SENSORY EVALUATION OF CHICKEN MEAT FED WITH DIFFERENT LEVEL OF PALM KERNEL CAKE FEEDING TRIAL

By

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Chicken is the primary source of protein for the majority of Malaysians. The average consumption of chicken meat is more than 50 kg per person per year. Even though there is high demand for chicken meat in Malaysia, the supply is equally efficient as the country has achieved 100% self-sufficiency in chicken production. However, there might be a problem of sustainability in the future as 70% of the raw material used in chicken feed are imported. Hence, efforts are currently being intensified to introduce alternative feedstuff which can replace or at least reduce the use of imported raw materials like soybean meal and maize.

Palm Kernel Cake (PKC), one of the by-products of the oil palm industry was found to be the best alternative ingredients that can be used to reduce the use of maize and soybean meal in chicken feed. This is because PKC is readily available in the country and given necessary treatments, it has a high potential

to be an alternative feedstuff in chicken feed. Nevertheless, changes in the chicken feed may alter the meat appearance, taste and texture. These changes must suit consumers' preferences to ensure that the chicken fed with PKC is marketable. Therefore, it becomes pertinent to conduct a sensory evaluation of the chicken fed with different level of Palm Kernel Cake feeding trial.

This research was divided into three parts (sensory evaluation 1, 2, and 3). Sensory evaluation 1 was conducted to evaluate the sensory characteristics and consumers' acceptance of cooked control chicken, cooked chicken fed with 10%, 20% and 30% treated PKC. Sensory evaluation 2 was conducted to evaluate the sensory characteristics and consumers' acceptance of cooked control chicken, cooked chicken fed with 10%, 20% and 30% untreated PKC. Lastly, sensory evaluation 3 was conducted to evaluate the sensory characteristics and consumers' acceptance of raw control chicken breast and leg, raw chicken breast and leg fed with 10% and 20% of treated and untreated PKC.

Descriptive analysis, one-way ANOVA, independent t-test, reliability test and mean score were used to analyze the data. The result of the one-way ANOVA in sensory evaluation 1 (chicken fed with different level of treated PKC) shows that there is significant difference in the overall consumers' acceptance and the sample with the highest means score is the chicken fed with 20% treated PKC. However, the result of sensory evaluation 2 shows that there is no significant difference between the chicken fed with untreated PKC and the

control chicken (chicken fed with traditional feed) in term of the sensory characteristics and overall consumers' acceptance. Similarly, the result of sensory evaluation 3 shows that there is no significant difference in the overall consumers' acceptance of the given chicken samples (raw chicken breast and leg fed with 0% PKC, raw chicken breast and leg fed with 10%, 20% treated PKC and raw chicken breast and leg fed with 10%, 20% untreated PKC).

Based on these findings, 20% treated PKC is the most suitable alternative to use in chicken feed as the consumers acceptance level is the highest compared to control chicken, chicken fed with 10% treated PKC and chicken fed with 30% treated PKC. Furthermore, the poultry meat industry must pay considerable attention to all aspects of the marketing prospects such as halal certification, freshness of chicken, safe to consume, taste good, good value for money and good advertising to ensure that the chicken supplied to market meets consumers' demand and preferences.

Keywords: palmkernel cake, sensory evaluation

SDG: GOAL 2 : Zero Hunger
GOAL 12: Responsible Consumption and Production

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk Ijazah Master Sains

PENILAIAN DERIA TERHADAP DAGING AYAM DENGAN TAHAP PEMAKANAN PERCUBAAN ISIRONG KELAPA SAWIT YANG BERBEZA

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Ayam adalah sumber protein utama bagi majoriti rakyat Malaysia. Purata penggunaan daging ayam adalah melebihi 50kg setahun bagi setiap seorang. Walaupun terdapat permintaan tinggi untuk daging ayam di Malaysia, bekalannya adalah efisien kerana negara telah mencapai 100% sara diri dalam pengeluaran ayam. Walau bagaimanapun, masalah kemampanan bekalan ayam mungkin berlaku pada masa akan datang apabila 70% daripada bahan mentah yang digunakan dalam makanan ayam adalah diimport. Oleh itu, usaha sedang dipergiatkan untuk memperkenalkan bahan makanan alternatif yang boleh menggantikan atau sekurang-kurangnya mengurangkan penggunaan bahan mentah yang diimport seperti kacang soya dan jagung.

