [a]	6.06± 1.42 [a]
Restaurant A	4.96± 0.86 [bcd]	5.86± 1.00 [a]
Restaurant B	6.03± 0.89 [abc]	5.00± 1.02 [ab]
Restaurant C	4.78± 1.23 [bcd]	2.87± 0.70 [cd]

Means (± SD) with the same letter are not significantly different at p > 0.05 for each row

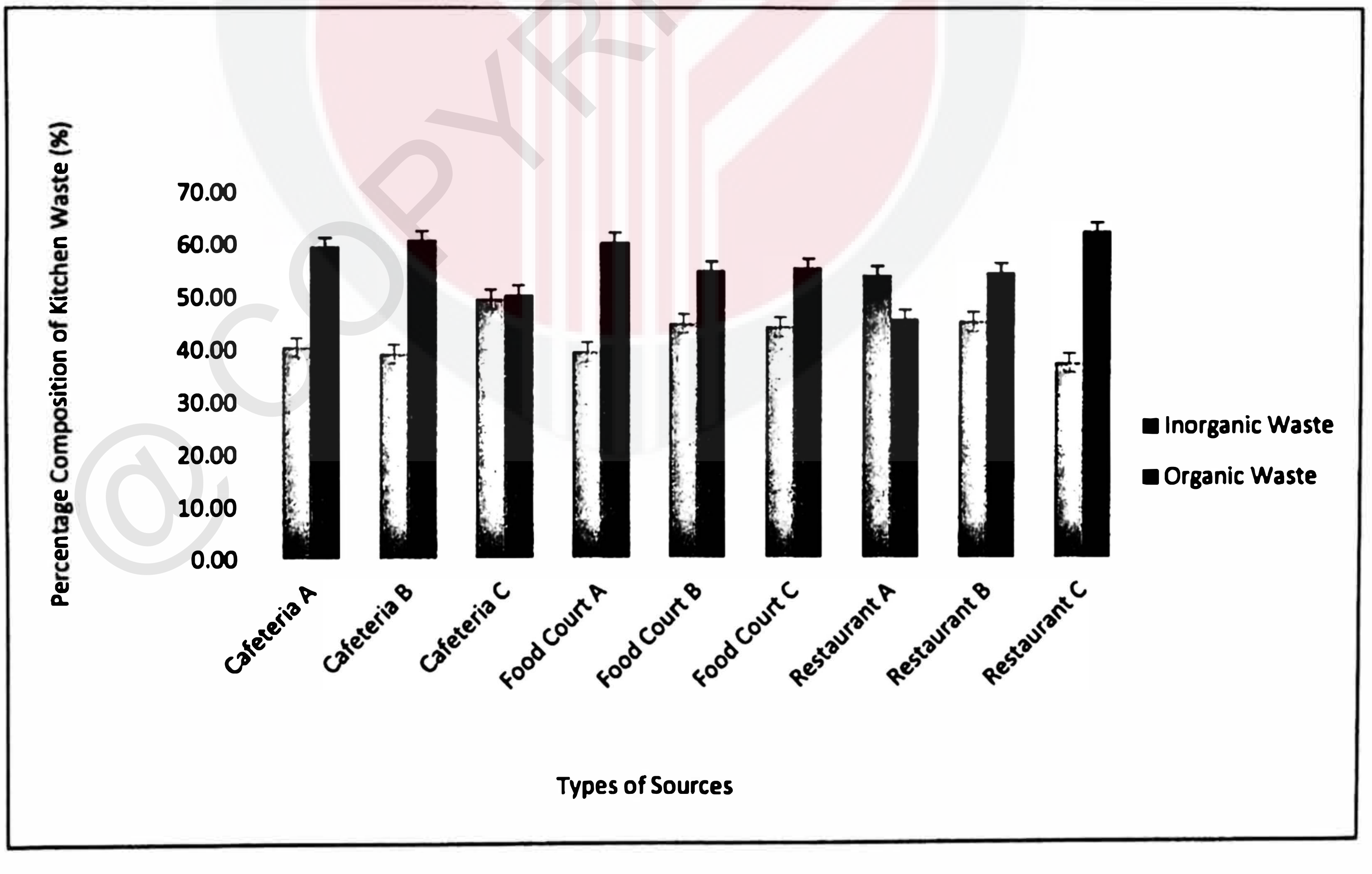

Figure 4.1.2. Composition of Kitchen Waste at Three Different Locations

Table 4.1.3 shows the average weight of FW at Cafeteria, Food Court and Restaurant. For OW, the range of average FW at three different locations were between 12.04 kg and 19.83 kg while for others category were between 4.80 kg and 6.96 kg. Meanwhile, the range of IOW were between 9.58 kg and 11.80 kg. For OW, the average weight of KW at cafeteria, food court and restaurant were 17.53 kg, 19.83 kg and 12.04 kg respectively. Average weight of FW for others category were 4.80 kg at cafeteria, 6.96 kg at food court and 6.30 kg at restaurant. The results for the average weight of FW for IOW for cafeteria, food court and restaurant were 10.93 kg, 11.80 kg and 9.58 kg. Food court have the highest average weight of OW, others category and IOW for FW where the value were 19.83 kg, 6.96 kg and 11.80 kg respectively. The results of FW show that there were not significant ($P>0.05$) at three different location. This is because the weight of FW was dependent on the number of consumer and the size of their business. Based on the observations, the higher the number of consumers at the location, the higher the amount of FW at the location.

Table 4.1.3. Average Weight of Food Waste at Cafeteria, Food Court and Restaurant

Type of Waste	Types of Location	Average Weight of Food Waste (kg)
Organic Waste	Cafeteria	17.53± 6.94 [a]
	Food Court	19.83± 6.05 [a]
	Restaurant	12.04± 8.43 [a]
Others	Cafeteria	4.80± 1.59 [a]
	Food Court	6.96± 3.36 [a]
	Restaurant	6.30± 4.33 [a]
Inorganic Waste	Cafeteria	10.93± 9.53 [a]
	Food Court	11.80± 6.33 [a]
	Restaurant	9.58± 6.52 [a]

Means (± SD) with the same letter are not significantly different at $p > 0.05$ for each row

Table 4.1.4 shows the average weight of KW at Cafeteria, Food Court and Restaurant. For OW, the range of average KW at three different locations were between 4.81 kg and 5.7 kg while for IOW were between 3.65 kg and 4.47 kg. For OW, the average weight of KW at cafeteria, food court and restaurant were 4.82 kg, 5.74 kg and 4.81 kg respectively. The results for the average weight of KW for IOW for cafeteria, food court and restaurant were 4.06 kg, 4.47 kg and 3.65 kg. Food court have the highest average weight of OW, and IOW for KW where the value were 5.74 kg and 4.47 kg respectively. The results of KW show that there were not significant ($P>0.05$) at three different location. This is because the weight of KW was dependent on the number of consumer and the size of their business. Based on the observations, the higher the number of consumers at the location, the higher the amount of KW at the location.

Table 4.1.4. Average Weight of Food Waste at Cafeteria, Food Court and Restaurant

Types of Waste	Types of Location	Average Weight of Kitchen Waste (kg)
Organic Waste	Cafeteria	4.82 ± 1.50^{a}
	Food Court	5.74 ± 1.28^{a}
	Restaurant	4.81 ± 2.77^{a}
Inorganic Waste	Cafeteria	4.06 ± 1.82^{a}
	Food Court	4.47 ± 1.48^{a}
	Restaurant	3.65 ± 2.13^{a}

Means (± SD) with the same letter are not significantly different at $p > 0.05$ for each row

4.1.1 Composition of Kitchen Waste

Kitchen waste was defined as food that are left over from cooking, such as vegetable and fruits peelings. Figure 4.1.1.1.1 shows that the total composition of KW at three different locations in Serdang, Selangor Darul Ehsan. The percentage compositions were 56% and

44% for OW and IOW respectively. It was shown that the percentage of OW in KW catogerised was higher than the percentage of IOW at three different types of location.