Isirong Kelapa Sawit (PKC), salah satu produk sampingan industri kelapa sawit dijumpai sebagai bahan alternatif terbaik yang dapat digunakan untuk mengurangkan penggunaan jagung dan kacang soya dalam makanan ayam. Ini kerana PKC sentiasa tersedia di negara ini dan dengan diberi rawatan yang

diperlukan, PKC mempunyai berpotensi tinggi untuk menjadi bahan makanan alternatif dalam makanan ayam. Walau bagaimanapun, perubahan dalam makanan ayam boleh mengubah penampilan daging, rasa dan tekstur. Perubahan ini mestilah sesuai dengan keinginan pengguna untuk memastikan ayam yang diberi makan dengan PKC boleh dipasarkan. Oleh itu adalah penting untuk menjalankan penilaian deria terhadap daging ayam dengan tahap pemakanan percubaan isirong kelapa sawit yang berbeza.

Kajian ini dibahagikan kepada tiga bahagian (penilaian deria 1, 2, dan 3). Penialian deria 1 dilakukan untuk menilai ciri-ciri deria dan penerimaan pengguna terhadap ayam kawalan, ayam yang diberi makan dengan 10%, 20% dan 30% PKC yang telah dirawat (kesemua ayam telah masak). Penilaian deria 2 dijalankan untuk menilai ciri-ciri deria dan penerimaan pengguna terhadap ayam kawalan, ayam yang diberi makan dengan 10%, 20% dan 30% PKC yang tidak dirawat (kesemua ayam penilaian deria 2 telah masak). Akhir sekali, penilaian deria 3 dijalankan untuk menilai ciri-ciri deria dan penerimaan pengguna terhadap dada dan peha ayam kawalan mentah, dada dan kaki ayam mentah yang diberi 10% dan 20% PKC yang dirawat dan tidak dirawat.

Analisis deskriptif, satu-hala ANOVA, ujian t *independent*, ujian reliabiliti dan skor min digunakan untuk menganalisis data. Hasil dari satu-hala ANOVA dalam penilaian deria 1 (ayam yang diberi makan dengan pelbagai PKC yang telah dirawat) memperlihatkan terdapat perbezaan yang signifikan dalam penerimaan pengguna secara keseluruhan dan sampel dengan skor min

tertinggi adalah ayam yang diberi makan dengan 20% PKC. Walau bagaimanapun, hasil penilaian deria 2 menunjukkan bahawa tidak ada perbezaan yang signifikan antara ayam yang diberi makan dengan PKC yang tidak dirawat dan ayam kawalan (ayam yang diberi makanan tradisional) dari segi ciri-ciri deria dan penerimaan pengguna secara keseluruhan. Begitu juga, hasil penilaian deria 3 menunjukkan bahawa tidak terdapat perbezaan yang signifikan dalam penerimaan pengguna secara keseluruhan terhadap sampel ayam yang diberikan (dada dan peha ayam mentah yang diberi makan dengan 0% PKC, dada dan peha ayam mentah yang diberi makan dengan 10%, 20% PKC yang telah dirawat, dan dada ayam mentah dan kaki ayam mentah yang diberi makan dengan 10%, 20% PKC yang tidak dirawat).

Berdasarkan penemuan ini, 20% PKC yang dirawat adalah alternatif yang paling sesuai digunakan dalam makanan ayam kerana tahap penerimaan pengguna adalah yang tertinggi berbanding ayam kawalan, ayam yang diberi makan dengan 10% PKC yang dirawat dan ayam yang diberi makan dengan 30% PKC yang dirawat. Selain itu, industri daging ayam mesti memberi perhatian yang besar terhadap semua aspek prospek pemasaran seperti pengesahan halal, kesegaran ayam, selamat dimakan, rasa yang sedap, berbaloi dengan nilai wang yang dilaburkan dan iklan yang baik untuk memastikan ayam yang dibekalkan kepada pasaran memenuhi permintaan dan pilihan pengguna.

Kata Kunci: isirong kelapa sawit, penilaian deria

SDG: *GOAL 2 : Zero Hunger*
GOAL 12: Resposible Consumption and Production

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LIST OF ABBREVIATIONS

CPKO	Crude Palm Kernel Oil
CPO	Crude Palm Oil
DAN	National Agro-Food Policy
DOA	Department of Agriculture
DOSM	Department of Statistic Malaysia
DVS	Department of Veterinary
GDP	Gross Domestic Product
ITAFoS	Institute of Tropical Agriculture and Food Security
MOA	Ministry of Agriculture and Agri-based Industry
MPOB	Malaysia Palm Oil Board
NAP	National Agriculture Policy
NKEA	National Key Economic Areas
PKC	Palm Kernel Cake
POS	Palm Oil Sludge
PPF	Palm Pressed Fibre

CHAPTER 1

INTRODUCTION

This chapter discussed about the introduction of the important to make study about sensory evaluation and consumer acceptance towards chicken meat fed with different level of palm kernel cake feeding trial. This chapter start with the important of agriculture in Malaysia that include the overview of agriculture sector, livestock industry, poultry meat industry, chicken feed, palm kernel cake (PKC) and sensory evaluation. This overview will describe the current chicken industry background situation in Malaysia and the important to make certain changes in certain part of the industry to boost the industry to the next level. In this study, the differences is by changing the chicken feed ingredient by adding PKC in certain level. This chapter also will include the problem statement, research objectives and significance of the study.