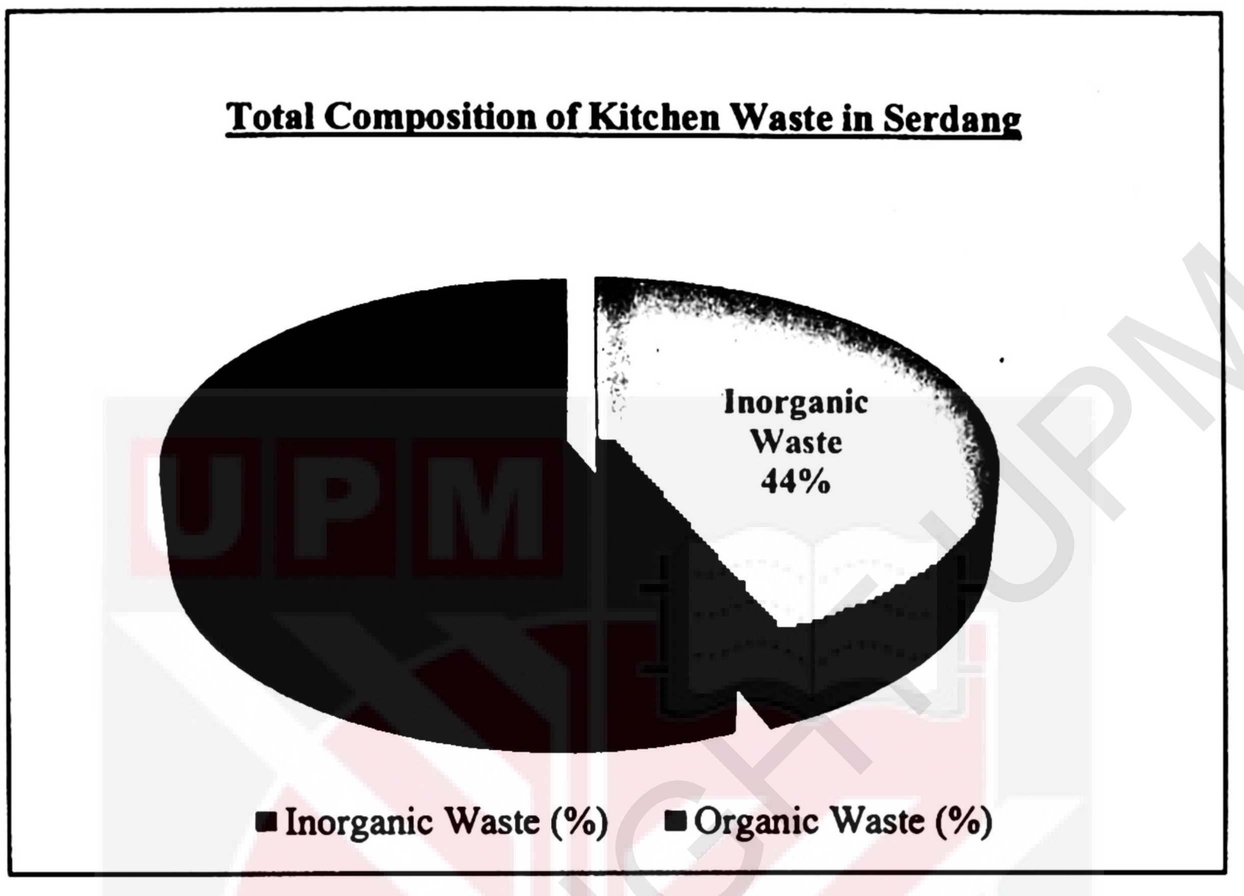

Figure 4.1.1.1 Total Percentage Composition of Kitchen Waste in Serdang

Based on the observation during the study, OW of kitchen waste consists of vegetable and fruits peelings and also waste from animals such as chicken, meat and fish while inorganic waste of kitchen waste in the restaurant mostly consists of plastics, bottles and newspaper. It was reported on two Brazilian landfills in Sao Polo and Salvado, municipal solid waste from these two landfills contained most kitchen waste which is made up of 40% of municipal solid waste with plastic content over 18% (Machado et. Al, 2006).

4.1.2 Composition of Food Waste

Food waste is food that is discarded or lost uneaten. Based on the study, OW was the major waste in the FW than IOW. It can be observed from Figure 4.1.2.1 that 76% of FW in Serdang was organic waste while another 24% of FW was inorganic waste. It can be observed that, the composition of organic waste in FW catogerised were excessed rice, dish (flesh and bone of chicken, fish), meat, vegetables and fruits.

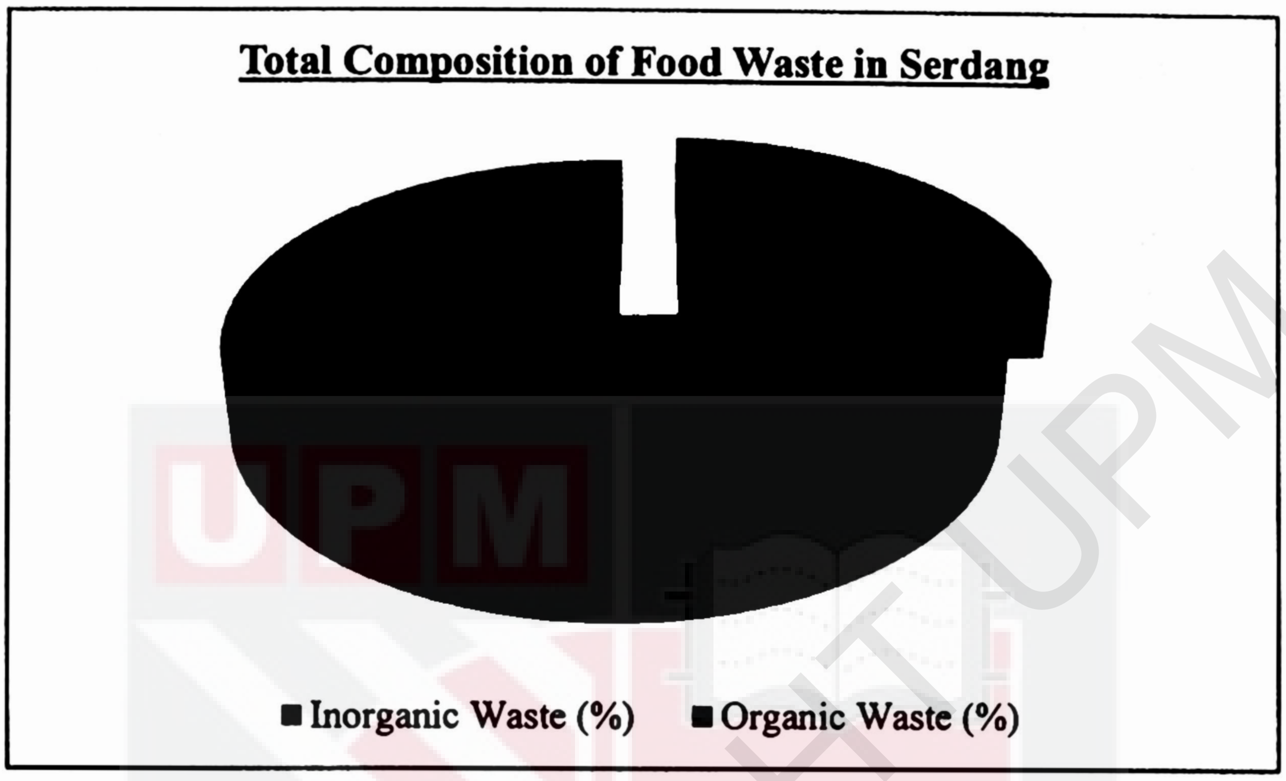

Figure 4.1.2.1 Total Composition of Food Waste in Serdang

In 2012, it was reported that Malaysians produced 33,000 tonnes of solid waste daily and will exceed the projected production of 30,000 tonnes by 2020. According to Moh and Abd Manaf (2014), the overall waste composition in Malaysia is dominated by municipal solid waste (MSW) (64%), followed by industrial waste (25%), commercial waste (8%) and construction waste (3%). MSW generally consist of around 20 different categories which are food waste, paper (mixed), cardboard, plastics (rigid, film and foam), textile, wood waste, metals (ferrous or nonferrous), diapers, newsprint, high grade and fine paper, fruit waste, green waste, batteries, construction waste and glass. These categories can be grouped into organic and inorganic. Generally, MSW in Malaysia consists of 50% of food waste, and 70% as disposed at the landfill sites (Nadzri, 2013) and households are the primary source of MSW in Malaysia.

4.1.3. Overall Food Waste and Kitchen Waste Analysis

Based on Figure 4.1.3.1, it was observed that the average weight of OW was 63% which was higher than the average weight of IOW which was 37% in FW and KW respectively. This is because the average weight of FW and KW at all places were depending on the size of their business and the number of customers daily. The bigger the size of their business, the higher the number of customers, hence the amount of waste from food service industry also high. It can be concluded that the total composition of OW in FW and KW were higher than the total composition of IOW at three different types of location in Serdang, Selangor.

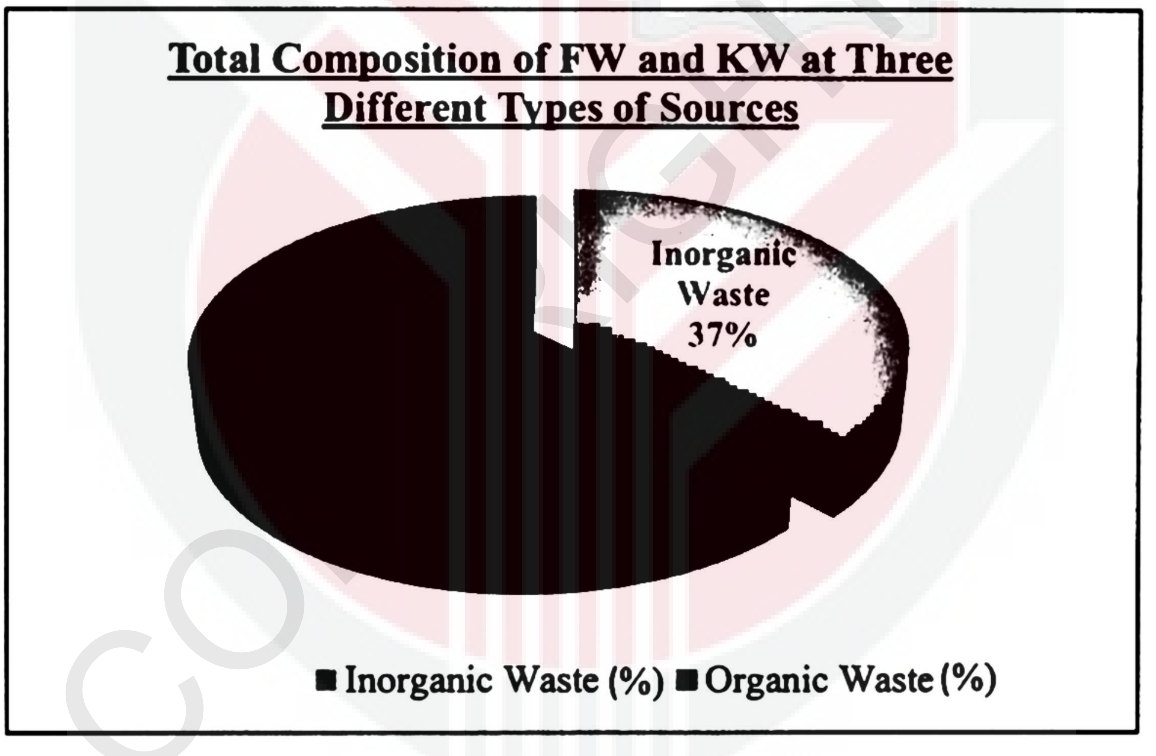

Figure 4.1.3.1 Total Percentage Composition of FW and KW at Three Different Types of Sources

4.2 Proximate Analysis

In addition to compositional characterisation of wastes from food services industry, selected samples from each of the studied areas were analysed the proximate analysis for the following parameters which are moisture content, protein content, fiber content, carbohydrate content, fat content and ash content.

4.2.1 Moisture Content

Table 4.2.1.1 shows the result for the percentage composition of moisture content for FW and KW. At cafeteria the range for moisture content of FW were in between of 0.80% and 5.38% while for KW were in between 0.67% and 0.86%. Moisture content of FW for Cafeteria A, B and C were 5.38%, 5.25% and 0.80% while for KW were 0.68%, 0.86% and 0.67% respectively. Cafeteria C have the lowest moisture content for FW and KW where the values were 0.80% and 0.67%. The results for moisture content of FW and KW shows that there were significant ($P<0.05$) for Cafeteria C. Meanwhile, the results for Cafeteria A and B, there were found that there were not significant ($P>0.05$) for FW and KW. This is because there was variety food composition in FW and KW.

At Food Court, the range for moisture content of FW were in between of 0.78% and 77.24% while for KW were in between 0.26% and 0.55%. Moisture content of FW for Food Court A, B and C were 0.78%, 77.24% and 18.78% while for KW were 0.55%, 0.26% and 0.39% respectively. Food Court A have the lowest moisture content for FW and KW where the values were 0.78% and 0.55%. the results for moisture content of FW and KW shows that there were significant ($P<0.05$) for Food Court C. Meanwhile, the results for Food Court A and B, there were found that there were not significant ($P>0.05$) for FW and KW. This is because there was variety food composition in FW and KW.

At Restaurant, the range for moisture content of FW were in between of 1.45% and 11.95% while for KW were in between 0.83% and 2.55%. Moisture content of FW for

Restaurant A, B and C were 11.95%, 5.26% and 1.49% while for KW were 2.55%, 0.83% and 1.09% respectively. Restaurant C have the lowest moisture content for FW which was 1.49% while for KW, Restaurant B have the lowest moisture content which was 0.83%. The results for moisture content of FW and KW shows that there were significant ($P<0.05$) for Restaurant A, B and C. This is because the type of food sold and size of restaurant scale were identical for Restaurant A, B and C.

Table 4.2.1.1 Percentage Composition of Moisture Content

Types of Location	Moisture Content (%)	
	Food Waste	Kitchen Waste
Cafeteria A	5.38±0.52 [d]	0.68± 0.04 [d]
Cafeteria B	5.25±0.08 [d]	0.86± 0.20 [d]
Cafeteria C	0.80±0.07 [e]	0.67± 0.05 [e]
Food Court A	0.78±0.10 [e]	0.55± 0.09 [e]
Food Court B	77.24±3.73 [a]	0.26± 0.10 [a]
Food Court C	18.78±4.07 [b]	0.39± 0.06 [b]
Restaurant A	11.95±3.11 [c]	2.55± 0.30 [c]
Restaurant B	5.26±0.17 [d]	0.83± 0.12 [d]
Restaurant C	1.49±0.38 [de]	1.09± 0.06 [de]

Means (± SD) with the same letter are not significantly different at $p > 0.05$ for each row

Table 4.2.1.2 shows the moisture content for the bran. The moisture content was 6.5%. Based on Table 4.2.1.1 Food Court A have the lowest moisture content for FW while Food Court B have the lowest moisture content for KW. All the value of moisture content below 15% were acceptable due to the recommended moisture content in stored grains is <15%. Dry matter content below 85% normally leads to spoilage of feed ingredients due to mold growth especially in tropical countries where temperature and relative humidity are relatively high throughout the year (Hamito, 2010). High dry matter content is also beneficial for livestock farmers because it increases the unit value of the feed components (Salome & Eliane, 2011).

Table 4.2.1.2 Moisture Content of Bran

	Bran			
Moisture Content (%)	6.51	±	1.65	c

Means (± SD) with the same letter are not significantly different at $p > 0.05$ for each row

4.2.2 Protein Content

Table 4.2.2.1 shows the result for the percentage composition of protein content for FW and KW. At cafeteria the range for protein content of FW were in between of 12.64% and 37.27% while for KW were in between 18.71% and 34.67%. Protein content of FW for Cafeteria A, B and C were 12.64%, 20.22% and 37.27% while for KW were 18.71%, 34.67% and 19.34% respectively. Cafeteria C and Cafeteria B have the highest protein content for FW and KW where the values were 37.27% and 34.67% respectively. The results for protein content of FW and KW shows that there were significant ($P<0.05$) for Cafeteria A, B and C. This is because the composition of waste in FW and KW mostly fish, meat, chicken and rice which high protein content.

At Food Court, the range for protein content of FW were in between of 20.78% and 27.56% while for KW were in between 16.53% and 26.60%. Protein content of FW for Food Court A, B and C were 0.78%, 77.24% and 18.78% while for KW were 0.55%, 0.26% and 0.39% respectively. Food Court A have the highest protein content for FW and KW where the values were 27.56% and 26.60%. The results for protein content of FW and KW shows that there were significant ($P<0.05$) for Food Court A, B and C. This is because the composition of waste in FW and KW mostly fish, meat, chicken and rice which high protein content.

At Restaurant, the range for protein content of FW were in between of 19.95% and 25.97% while for KW were in between 20.27% and 53.75%. Protein content of FW for Restaurant A, B and C were 25.97%, 22.19% and 19.95% while for KW were 20.27%, 53.75% and 46.56% respectively. Restaurant A have the highest protein content for FW which was 25.97% while for KW, Restaurant B have the highest protein content which was 53.75%. The results for protein content of FW and KW shows that there were significant ($P<0.05$) for Restaurant A, B and C. This is because the composition of waste in FW and KW mostly fish, meat, chicken and rice which high protein content.

Table 4.2.2.1. Percentage Composition of Protein Content

Types of Location	Protein Content (%)	
	Food Waste	Kitchen Waste
Cafeteria A	12.64 ± 0.69^{f}	18.71 ± 0.63^{f}
Cafeteria B	20.22 ± 0.41^{e}	34.67 ± 0.64^{c}
Cafeteria C	37.27 ± 0.26^{a}	19.34 ± 0.28^{ef}
Food Court A	27.56 ± 3.76^{bc}	26.60 ± 0.65^{d}
Food Court B	23.97 ± 0.44^{cd}	16.53 ± 0.78^{g}
Food Court C	20.78 ± 0.43^{e}	19.27 ± 0.17^{ef}
Restaurant A	25.97 ± 1.57^{bc}	20.27 ± 0.45^{e}
Restaurant B	22.19 ± 0.28^{de}	53.75 ± 0.35^{a}
Restaurant C	19.95 ± 0.42 e	46.56 ± 1.15 b

Means (± SD) with the same letter are not significantly different at $p > 0.05$ for each row

Table 4.2.2.2 shows the protein content for the bran. The protein content was 7.09%. Based on Table 4.2.2.1 Cafeteria C have the highest protein content for FW while Restaurant B have the highest protein content for KW where the values were 37.27% and

53.75%. Percentage composition for bran was 7.09% which is closed to the protein content for the broken rice which is 9.84% (Salome & Eliane, 2011).

From the research about Determination of Chemical Composition and Ant Nutritive Components for Poultry Feed Ingredients, it was stated that the variation in protein content between broken rice and maize bran were probably due to the types of component founds in the waste. This means that it was important to know the physical composition of the waste since it has large influence in the chemical composition.

Based on the observations on the physical composition of FW for Restaurant A, there were leftover rice, fish, processed food and egg while for KW which was Restaurant B, there were waste from the fish, chicken, and also several vegetables peelings. All of these physical components in the waste had led to the high percentage component of protein compared to the other places.

The value of protein for FW and KW was higher compared to the value of protein for bran and broken rice. This shown that, the waste from food service industry has a higher potential to replace the feed ingredients for animal feed. This is because the higher value of protein will let the animal grow faster as proteins were used in the construction of body tissues such as muscles, nerves, cartilage, skin, feathers, beak, and others (Jacquie,2018).

Table 4.2.2.2 Protein Content of Bran

	Bran
Protein Content (%)	7.09 ± 0.10 [c]

Means (± SD) with the same letter are not significantly different at $p > 0.05$ for each row

4.2.3 Carbohydrate Content

Table 4.2.3.1 shows the result for the percentage composition of carbohydrate content for FW, KW and bran. For cafeteria A, B and C, carbohydrate content for FW were 77.7%, 63.08% and 79.3% while for KW were 9.15%, 7.88% and 36.7% respectively. At cafeteria, FW have higher carbohydrate content compared to the KW. It was observed that Cafeteria C have the highest percentage composition which was 79.3% and 36.7% of carbohydrate content for FW and KW respectively.

For food court A, B and C, carbohydrate content for FW were 27.85%, 63.45% and 7159.01% while for KW were 17.46%, 61.63% and 29.01% respectively. At food court, KW have higher carbohydrate content compared to the FW. It was observed that Food Court B have the highest percentage composition of carbohydrate content for FW and KW which was 63.45% and 61.63% respectively.

For restaurant A, B and C, protein content for FW were 26.03%, 23.30% and 19.76% while for KW were 20.08%, 53.56% and 46.46% respectively. At restaurant, KW have higher carbohydrate content compared to the FW. It was observed that Restaurant C and Restaurant A the highest percentage composition of carbohydrate content for FW which was 71.49% and 65.96% for FW and KW respectively.

All the value for carbohydrate content at three different places were different due to the variety composition of FW and KW. Based on the table 4.2.3, the highest carbohydrate content in FW was Cafeteria A which was 77.7% while for KW was Restaurant A which was 65.96%. Hence the value of carbohydrate content of FW was closedly to the bran which was 64.51%. Based on Salome & Eliane (2011), they stated that carbohydrate content for two types of poultry feed which were broken rice and maize bran were 75.21% and 69.15% respectively.

Poultry diets must be formulated to provide all of the bird's nutrient requirements if optimum growth and production is to be achieved. The major source of energy for poultry. Most of the carbohydrate in poultry diets was provided by cereal grains (Poultry Hub,2019). Therefore, the higher the composition of carbohydrate, the higher source of energy for the poultry.