Sensory evaluation is a way of examining consumers' opinions about the desired attributes of a food product. In the poultry industry, sensory evaluation can be used to identify and ensure that the chickens are available in the market, meet consumers' demand and are marketable. This study aims to utilize sensory evaluation to reveal the meat attributes of poultry birds fed with different level of palm kernel cake (PKC) according to a feeding trial. Since the poultry industry is an integral part of the agricultural sector, it becomes pertinent to introduce and discuss the agricultural scenario in Malaysia and the impact of the poultry industry on the country's GDP especially the broiler sub-sector. Hence, changing the form of the chicken meat through innovations

such as feed formulation might affect consumers' taste and preferences, and consequently will have a significant effect on the poultry industry. The chicken meat sensory evaluation study is inevitable to gauge the acceptance of consumers due to the changes in feed formulation regimes.

1.1 The Importance of Agriculture in Malaysia

Every country in the world is concerned about food security and the need to prevent deficiency in food supply. The agricultural sector is in charge of the production of food to ensure adequate and sufficient supply. The Ministry of Agriculture and Agro-based Industry (MOA) is responsible for coordinating the agricultural sector in Malaysia. Formal efforts made to encourage the growth of the agricultural sector in Malaysia can be traced back to the late 19th century. During this period, the Department of Veterinary (DVS), the Department of Agriculture (DOA) and the Colonel Fisheries Unit now known as the Department of Fisheries were established with the aim of boosting the agricultural sector. Since then, various policies have been introduced to enhance the growth of the sector. Presently, the National Agro-food Policy (2011-2020) along with NKEA (National Key Economic Areas), which was introduced in 2010, is the main policy driver.

The National Agro-food Policy (2011-2020) was introduced to replace the previous agricultural related policies such as the National Agriculture Policy 1 (NAP 1, 1984-1991), National Agriculture Policy 2 (NAP 2, 1992 – 1997) and National Agriculture policy 3 (NAP 3, 1998-2010). The National Agro-Food Policy (DAN, 2011-2020) succeeds the NAP 3 and emphasizes many aspects

in increasing and boosting the agricultural sector in Malaysia. The main objectives of National Agro-Food Policy are to stimulate food security, promote sustainability of the agro-food industry and increase agropreneurs' income.

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1.1.1 Overview of the Agricultural Sector Malaysia

Based on Table 1.1, the contribution of the agricultural sector to the Gross Domestic Product (GDP) fluctuates around 10% to 8% from 2010 to 2016. Nevertheless, comparing it with other sectors especially manufacturing and services, the contribution can be considered low. Thus, the government needs to intensify its efforts towards improving the contribution of the agricultural sector to the country's GDP.

Table 1.1: Contribution of the Economic Sectors to the GDP at 2016 Prices (RM Million) from 2010 – 2016

Economic Sectors	Agriculture	Mining and quarrying	Manufacturing	Construction	Services
2010	82,882	89,793	192,493	28,213	420,382
Share (%)	10.1	10.9	23.4	3.4	51.2
2011	104,424	95,905	212,618	30,892	459,182
Share (%)	11.5	10.5	23.3	3.4	50.4
2012	95,122	101,474	224,730	37,909	501,830
Share (%)	9.8	10.4	23.1	3.9	51.7
2013	92,830	103,484	232,659	42,692	536,186
Share (%)	9.1	10.2	22.8	4.2	52.6
2014	98,177	109,064	253,087	48,650	585,518
Share (%)	8.9	9.9	22.9	4.4	52.9
2015	97,946	103,716	263,366	54,138	623,857
Share (%)	8.5	9.0	22.7	4.7	53.9
2016	106,471	104,695	273,900	59,785	668,739
Share (%)	8.7	8.5	22.3	4.9	54.4

(Source: Department of Statistic Malaysia, 2017)

In 2016, the agriculture sector contributes about 8.7% to the total GDP. Between 2013 and 2016, the oil palm industry is the highest contributor in the

agricultural sector, followed by other agricultural activities, livestock, forestry and lodging, marine fishing, rubber, and aquaculture (refer to Table 1.2). With regards to food supply in the country, the livestock sub-sector is the second highest contributor and plays an important role in the supply of protein to the Malaysian population.