Table 4.2.3.1. Percentage Composition of Carbohydrate Content

Different Types of Location	Percentage Composition (%)		
	Food Waste	Kitchen Waste	Bran
Cafeteria A	77.7	9.15	64.51
Cafeteria B	63.08	7.88	
Cafeteria C	79.3	36.7	
Food Court A	27.85	17.46	
Food Court B	63.45	61.63	
Food Court C	59.01	29.01	
Restaurant A	45.04	65.96	
Restaurant B	46.53	7.16	
Restaurant C	71.49	2.51	

4.2.4 Fiber Content

Table 4.2.4.1 shows the result for the percentage composition of fiber content for FW and KW. At cafeteria the range for fiber content of FW were in between of 69.13% and 89.25% while for KW were in between 69.35% and 97.74%. Fiber content of FW for Cafeteria A, B and C were 89.25%, 75.94% and 69.13% while for KW were 85.77%, 69.35% and 97.74% respectively. Cafeteria B have the lowest fiber content for FW while Cafeteria C have the lowest fiber content in KW where the values were 69.13% an 69.35%. The results for fiber content of FW and KW shows that there were significant ($P<0.05$) for Cafeteria A, B and C. This is because the composition of waste in FW and KW mostly contain excessive rice, fruits and vegetables peeling.

At Food Court, the range for fiber content of FW were in between 76.40% and 80.11% while for KW were in between 84.65% and 94.12%. Fiber content of FW for Food Court A, B and C were 80.11%, 77.15% and 76.40% while for KW were 85.18%, 94.12% and 84.65% respectively. Food Court C have the lowest fiber content for FW and KW where the values were 76.40% and 84.65%. The results for fiber content of FW shows that there were significant ($P<0.05$) for Food Court A, B and C. Whereas for KW, the results of fiber content show that there were not significant ($P>0.05$) for Food Court A and C. This is because the composition of waste that contain high fiber not constant at each food court.

For Restaurant, the range for fiber content of FW were in between 76.40% and 80.11% while for KW were in between 84.65% and 94.12%. Fiber content of FW for Restaurant A, B and C were 85.61%, 77.49% and 78.67% while for KW were 72.18%, 97.60% and 85.72% respectively. Restaurant B have the lowest fiber content for FW which was 77.49% while for KW, Restaurant A have the lowest fiber content which was 72.18%. The results for fiber content of FW and KW shows that there were significant ($P<0.05$) for Restaurant A, B and C. This is because the composition of FW and KW almost similar at all restaurants.

Table 4.2.4.1 Percentage Composition of Fiber Content

Types of Location	Fiber Content (%)	
	Food Waste	**Kitchen Waste**
Cafeteria A	89.25± 0.55 [a]	85.77±0.49 [c]
Cafeteria B	75.94± 0.28 [f]	69.35±0.82 [e]
Cafeteria C	69.13± 0.86 [g]	97.74±0.68 [a]
Food Court A	80.11± 0.52 [c]	85.18±0.72 [c]
Food Court B	77.15± 0.62 [e]	94.12±0.66 [b]
Food Court C	76.40± 0.44 [ef]	84.65±1.21 [c]
Restaurant A	85.61± 0.45 [b]	72.18±0.81 [d]
Restaurant B	77.49± 0.95 [e]	97.60±1.05 [a]
Restaurant C	78.67± 0.66 [d]	85.72±0.60 [c]

Means (± SD) with the same letter are not significantly different at $p > 0.05$ for each row

Table 4.2.4.2 shows the fiber content for the bran. The fiber content was 96.21%. Based on Table 4.2.4.1 Cafeteria C have the lowest fiber content for FW while Cafeteria B have the lowest fiber content for KW where the values were 69.13% and 69.35%. Hence, the fiber component for FW and KW were nearly the percentage for bran which was 84.54%.

Although fiber in poultry nutrition is often associated with reduced energy available due to its minor rule in energy suuply and interference with digestive processes, low to moderate amounts of fiber might be beneficial for gastrointestinal development and health. Thereby enhancing nutrient digestibility and growth performance.

Apart from that, the fiber composition in broken rice and maize grain were 2.04% and 22.23% (Salome & Eliane, 2011) which were lower that the obtained results and the bran. The results obtained from the food waste and kitchen waste contain high in fiber composition due to its physical component in the waste. Based on the observation, the food waste and kitchen waste contain leftover vegetables and fruits and also peeling from the vegetables and fruits which were high in fiber (MOTT Children Hospital, Michigan Medicine, 2019).

Although fiber in poultry nutrition is often associated with reduced energy availability due to its minor role in energy supply. Low to moderate amounts of fiber might be beneficial for gastrointestinal development, function, and health, thereby enhancing nutrient digestibility and growth performance (Sonja, 2015).

Table 4.2.4.2 Fiber Content of Bran

	Bran
Fiber Content (%)	96.21 ± 2.50 [a]

Means (± SD) with the same letter are not significantly different at $p > 0.05$ for each row

4.2.5 Fat Content

Table 4.2.5.1 shows the result for the percentage composition of fat content for FW and KW. At cafeteria the range for fat content of FW were in between of 2.30% and 19.66% while for KW were in between 2.91% and 62.61%. Fat content of FW for Cafeteria A, B and C were 2.30%, 19.60% and 9.74% while for KW were 62.61%, 48.93% and 2.91% respectively. Cafeteria A have the lowest fat content for FW while Cafeteria C have the lowest fat content in KW where the values were 2.30% an 2.91%. The results for fat content of FW and KW shows that there were significant ($P<0.05$) for Cafeteria A, B and C. This is because FW and KW have same composition in their waste for the three types of location.

At Food Court, the range for fat content of FW were in between 6.27% and 27.46% while for KW were in between 13.32% and 51.71%. Fat content of FW for Food Court A, B and C were 27.46%, 6.27% and 9.42% while for KW were 51.71%, 13.32% and 44.22%

respectively. Food Court B have the lowest fat content for FW and KW where the values were 6.27% and 13.32% respectively. The results for fat content of FW and KW shows that there were significant ($P<0.05$) for Food Court A, B and C. This is because FW and KW have same composition in their waste for the three types of location.

For Restaurant, the range for fat content of FW were in between 5.55% and 12.91% while for KW were in between 3.63% and 32.16%. Fat content of FW for Restaurant A, B and C were 12.91%, 11.02% and 5.55% while for KW were 3.63%, 32.16% and 38.68% respectively. Restaurant C have the lowest fat content for FW which was 5.55% while for KW, Restaurant A have the lowest fat content which was 3.63%. The results for fiber content of FW and KW shows that there were significant ($P<0.05$) for Restaurant A, B and C. This is because the composition of FW and KW almost similar at all restaurants.

Table 4.2.5.1. Percentage Composition of Fat Content

Types of Location	Fat Content (%)	
	Food Waste	Kitchen Waste
Cafeteria A	2.30± 0.16 ^{g}	62.61± 1.07 ^{a}
Cafeteria B	19.66± 0.78 ^{b}	48.93± 0.52 ^{c}
Cafeteria C	9.74± 0.15 ^{e}	2.91± 0.16 ^{h}
Food Court A	27.46± 0.78 ^{a}	51.71± 2.08 ^{b}
Food Court B	6.27± 0.14 ^{f}	13.32± 0.61 ^{g}
Food Court C	9.42± 0.37 ^{e}	44.22± 0.80 ^{d}
Restaurant A	12.91± 0.54 ^{c}	3.63± 0.32 ^{h}
Restaurant B	11.02± 0.58 ^{d}	32.16± 0.37 ^{f}
Restaurant C	5.55± 0.57 ^{f}	38.68± 0.57 ^{e}

Means (± SD) with the same letter are not significantly different at $p > 0.05$ for each row

Table 4.2.5.2 shows the fat content for the bran. The fat content was 3.41%. Based on Table 4.2.5.1 Cafeteria A have the lowest fat content for FW while Cafeteria C have the lowest fat content for KW where the values were 2.30% and 2.91%. Hence, the fat component for FW and KW were nearly the percentage for bran which was 3.49%. Salome and Eliane (2011) were stated that percentage component for fat in broken rice and maize bran were 1.48% and 12.29% which were nearly to the value for FW and bran.

Fat must be present in the diet for poultry to absorb the fat-soluble vitamins A, D, E, and K. In addition to its role in nutrition, fat is added to feed to reduce grain dust. Fat also improves the palatability of feed. In feed, it has a tendency to go bad or become rancid. To prevent feed from going rancid, antioxidants were added to poultry diets containing high fat. A common antioxidant listed on feed labels is ethoxyquin (Jacquie, 2018).

Table 4.2.5.2. Fat Content of Bran

	Bran
Fat Content (%)	3.49 ± 0.37 d

Means (± SD) with the same letter are not significantly different at p > 0.05 for each row

4.2.6 Ash Content

Table 4.2.6.1 shows the result for the percentage composition of ash content for FW and KW. At cafeteria the range for ash content of FW were in between of 2.37% and 3.32% while for KW were in between 7.19% and 8.04%. Ash content of FW for Cafeteria A, B and C were 2.37%, 3.32% and 3.12% while for KW were 7.71%, 7.19% and 8.04% respectively. Cafeteria C have the lowest ash content for FW while Cafeteria B have the lowest ash content in KW where the values were 3.12% an 7.19%. The results for ash content of FW shows that there were significant (P<0.05) for Cafeteria A, B and C. Meanwhile, the results for Food Court B and C were found that there were not significant (P>0.05) for KW. This is because KW have variety of discarded food from kitchen.

At Food Court, the range for ash content of FW were in between 2.54% and 15.92% while for KW were in between 6.14% and 8.24%. Ash content of FW for Food Court A, B and C were 15.92%, 2.54% and 7.35% while for KW were 6.14%, 8.24% and 7.19% respectively. Food Court B have the lowest ash content for FW whereas Food Court A have the lowest ash content for KW where the values were 2.54% and 6.14% respectively. The results for ash content of FW shows that there were significant ($P<0.05$) for Food Court A, B and C. Whereas for KW, the results of ash content show that there were not significant ($P>0.05$) for Food Court B and C. This is because the composition of KW has variety of discarded food from kitchen.