Table 1.2: Contribution of the Agricultural Sub-sectors to the GDP at 2016 Prices (RM Million) from 2013 – 2016

Agricultural Sub-sector	2013	Share (%)	2014	Share (%)	2015	Share (%)	2016	Share (%)
Oil palm	38,618	41.9	41,325	42.5	37,853	39.0	42,758	40.6
Other agriculture	17,720	19.2	20,196	20.8	23,109	23.8	24,593	23.3
Livestock	10,972	11.9	12,080	12.4	12,694	13.1	13,749	13.0
Forestry and logging	8,564	9.3	8,926	9.2	8,618	8.9	8,982	8.5
Marine fishing	7,505	8.1	8,129	8.4	8,006	8.3	8,551	8.1
Rubber	5,590	6.1	3,332	3.4	3,348	3.5	3,545	3.4
Aquaculture	3,228	3.5	3,317	3.4	3,335	3.4	3,236	3.1
Total	92,197	100	97,305	100	96,963	100	105,414	100

(Source: Department of Statistic Malaysia, 2017)

1.1.2 Overview of the Livestock Industry

Referring to Table 1.3, poultry meat is the major source of meat and meat products in Malaysia, followed by pork, beef, and mutton. The livestock industry showed an increasing trend with slight fluctuations between 2010 and 2016.

Table 1.3: Output of Livestock Products (tonnage), 2010-2016

No.	Commodity	2010	2011	2012	2013	2014	2015	2016
1	Beef (M. Ton)	46,510	48,835	51,277	51,715	52,857	50,493	50,283
2	Mutton (M. Ton)	2,386.5	3,091.5	4,806.2	4,688.8	4,546.1	4,367.3	4,463.5
3	Pork (M. Ton)	234,000	214,308	218,471	217,422	217,558	215,760	221,848
4	Poultry Meat ('000 M. Ton)	1,295.6	1,289.9	1,374.37	1,458.09	1,572.79	1,613.92	1,671.40
5	Chicken/ Duck Eggs (Mil. Eggs)	9,826	10,358	10,736.70	11,399.3	12,127.08	13,221.8	13,842.2
6	Milk (Mil. Litres)	67	70.87	72.41	73.99	75.27	76.04	36.74
7	Raw Hides & Skins (M. Ton)	12,054	12,656	12,901	12,994	13,282	12,693	12,640

(Source: Department of Veterinary Services, 2017)

Referring to Table 1.4, Malaysians consume more poultry meat compared to the other types of meat. In 2016, the per capita consumption of poultry meat slightly stands above 50 kg per person. Unlike the other types of meat such as beef and pork, the consumption of poultry meat is not prohibited by any religion or culture as every individual consumes it.

Table 1.4: Per Capita Consumption of Livestock Products, 2010-2016

No.	Commodity	2010	2011	2012	2013	2014	2015	2016
1	Beef (Kg)	5.45	5.76	6.15	6.74	6.91	7.05	7.06
2	Mutton (Kg)	0.69	0.69	0.83	1.01	1.18	1.25	1.30
3	Pork (Kg)	21.65	21.01	19.13	18.74	18.79	18.7	18.57
4	Poultry Meat (Kg)	43.32	43.58	44.4	46.49	49.83	50.67	50.32
5	Chicken/Duck Eggs (Egg)	303	309	308	319	352	373	385
6	Milk (Kg)	27.85	18.52	35.45	32.38	35.17	35.68	37.99

(Source: Department of Veterinary Services, 2017)

Looking at Table 1.5, only poultry meat and chicken/duck egg are consistently above 100% self-sufficiency level. The Pork meat was self-sufficient in 2011

and the sufficiency level of the following years (2012 -2016) were also close 100%. Other than these three, the self-sufficiency values of other sub-livestock commodities are too low and are declining on average between 2010 and 2016.

Table 1.5: Self-sufficiency Level of Livestock Products (%), 2010-2016

No.	Commodity	2010	2011	2012	2013	2014	2015	2016
1	Beef	30.12	29.17	28.26	25.66	25.28	23.5	22.41
2	Mutton	12.13	11.73	19.71	15.51	12.74	11.46	10.77
3	Pork	95.25	101.95	96.74	96.94	95.66	94.62	92.60
4	Poultry Meat	105.55	105.36	104.88	104.85	104.3	104.48	104.51
5	Chicken/ Duck Eggs	114.63	115.35	118.17	119.35	113.79	113.55	113.21
6	Milk	8.49	7.22	6.92	7.64	7.07	6.99	3.04

(Source: Department of Veterinary Services, 2017)

Thus, the broiler sub-sector is important in supplying relatively cheap protein to Malaysians. Any changes in the texture or other sensory attributes of the meat will impact consumer acceptance.

1.1.3 Poultry Meat Industry

In 2015, about 662 agroprenuers establishments engaged in the poultry meat industry and provided about 34,805 jobs with total salaries worth RM 726.2 million (Department of Statistics Malaysia, 2017). Since broiler chicken is a type of poultry meat, the poultry meat industry is also the highest contributor in the livestock industry in 2015 with a gross output of RM9,085 million compared to RM 3,852.4 million in 2010 (DOSM, 2017). Even though Malaysia has achieved more than 100% self-sufficiency level in the local production of poultry meat especially the supply of chicken meat, there are still lingering

concerns with regards to domestic production and availability of poultry feed. Based on Table 1.6, the importation of animal feedstuff exceeds the corresponding exportation which results in a negative balance of trade values between 2012 and 2016. This situation has a high impact on the poultry meat industry due to the need to sustain the feedstuff stock and ensure the growth of the industry. This deficit in the balance of trade dated back to the early 70's.

Table 1.6: Export and Import of Animal Feedstuff from Jan - Dec (RM Million)

Commodity		2012	2013	2014	2015	2016
Animal Feedstuff (excluding unmilled cereals)	Export	1,542	1,770	1,778	1,623	1,809
	Import	3,376	4,038	4,288	3,994	3,675
	Balance of trade	-1,834	-2,268	-2,510	-2,371	-1,866

(Source: Department of Statistics Malaysia, 2014 - 2017)

1.1.4 Chicken Feed

According to the Guide to Broiler Chicken Farming prepared by DVS in 2006, the chicken feed accounts for more than 70% of the total production cost. This shows that chicken feed is the most important input in broiler chicken production. Based on Table 1.7, maize and soybean meal are the two major ingredients in chicken feed. That is, maize and soybean meal account for more than 70% of the total ingredients required to supply adequate level of energy and protein in chicken feed (DVS, 2016).

Currently, these ingredients are readily available as they can be easily imported. In 2016, Malaysia imports maize from Argentina, Brazil, and USA

(MOA, 2017). Since the major feed ingredients such as soybean and maize are imported (MOA, 2017), the poultry meat industry can be said to be import dependent with regards to the supply of raw materials.

Table 1.7: Common Ingredients in Broiler Chicken Feed Formulation

Energy source • Maize (55%-67%)
Plant protein sources • Soybean meal (20%-29%)
Animal protein source • Fishmeal
Other supplements • Limestone • Dicalcium phosphate • Stabilize fat • Traced mineralized salt • Vitamin Premix • Methionine

(Source: Department of Veterinary Services, 2016)

Over-reliance on imported raw material can affect the sustainability of the poultry meat industry. This might result from situations that can cause deficiencies in the supply of ingredients required for the formulation of chicken feed. These include:

- the countries stop exporting their product
- presence of diplomatic problem between Malaysia and the exporting countries
- exporting countries experiencing insufficient stock of raw material
- exporting countries only have sufficient product to cater for their needs
- the advent of natural disaster in exporting country

Based on these unpredictable situations that may occur in the future, the poultry meat industry must take necessary precautions to safeguard its sustainability. An effective means of addressing this problem is exploring the alternative ingredients that are easily available in Malaysia. One of the most suitable alternative ingredients is the palm kernel cake (PKC). This is a by-product of the palm oil industry which can replace or at least reduce the proportion of maize and soybean meal used in the formulation of chicken feed.

1.1.5 Palm Kernel Cake, PKC

Malaysia is the second largest producer of palm oil products after Indonesia. The Palm oil industry is the highest contributor in the Agricultural sector (DOSM, 2017). The oil palm industry not only produces palm oil but also provides other products and by-products. One of the by-products of palm oil that can be utilized as an animal feedstuff is the palm kernel cake (PKC). Referring to Table 1.8, the crude palm oil (CPO) produced is over 17 million tonnes, the crude palm kernel oil (CPKO) is over 1.9 million tonnes and the palm kernel cake (PKC) is over 2 million tonnes every year.