For Restaurant, the range for ash content of FW were in between 2.26% and 13.84% while for KW were in between 3.60% and 10.82%. Ash content of FW for Restaurant A, B and C were 12.85%, 13.84% and 2.26% while for KW were 3.60%, 9.32% and 10.85% respectively. Restaurant C have the lowest fiber content for FW which was 2.26% while for KW, Restaurant A have the lowest fiber content which was 3.60%. The results for fiber content of FW and KW shows that there were significant ($P<0.05$) for Restaurant A, B and C. This is because the composition of FW and KW almost similar at all restaurants.

Table 4.2.6.1. Percentage Composition of Ash Content

Types of Location	Ash Content (%)	
	Food Waste	Kitchen Waste
Cafeteria A	2.37±0.06 f	7.71±0.61 bc
Cafeteria B	3.32±0.04 e	7.19±3.38 bc
Cafeteria C	3.12±0.14 e	8.04±0.38 bc
Food Court A	15.92±0.37 a	6.14±0.43 c
Food Court B	2.54±0.21 f	8.24±0.42 bc
Food Court C	7.35±0.22 d	7.19±0.08 bc
Restaurant A	12.85±0.16 c	3.60±0.26 d
Restaurant B	13.84±0.30 b	9.32±0.62 ab
Restaurant C	2.26±0.08 f	10.85±0.37 a

Means (± SD) with the same letter are not significantly different at $p > 0.05$ for each row

Table 4.2.6.2 shows the ash content for the bran. The ash content was 18.40%. Based on Table 4.2.6.1, Restaurant C have the lowest ash content for FW while Restaurant A have the lowest fiber content for KW where the values were 2.26% and 3.60%. Hence, the fiber component for FW and KW were nearly the percentage for bran which was 18.40%. Therefore, the value of ash content in waste from food service industry was lower than the value for bran. Apart from that, the value of ash content for waste from food service was higher than broken rice and maize bran which were 1.57% and 4.99% respectively stated by (Salome & Eliane, 2011). Reducing the amount of minerals in the diet can help to minimize certain growth and urinary tract problems (Cindy,2018).

Table 4.2.6.2. Ash Content of Bran

	Bran
Ash Content (%)	18.40 ± 0.30 b

Means (± SD) with the same letter are not significantly different at $p > 0.05$ for each row

4.3 Comparison of Proximate Analysis Between Cafeteria, Food Court and Restaurant

Based on the Table 4.3.1, at Cafeteria, moisture content for FW and KW were 3.81% and 0.74%. KW from Cafeteria were the least moisture content compared to the FW. Protein content for FW was lower than KW which were 23.38% and 24.24%. Carbohydrate of FW was higher than KW which were 55.73% and 33.76%respectively. Fiber, fat and ash content of KW were higher than FW where their values were 84.29%, 32.93% and 8.33%.

For food court, moisture content for FW and KW were 32.27% and 0.40%. KW from food court were the least moisture content compared to the FW. Protein content for FW was higher than KW which were 24.10% and 19.42%. Carbohydrate, fiber, fat content of KW was higher than FW where their values were 36.58%, 87.98%[a] and 36.41%. Ash content of KW was lower than FW where their values were 8.60% and 7.19% respectively.

Meanwhile for restaurant, moisture content for FW and KW were 6.23% and 1.49%. KW from restaurant were the least moisture content compared to the FW. Protein content for FW was lower than KW which were 22.70% and 40.19%. Carbohydrate and fiber content of FW were higher than KW where 55.45% and 80.59% respectively. Next, fat and ash content of FW were lower than KW where their values were 9.83% and 5.79%.

Based on the results obtained in Table 4.3.1, FW at cafeteria is the most suitable location in this study to utilize FW as poultry feed. This is because the compositon of the carbohydrate for FW is the highest which the main source of energy for the poultry. Besides, it contains the lowest moisture content in FW which is below 15%. Fat is the crucial component in feed composition. This is because the higher fat composition in the feed will lead to the rancidity. Hence, KW was not suitable to be utilized as poultry feed.

Table 4.3.1. Comparison Proximate Analysis Between Food Waste, Kitchen Waste at Three Different Location

Proximate Analysis	Percentage Composition (%)		
	Food Waste		
	Cafeteria	**Food Court**	**Restaurant**
Moisture	3.81±2.60[a]	32.27±39.98[a]	6.23±5.30[a]
Protein	23.38±12.61[a]	24.10±3.39[a]	22.70±3.04[a]
Carbohydrates	55.73	20.65	55.45
Fiber	78.11±10.23[a]	77.88±1.96[a]	80.59±4.39[a]
Fat	10.57±8.71[a]	14.38±11.44[a]	9.83±3.82[a]
Ash	6.51±6.37[a]	8.60±6.78[a]	5.79±6.11[a]
	Kitchen Waste		
Moisture	0.74±0.10[a]	0.40±0.15[a]	1.49±0.93[a]
Protein	24.24±9.038[a]	19.42±7.10[a]	40.19±17.62[a]
Carbohydrates	33.76	36.58	25.57
Fiber	84.29±14.25[a]	87.98±5.32[a]	77.03±7.54[a]
Fat	32.93±26.024[a]	36.41±20.35[a]	24.83±18.64[a]
Ash	8.33±0.80[a]	7.19±1.049[a]	7.92±3.82[a]

Means (± SD) with the same letter are not significantly different at $p > 0.05$ for each row

Based on the summary in Table 4.3.1 and 4.3.2, the results obtained on the proximate properties of FW and KW, the waste from food service industry can be used to make poultry feed due to their similarity properties to the bran, broken rice and maize bran. All the proximate properties almost similar but the content of fat for kitchen waste was too high in order to utilize as poultry feed. This is because the higher the fat content, the higher the tendency to go bad or become rancid. It can be prevented by adding antioxidants to poultry diets containing high fat. A common antioxidant listed on feed labels is ethoxyquin (Jacquie, 2018).

Table 4.3.2. Proximate Composition of Bran, Broken Rice and Maize

Proximate Analysis	Percentage Composition (%)		
	Bran	Broken Rice	Maize Bran
Moisture	6.3	11.9	10.5
Protein	7.14	9.84	5.36
Fat	3.81	1.48	12.29
Fiber	84.54	2.04	22.23
Ash	18.24	1.57	4.99
Carbohydrate	64.51	75.21	69.15

4.4 Physical Properties of Food Waste Pellets and Kitchen Waste Pellets

In addition to compositional characterisation of wastes from food services industry, pellets of food waste and kitchen waste were analysed for their physical properties which are friability (%), true density (kg/m^3), bulk density (kg/m^3), porosity (%) and tensile strength (kg.s).

4.4.1 Friability

Friability is the tendency of a solid substance to break into smaller pieces under contact (Grykzova et al., 2008). The ability of the compressed pellets is measured to avoid fracture and breaking apart during handling and transportation (Zainuddin, 2014). The previous study by Karunanithy et al. (2012), suggested that fines up to 5% by weight would be an acceptable level, but greater than 5% would reduce storage capacity and create problems in flow characteristics. The low friability from compaction process indicates that the pellets were able to withstand the shear forces when subjected to mechanical attrition or shock (Zainuddin, 2014).

Based on the Table 4.4.1.1, the results show that the friability of pellets varied between 2.03% and 7.09 % for KW while between 5.57% and 20.29% for FW. FW pellets have friability for moisture content of 40%, 50% and 60% were 20.29%, 13.53% and 5.57% respectively. Meanwhile, the friability of KW pellets for moisture content of 40%, 50% and 60% were 7.09%, 2.03% and 2.84%.

Table 4.4.1.1. Percentage Friability of FW and KW Pellets

Type of Pellets	Moisture Content (%)	Friability (%)
Food Waste	40%	20.29 ± 0.40^{a}
	50%	13.53 ± 0.46^{b}
	60%	5.57 ± 0.36^{c}
Kitchen Waste	40%	7.09 ± 0.31^{a}
	50%	2.03 ± 0.23^{b}
	60%	2.84 ± 0.21^{b}

Means (± SD) with the same letter are not significantly different at $p > 0.05$ for each row

Based on the graph on Figure 4.4.1.1, it was showed that porosity of FW pellets was higher than KW pellets as the moisture content increase. FW pellets with 40% moisture content have the highest value of friability which was 7.09% and the lowest with 50% moisture content was 2.03%. KW pellets with 40% moisture content have the highest value of friability which was 20.29% and the lowest with 60% moisture content was 5.57%. Meanwhile, the low friability indicated that the pellets were able to withstand the shear forces when subjected to mechanical shock or attrition (Zainuddin et al., 2014). According to the value obtained, pellets from KW at 50% and 60% of moisture content showed an acceptable value which is below 5% while the value for the pellets from FW for all moisture content and 40% moisture content of KW have greater value than 5% which will help in reducing storage capacity. The result shows that there was significant ($P < 0.05$) in the FW and KW pellet's friability percentage for 40% and 50% of moisture content. Thus, the FW and KW pellets from compaction process with 60% and 50% of moisture content respectively were found to have the optimum condition to produce pellets since the friability test resulted that the friability percentage was the lowest compared to the others