Table 1.8: Oil Palm Industry Production of CPO and By-Products, 2012 - 2016 (Tonnes)

Year	Crude Palm Oil (CPO)	Crude Palm Kernel Oil (CPKO)	Palm Kernel Cake (PKC)
2012	18,785,030	2,164,024	2,399,204
2013	19,216,459	2,269,822	2,516,664
2014	19,667,016	2,277,382	2,518,947
2015	19,961,581	2,276,466	2,519,990
2016	17,319,177	1,959,423	2,173,000

(Source: Malaysia Palm Oil Board, 2013 - 2017)

Palm kernel is produced after the first stage of oil extraction. The Palm kernel will then be crushed to get CPKO using the expelling method. Through the expelling method, PKC will be derived as a by-product of CPKO (Subramaniam *et al*, 2010).

Besides PKC, other by-products derived from the oil extraction process are palm oil sludge (POS) and palm pressed fibre (PPF). However, PKC appears to be a better animal feed ingredient due to its high protein and low fibre compared to the other two (Kum & Wan Zahari, 2011; Wan Zahari & Alimon, 2004). Table 1.9 shows the composition of PKC, POS, PPF, Maize and Soybean meal with regards to their dry matter, crude protein, and crude fibre. According to Table 1.9, even though PKC is the most suitable animal feed ingredient among the palm oil by-products, the soybean meal remains the best option due to its higher protein and lower fibre content.

Table 1.9: Composition of PKC, POS, PPF, Maize and Soybean Meal (% Dry Matter)

Type of material	Dry matter	Crude Protein	Crude fibre
Palm Kernel Cake, PKC	89.8	17.2	17.1
Palm Oil Sludge, POS	89.0	12.5	20.1
Palm Pressed Fibre, PPF	91.2	16.8	19.7
Maize	89.7	10.6	4.3
Soybean meal	86.6	48.4	8.5

(Source: Kum & Wan Zahari, 2011; Department of Veterinary Services, 2005)

PKC is commonly adopted as feedstuff for the ruminant animals. However, it is rarely used in non-ruminant animals like chicken due to the high fibre content (Sharmila *et al*, 2014). Based on Table 1.11, the ruminant livestock can tolerate more than 50% PKC in their feed except for sheep and goat while previous

studies recommend a maximum of 20% PKC in broiler feed. (Wan Zahari & Alimon, 2004). As shown in Table 1.10, the crude protein needed in chicken feed is about 20% which is quite close to that of PKC while the fibre content in PKC is too high and the maximum amount that can be accepted in chicken feed is 6.9%.

Table 1.10: General Composition of Chicken Feed (% Dry Matter)

Type of chicken feed	Dry matter	Crude Protein	Crude fibre
Starter	91.7	19.8	4.0
Grower	90.2	22.6	6.9
Finisher	90.1	20.0	6.3

(Source: Department of Veterinary Services, 2005)

1.11: Recommended Level of PKC in Livestock

Livestock	Recommended level (%)
Beef cattle	50-80
Dairy cattle	30-50
Sheep	Maximum 30
Goat	30-50
Poultry-broiler	15-20
Poultry-layer	15-25
Swine	15-25
Freshwater fish	10-20

(Source: Wan Zahari and Alimon, 2004)

The nutrient content of PKC can be altered to improve the composition. That is, the Protein and fibre contents can be remediated through specific treatments. There are three types of treatments which are the physical, chemical and biological treatments. The physical treatment can be conducted using the extruding method, the extracting method, and the protein isolation method. The chemical treatment uses acid or alkaline solution to improve the nutrients in PKC. Lastly, the biological treatment is conducted using enzymes (Sharmila et al, 2014). Alterations in feed formulation and ingredients might

affect the texture, sensory and taste of the chicken meat and this necessitate the evaluation of the sensory aspect of chicken fed with PKC to gauge consumers' acceptability of such chicken meat.

1.1.6 Sensory Evaluation

Sensory evaluation is a way of assessing how people differentiate between foods. In other words, how people are able to compare the foods being evaluated. The comparison serves to assess whether the food being evaluated is preferred over the other or at least can be accepted by the people. For example, in Japan, chicken breast is among chicken parts that get the least preference among Japanese. To change this preference, a study was conducted to facilitate the acceptance of chicken breast among Japanese. Two treatments were administered to the chicken breast which includes cooking at high pressure and adding sodium hydrogen carbonate. Through sensory evaluation, Japanese found that the new type of chicken breast was tenderer, juicier and has better taste than the untreated one (Tabe *et al*, 2013).

Sensory evaluation uses certain sensory characteristics to evaluate the salient attributes of foods. Generally, the sensory characteristics are appearance, aroma, flavour, and texture (De Toledo *et al*, 2005; Harp *et al*, 1998). These four general sensory characteristics can be expanded based on the sensory research being conducted.

There are two common reasons why sensory evaluation is used in food research. Firstly, to determine whether people are able to differentiate between

the foods that need to be evaluated in term of the sensory characteristics. For instance, when comparing two samples based on colour characteristics, does one of the samples appears more yellowish than the other or there is no significant difference. Assessing the difference in term of sensory characteristics may influence people acceptance level. This leads to the second reason; sensory evaluation can help to reveal people preference between the foods being evaluated.

It cannot be concluded that a significant difference in term of sensory characteristics will lead to a significant difference in term of likeliness or preference. This may happen the other way around. In some case, people can differentiate between the foods, but their preferences may remain relatively unchanged. For example, adding different level of fat to culinary sauces will not affect the likeliness of the taste of the sauce although the panellists can differentiate the taste between sauces (Rapp *et al*, 2007).

The idea of altering the chicken feed by adding PKC will benefit both the farmers and the country as it serves to utilize the alternative sources of feedstuff available in the country. This will promote sustainable chicken feed stock and reduce the country's reliance on imported raw material. However, the decision to buy or not to buy the resultant product comes from the consumers.

In this study, the chickens used for the sensory evaluation experiment were gathered from the research conducted by the Institute of Tropical Agriculture

and Food Security (ITAFoS) under Universiti Putra Malaysia (UPM). The study was conducted to change the PKC nutritional value using extrusion treatment (Muhammad Akhmal *et al*, 2017) and the resultant feedstuff was introduced to poultry meat feed formulation. The finding showed that the extrusion treatment changed and improved the PKC nutrition value. After the new discovery, ITAFoS continued the research by comparing the performance of broiler chickens fed with treated PKC and untreated PKC. The experiment consisted of seven types of broiler chickens. The first one is the control chicken which is the broiler chicken fed without PKC or broiler chicken fed with traditional chicken feed. The second one is the chicken fed with 10% extrusion treated PKC. The third is the chicken fed with 20% extrusion treated PKC. Fourth, chicken fed with 30% extrusion treated PKC. Fifth, chicken fed with 10% untreated PKC. Sixth, chicken fed with 20% untreated PKC. The last one which is seventh is the chicken fed with 30% untreated PKC. A detailed discussion of the experiment will be presented in the methodology chapter.

Altering the feed ingredients may or may not change the taste, texture and appearance of the chicken vis-a-vis the traditional chicken fed with the established feed formulated by the feed manufacturer in which the main ingredients are maize (50%) and soybean (30%) (the percentage might change based on the type of feed formulation i.e. either for starter, grower or finisher stage of the poultry). Typically, almost 80% of the ingredients used in poultry feed come from maize and soybean. Thus, changing the percentage of these two ingredients as stated earlier might alter the texture, taste and sensory attributes of the chicken and this emphasizes our concern which is the

consumers' acceptance of these changes if there is any. Hence, it becomes important to conduct sensory evaluation and reveal whether consumers can differentiate between the appearance, aroma, flavour and texture of chicken fed with PKC and chicken fed without PKC. This research will also examine consumers' acceptance toward chicken fed with PKC to see if the new feed formulation has the potential required for effectual adoption in the country.

1.2 Problem Statement

The Malaysian poultry meat industry can boast of its ability to produce sufficient chicken required in the market. However, this success story embodies a potential problem that may emanate in the future as the industry relies on imported ingredients such as maize and soybean to produce chicken feed. This makes it necessary to channel efforts towards finding alternative ingredients. Over-reliance on imported ingredients may lead to unpredictable insufficiency in chicken feed stock in the future. To avoid this unpredictable problem, PKC (a by-product from the oil palm industry) can serve as the best alternative ingredient and can replace or reduce the proportion of maize and soybean meal used in chicken feed formulation. This is because it can be easily obtained in Malaysia and given the necessary treatments, it has high potential to be an alternative ingredient.

Nevertheless, changes in the chicken feed may or may not alter the chicken meat appearance, taste and texture. The changes in appearance, taste and texture must suit consumers' preferences to ensure the marketability of chickens that consume PKC as part of the ingredients in their feed. This necessitates sensory evaluation to assess whether the consumers can

differentiate between the chicken fed with PKC as a certain percentage of the feed ingredients and chicken fed without PKC with regards to the chicken meat's appearance, taste, texture and other relevant sensory characteristics. Through sensory evaluation, the research will also examine consumers' acceptance level towards chicken fed PKC and chicken fed without PKC.