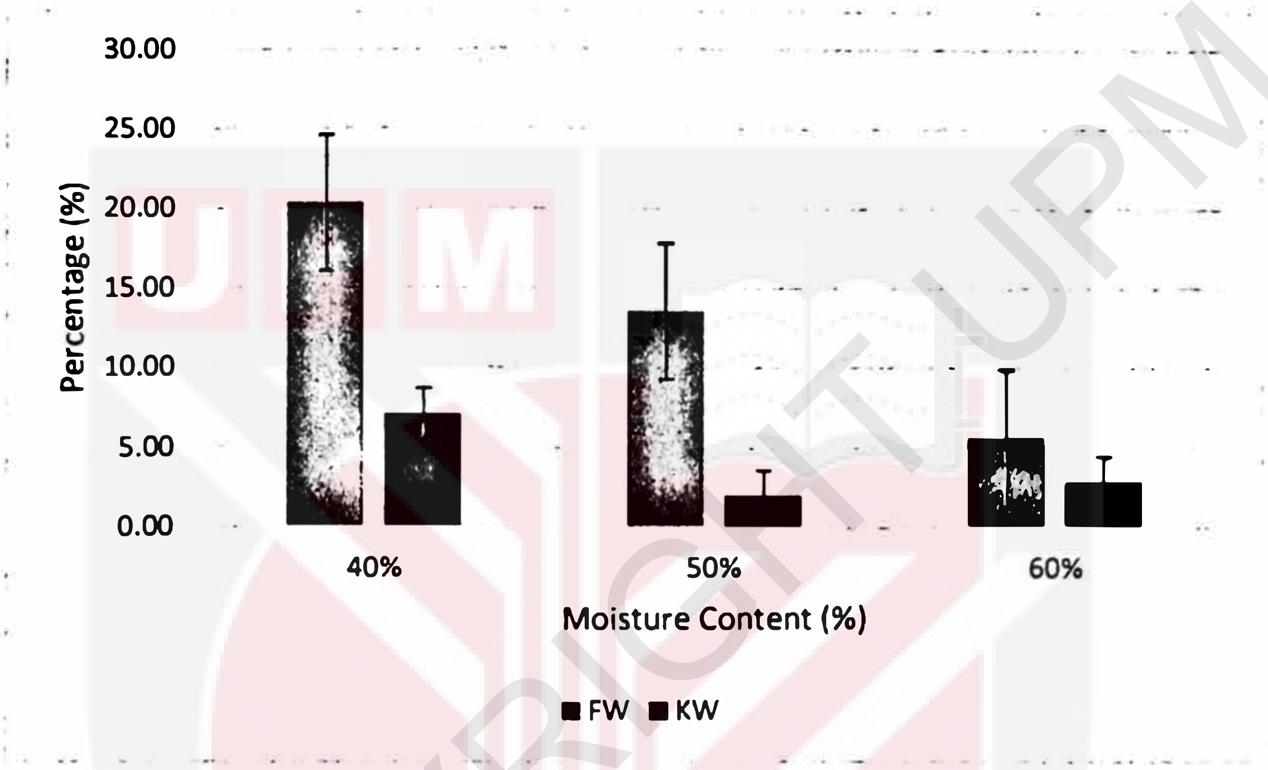

Figure 4.4.1.1. Percentage Friability of FW and KW Pellets

4.4.2 True Density

True density measures the average density of a large volume of the powder in a specific medium usually air. It is a fundamental material property for accurate characterization of powder mechanical properties (Zainuddin et al.,2014).

Based on the Table 4.4.2.1 above, true density of the FW pellets for all the moisture content ranged between 1442.98 kg/m^3 to 1447.53 kg/m^3 while for KW pellets were in the range of 1246.97 kg/m^3 to 1252.23 kg/m^3. True density of FW pellets for moisture content of 40%, 50% and 60% were 1445.37 kg/m^3, 1442.98 kg/m^3 and 1447.53 kg/m^3

respectively. Meanwhile, the true density of KW pellets for moisture content of 40%, 50% and 60% were 1246.97 kg/m^3, 1248.6 kg/m^3 and 1252.23 kg/m^3.

Table 4.4.2.1. True Density of KW and FW Pellets

Type of Pellets	Moisture Content (%)	True Density (kg/m^3)
Food Waste	40%	1445.37±0.65^b
	50%	1442.98±0.55^c
	60%	1447.53±0.55^a
Kitchen Waste	40%	1246.97±0.31^c
	50%	1248.6±0.52^b
	60%	1252.23±0.40^a

Means (± SD) with the same letter are not significantly different at $p > 0.05$ for each row

Based on Figure 4.4.2.1, FW pellets have higher true density than the KW pellets as the moisture content increase. FW and KW pellets shows moisture content at 60% yielded the highest true density value where 1447.53 kg/m^3 and 1252.23 kg/m^3 respectively whereas moisture content at 50% of FW, gave the lowest value of true density which was 1442.98 kg/m^3. The results of this experiment exhibited the difference pattern as Barnwal et al. (2011), whereby the true density of maize powder for animal feed decreased with increasing moisture content. According to Kaliyan and Morey (2009), density depended on the types of feedstock, machines and process variables. In conclusion, all the results for FW and KW pellets gave significant differences at ($P < 0.05$) for 50% and 60% moisture content, and these true density values were used to determine the percentage of porosity.

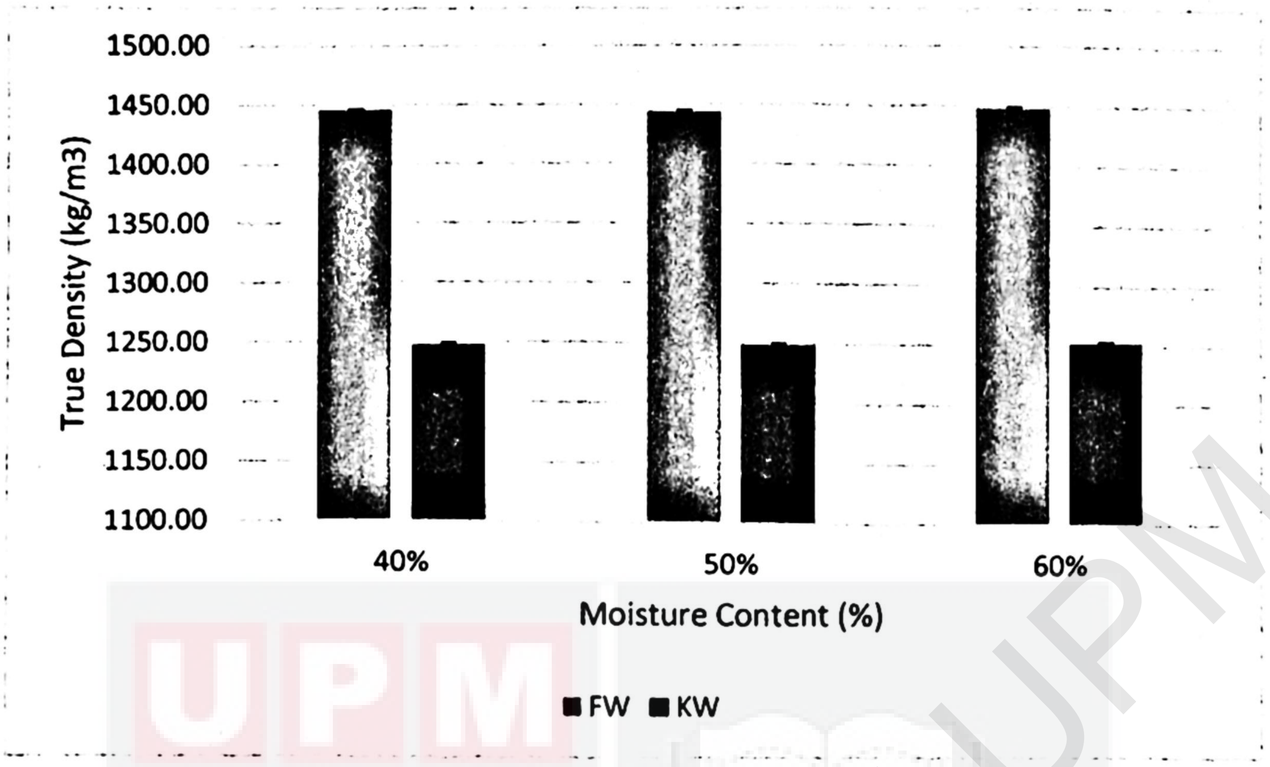

Figure 4.4.2.1 True Density of FW and KW Pellets

4.4.3 Bulk Density

Bulk density had a significant role in transport and storage efficiency. In addition, bulk density provided a strong influence in the form of transport equipment, storage and conversion process (Karunanithy et al., 2012).

Based on the results obtained in Table 4.4.3.1, bulk density of the FW pellets for all the moisture content ranged between 289.85 kg/m^3 and 323.09 kg/m^3 while for KW pellets were in the range of 147.86 kg/m^3 to 164.77 kg/m^3. Bulk density of FW pellets for moisture content of 40%, 50% and 60% were 310.58 kg/m^3, 323.09 kg/m^3 and 289.85 kg/m^3 respectively. Meanwhile, the bulk density of KW pellets for moisture content of 40%, 50% and 60% were 164.77 kg/m^3, 177.12 kg/m^3 and 147.86 kg/m^3.

Table 4.4.3.1. Bulk Density of FW and KW Pellets

Type of Pellets	Moisture Content (%)	Bulk Density (kg/m^3)
Food Waste	40%	310.58±7.5^{a}
	50%	323.09±7.53^{a}
	60%	289.85±4.4^{b}
Kitchen Waste	40%	164.77±0.81^{ab}
	50%	177.12±3.45^{a}
	60%	147.86±14.70^{b}

Means (± SD) with the same letter are not significantly different at $p > 0.05$ for each row

Based on the figure 4.4.3.1, FW pellets have higher bulk density than KW pellets. Meanwhile, FW and KW pellets with 50% moisture content have the highest value of bulk density which are 323.09 kg/m^3 and 177.12 kg/m^3 and the lowest with 60% moisture content which are 289.85 kg/m^3 and 147.86 kg/m^3 respectively. The bulk density of the FW and KW pellets were found not significant where ($P > 0.05$) with the 40% moisture content. This result was proven by Ashwin et al. (2017) that the maize grains bulk density at different moisture levels varied from 758.80 kg/m^3 to 721.87 kg/m3 indicated a decrease in bulk density with an increase in moisture content from 12 to 20 (% wb). This was due to the fact that an increase in mass owing to moisture gain in the sample was lower than accompanying volumetric expansion of the bulk. Meanwhile, White and Jayas (2001), reported that there was no significant difference on bulk density of canola meal pellets by increasing the moisture content. Several researchers have reported that densification would result in bulk densities in the range of 450 to 700 kg/m^3 depending upon feedstock and densification conditions (Kaliyan and Morey, 2009b; Kaliyan et al., 2009).

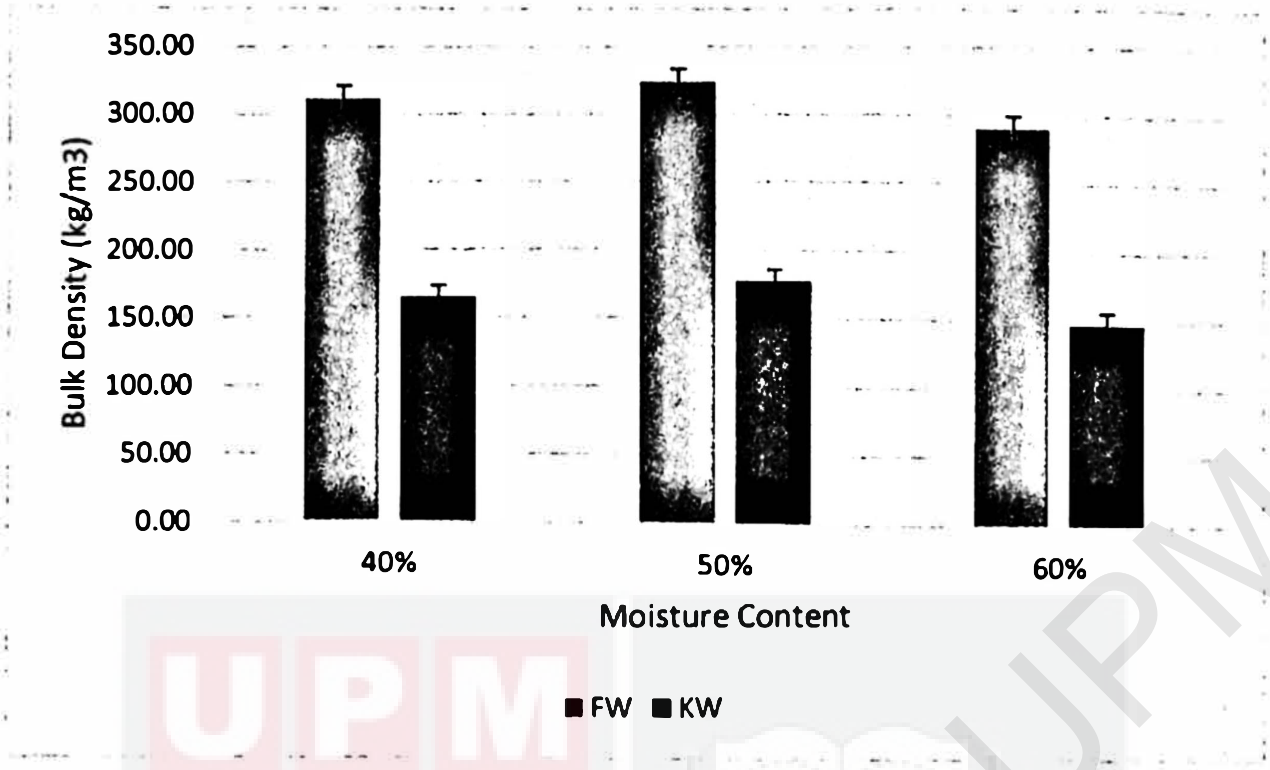

Figure 4.4.3.1 Bulk Density of FW and KW Pellets

4.4.4 Porosity

Porosity has influence in the transportation and the storage of pellets. Based on the table 4.4.4.1, porosity of the FW pellets for all the moisture content ranged between 78.45% and 79.03% while for KW pellets were in the range of 86.72% and 87.30%. Porosity of FW pellets for moisture content of 40%, 50% and 60% were 78.62%, 78.45% and 79.03% respectively. Meanwhile, the porosity of KW pellets for moisture content of 40%, 50% and 60% were 86.77%, 86.72% and 87.30% respectively.

Table 4.4.4.1. Porosity of FW and KW Pellets

Types of Pellets	Moisture Content (%)	Porosity (%)
Food Waste	40%	78.62±1.28[a]
	50%	78.45±1.33[a]
	60%	79.03±1.10[a]
Kitchen Waste	40%	86.77±0.64[a]
	50%	86.72±0.98[a]
	60%	87.30±2.02[a]

Means (± SD) with the same letter are not significantly different at $p > 0.05$ for each row

Based on the Figure 4.4.4.1, KW pellets have higher porosity than FW pellets. FW and KW pellets shows moisture content at 60% yielded the highest porosity value of 78.62% and 87.30% whereas moisture content at 50%, gave the lowest value of porosity, 78.45% and 86.72% respectively. There was no significant difference (P > 0.05) in terms of the porosity values obtained for all the moisture content (40-60%). Furthermore, high porosity of feedstock at moisture content 60% indicated that the sample was compacted, thus resulting in higher compressibility. Meanwhile, the increasing trends in porosity with increase in moisture content have been observed for maize grain, barely, Cucurbit seeds and rice (Ashwin et al., 2017). The results also contradicted with Mahapatra et al. (2010), who found that the porosity of feedstocks increased with the increase in moisture content. This might be due to the different types of feedstocks, machines and process variables used (Kaliyan and Morey, 2009).

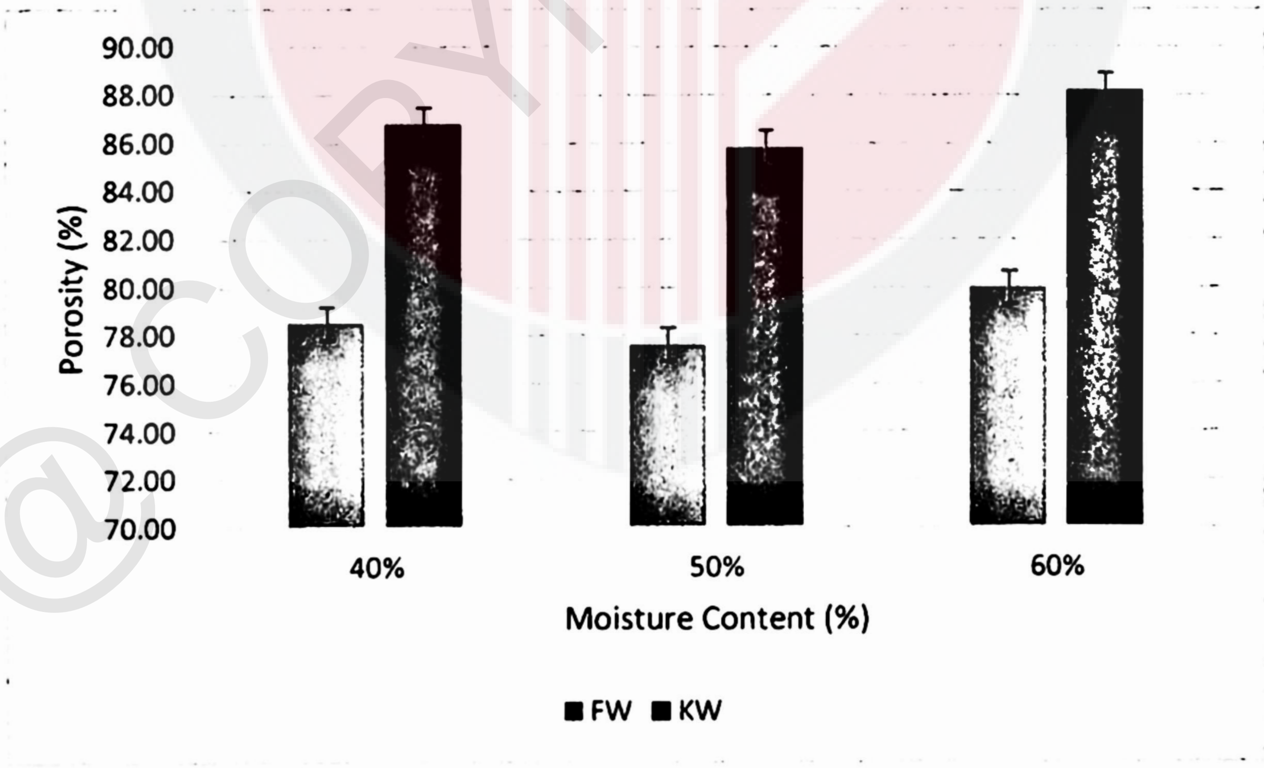

Figure 4.4.4.1. Percentage Porosity of FW and KW Pellets

4.4.5 Tensile Strength

According Zainuddin et al., (2015), tensile strength is to study the relationship between the moisture content during pelletising while keeping the quality of the pellets and the higher level of moisture content. The tensile strength of the pellets can increase the tensile strength of the pellets increase with the higher level of moisture. Compressive resistance is the maximum crushing load a pellet can endure before it started to crack of fracture.

Based on the results obtained on Table 4.4.5.1, work compression of the FW pellets for all the moisture content ranged between 0.33 kg.s and 3.06 kg.s while for KW pellets were in the range of 3.21 kg.s and 4.59 kg.s. Work compression of FW pellets for moisture content of 40%, 50% and 60% were 0.33 kg.s, 1.13 kg.s and 3.06 kg.s respectively. Meanwhile, the work compression of KW pellets for moisture content of 40%, 50% and 60% were 3.21 kg.s, 6.08 kg.s and 4.59 kg.s respectively.

Table 4.4.5.1. Work Compression for FW and KW Pellets

Type of Pellets	Moisture Content (%)	Work Compression (kg.s)
Food Waste	40%	0.33 ± 0.01^{c}
	50%	1.13 ± 0.32^{b}
	60%	3.06 ± 0.38^{a}
Kitchen Waste	40%	3.21 ± 1.11^{b}
	50%	6.08 ± 0.99^{a}
	60%	4.59 ± 0.80^{ab}

Means (± SD) with the same letter are not significantly different at $p > 0.05$ for each row

Based on the Figure 4.4.5.1, KW pellets have the highest work compression than KW pellets. The highest work compression for KW pellets was 6.08 kg.s at moisture content 50% while FW pellets was 3.06 kg.s at 60% moisture content . There was no significant difference (P > 0.05) in terms of the work compression values obtained for all the moisture content (40-60%).

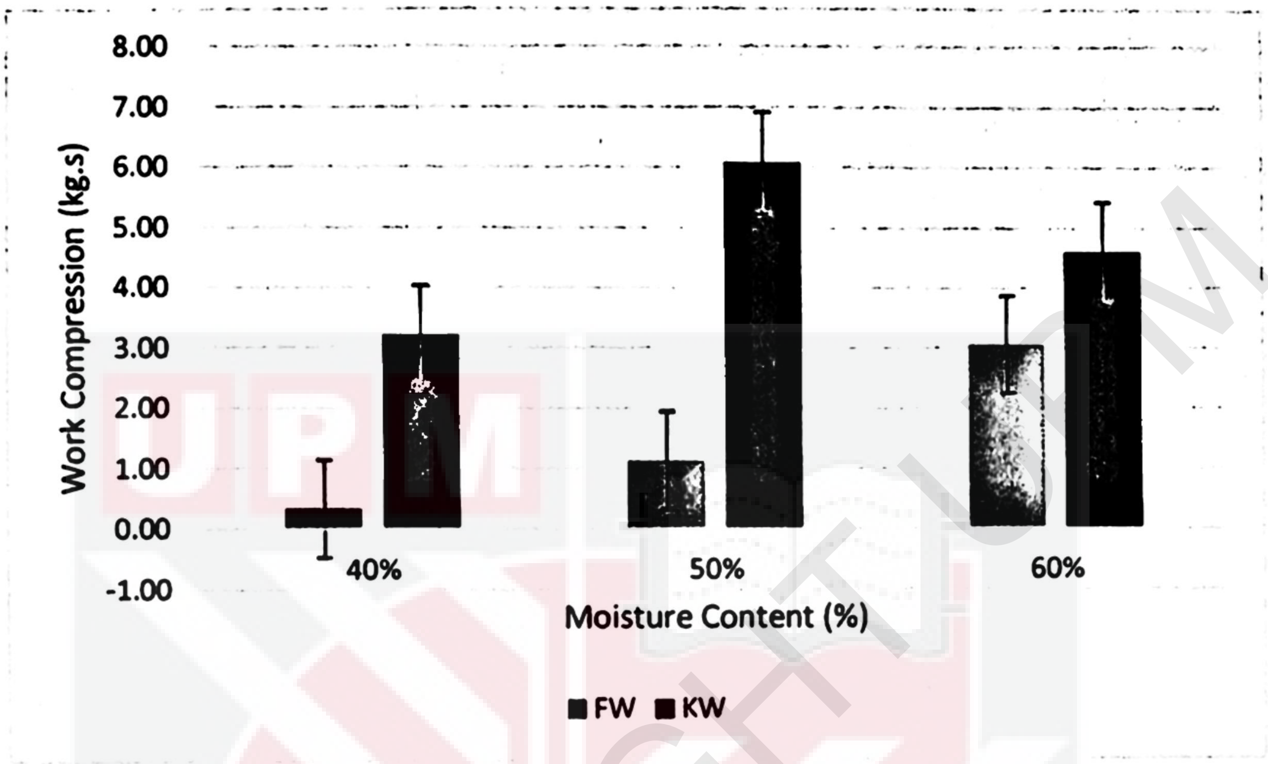

Figure 4.4.5.1 Tensile Strength of FW an KW Pellets

CHAPTER 5

CONCLUSIONS AND RECOMMENDATION

5.1. Conclusions

Waste from food service industry is zero cost material and non-edible resources. This study investigated and confirmed that the waste has a great potential to be used for utilization of kitchen waste and food waste .as poultry feed.

The first objective has been achieved which are food waste contains 56% of organic waste and 44% of inorganic waste while the kitchen waste contains 76% of organic waste and 24% of inorganic waste from three different locations. The food waste from cafeteria is the most suitable to be utilized as poultry feed as their proximate composition similarly to bran.

Second objective is to analysis the proximate composition of food waste and kitchen waste. Food waste from Cafeteria is the most suitable location to utilize as poultry feed. Hence, their FW proximate composition were 3.81%, 23.38%, 55.73%, 78.11%, 10.57%, 6.51% for composition of moisture, protein, carbohydrates, fiber, fat and ash content respectively.

Finally, the palletization process was done by the compaction process as well as the determination for physical properties of the pellets with different moisture content which are 40%, 50% and 60%. The physical properties of pellets that were determined are friability (%), bulk density (kg/m^3), true density (kg/m^3), porosity (%) and tensile strength (kg.s). In conclusion, food waste and kitchen waste can be utilized as poultry feed in pellets form. However, food waste pellets at 60% moisture content was better to utilize as poultry feed compared to kitchen waste pellets which are easily to fracture. Food waste pellets at 60% of moisture content give friability, bulk density, true density, porosity and tensile strength of 5.57%, 1447.53 kg/m^3, 289.85±4.4^b kg/m^3, 79.03±1.10^a % and 3.06±0.38^a kg.s respectively.

5.2. Recommendations

As for recommendations and for future research, the analysis for the determination of mineral such as Ca, K, Cl and Na element content can be done to determine more benefits of waste from food service industry that can be developed for many food applications. Minerals are inorganic chemicals (chemicals not containing carbon) which help control body processes and are required for normal health and growth of poultry.

Another rocommendations for the pelleting process of FW and KW, the sample for pelleting process can be moisturized with water at another different moisture content levels which were 45%, 55% and 65%. This is because the moisture content can affect the physicochemical and stability of the pellets.

Besides, another physical and mechanical properties of pellet can be done in order to help in solving problems concerning feed effectiveness and feed handling and storage. Physical and chemical that can be added in the future research are actual diameter, weight, water stability, angle of repose and crushing load.

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APPENDICES

Appendix 1 Weight of Kitchen Waste

Different Types of Sources	Inorganic Waste (kg)				Organic Waste (kg)			
	1	2	3	Average	1	2	3	Average
Cafeteria A	1.87	2.87	1.90	2.22	3.25	2.90	3.62	3.26
Cafeteria B	3.56	1.98	2.84	2.80	4.23	3.14	5.64	4.34
Cafeteria C	1.84	1.39	2.85	2.03	1.39	2.06	2.73	2.06
Food Court A	3.63	3.93	4.74	4.10	5.34	6.44	6.99	6.25
Food Court B	5.74	6.09	4.98	5.61	6.82	5.92	7.83	6.86
Food Court C	6.83	4.43	6.93	6.06	5.89	8.95	7.95	7.59
Restaurant A	4.93	5.74	6.92	5.86	4.92	5.83	4.12	4.96
Restaurant B	5.83	3.86	5.32	5.01	6.97	5.93	5.19	6.03
Restaurant C	2.86	2.17	3.57	2.87	4.97	5.90	3.47	4.78

Appendix 2 Weight of Food Waste

Different Types of Sources	Inorganic Waste (kg)				Organic Waste							
					Organic Waste (kg)				Others (kg)			
	1	2	3	Average	1	2	3	Average	1	2	3	Average
Cafeteria A	2.93	4.23	3.88	3.68	10.46	13.17	11.62	11.75	3.46	4.07	2.92	3.48
Cafeteria B	3.67	4.92	5.24	4.61	12.23	15.14	13.64	13.67	5.03	3.97	6.55	5.18
Cafeteria C	4.22	4.98	3.28	4.16	9.23	8.77	8.22	8.74	2.47	3.97	4.72	3.72
Food Court A	8.68	7.32	6.18	7.39	17.62	15.31	13.92	15.62	5.63	4.46	2.98	4.36
Food Court B	12.87	15.76	14.09	14.24	27.46	25.98	23.87	25.77	12.87	10.64	8.96	10.83
Food Court C	17.82	15.79	16.83	16.82	21.67	23.13	20.05	21.62	10.43	13.82	9.64	11.30
Restaurant A	12.27	24.81	28.07	21.72	25.12	28.32	22.22	25.22	6.90	5.24	7.54	6.56
Restaurant B	12.71	13.89	23.05	16.55	18.13	19.76	22.28	20.06	5.66	4.99	3.97	4.87
Restaurant C	7.91	6.98	8.41	7.77	6.87	5.46	4.91	5.75	2.91	4.79	3.97	3.89

Appendix 3 Calculation of Moisture Content

$$\frac{(Initial\ weight\ of\ filled\ crucible) - (Final\ weight\ of\ filled\ crucible)}{(Initial\ weight\ of\ filled\ crucible) - (Initial\ weight\ of\ empty\ crucible)}$$

$$\times 100\%$$

<u>Example for Cafeteria A (Food Waste)</u>

$$\frac{(41.277) - (41.175)}{(41.277) - (39.253)} \times 100\% = 5.048\ \%$$

Appendix 4 Calculation of Carbohydrate Content

$$\%\ Carbohydrate$$

$$= 100\% - \%moisture\ content - \%protein - \%fat - mineral\ \%$$

<u>Example for Cafeteria A (Food Waste)</u>

$$\%\ Carbohydrate = 100\% - 5.08\% - 12.48\% - 2.40 - 2.34\% = 77.70\%$$

Appendix 5 Calculation of Fiber Content

$$\%\ Crude\ Fiber = \frac{Weight\ of\ Residue\ Without\ Ash}{Weight\ of\ Sample} x\ 100\%$$

<u>Example for Cafeteria A (Food Waste)</u>

$$\%\ Crude\ Fiber = \frac{0.898}{1.036} x\ 100\% = 89.35\%$$

Appendix 6 Calculation of Fat Content

$$\%\ Fat = \frac{Weight\ of\ Fat}{Weight\ of\ Sample} x\ 100\%$$

Example for Cafeteria A (Food Waste)

$$\% \, Fat = \frac{0.025}{1.024} x \; 100\% = 2.403\%$$

Appendix 7 Calculation of Ash Content

$$\% \, Ash = \frac{Weight \; of Ash}{Weight \; of \; Sample} x \; 100\%$$

Example for Cafeteria A (Food Waste)

$$\% \, Ash = \frac{0.025}{1.065} x \; 100\% = 2.301\%$$