It will be a good indicator if the consumers could not differentiate between chicken fed with PKC and chicken fed without PKC. This shows that people are not aware of the changes in the chicken feeds and will accept the chicken fed with PKC like the chicken fed with traditional ingredients. However, if there are ways around where people cannot differentiate between chicken fed with PKC and chicken fed without PKC, it will be great to determine the level of PKC that will be preferred among the consumers.

Thus, this research will conduct a sensory evaluation towards chicken meat fed with different level of Palm Kernel Cake feeding trial to determine how consumers can differentiate between these chicken meats with regards to various sensory characteristics such as appearance, texture, taste etc. It will also examine consumers' acceptance level towards the chicken meats. Marketing prospect has a link with consumer acceptance where it will offer an elements to offer in market to drive the products can enter the market thus the marketing prospects also will be determine to see the market among consumers for chicken meat fed with PKC.

1.3 Research Objectives

1.3.1 General Objective

To conduct a sensory evaluation towards chicken meat fed with different leve of Palm Kernel Cake feeding trial.

1.3.1.1 Specific Objectives

1. To determine the different sensory characteristics of chicken meat fed with different level of PKC feeding trial.
2. To assess the differences in overall consumers' acceptance of chicken meat fed with different level of PKC feeding trial.
3. To determine the marketing prospects of chicken meat fed with PKC among the consumers

1.4 Significance of Study

This research focuses on examining consumers' sensory evaluation of chicken meat after various alterations of the feed ingredients. The findings from this study can benefit the poultry meat industry especially the chicken feed producers as it can be a guideline for introducing PKC as an alternative ingredient in feed formulation. Due to the inadequate production and rising importation of the traditional ingredients (maize and soybean meal), introducing chicken feed with PKC as part of the ingredients is an important idea because through relevant modifications (treatments), the new ingredient can be employed to ensure sustainability in the supply of raw material in the country. The Malaysian oil palm industry is a sustainable one which produces

renewable resources with utmost adherence to the recommended ethical practices. Thus, adopting the PKC is not only beneficial to the poultry meat industry but also ensures maximum utilization of local products.

REFERENCES

A'dilah, M. M., & Alimon, A. R. *Improving the nutritive value of palm kernel cake (PKC) through chemical pre-treatment and fungal fermentation*. Paper presented at the 32nd Annual Conference Malaysian Society of Animal Production (MSAP) Kuantan, Pahang, Malaysia. 2011.

Ackbarali, D. S., & Maharaj, R. (2014). Sensory evaluation as a tool in determining acceptability of innovative products developed by undergraduate students in food science and technology at The University of Trinidad and Tobago. *Journal of Curriculum and Teaching*, 3(1): 10-27.

Alimon, A. R. (2015). The Nutritive Value of Palm Kernel Cake for Animal Feed. *Palm Oil Developments*, 40: 12-14.

Amerine, M. A., Pangborn, R. M., & Roessler, E. B. (1965). *Principles of Sensory Evaluation of Food*. New York: Academic Press.

Ampah, I. T. (2016). An assessment of effectiveness of marketing mix as a satisfaction tool at local authorities in Ghana. *British Journal of Economics, Management & Trade*, 11(4): 1-19.

AMSA. (2015). Research Guidelines for Cookery, Sensory Evaluation, and Instrumental Tenderness Measurements of Meat. American Meat Science Association. Retrieve Nov 28, 2015, from http://www.meatscience.org/docs/default- source/publications-resources/amsa-sensory-and-tenderness-evaluation-guidelines/research-guide/2015-amsa-sensory-guidelines-1-0.pdf?sfvrsn=6

Anaeto, M., Chioma, G. O., & Omosebi, D. J. (2009). Palm Kernel Cake as Substitute for Maize in Broiler Finisher Diet. *International Journal of Poultry Science*, 8 (12): 1206-1208.

Azizan, A. R., Shariff, H., Kan, Y. T & Poh, T. T. (1989). Effect of PKC Supplementation on the Postweaning Live Weight Gain of KK Male Weaners. *Proceeding of the 12fh Malaysian Society of Animal Production Annual Conference* (pp 105 -110). Genting Highland, Pahang.

Babatunde G. M., Fetuga B. L., Odumosu O. O. & Oyenuga V. A. (1975). Palm kernel meal as a major protein concentrate in the diets of pigs in the tropics. *Journal of Science Food Agriculture*, 26: 1279-1291.

Baston, O., & Barna, O. (2010). Raw chicken leg and breast sensory evaluation. *Annals. Food Science and Technology*, 11(1): 25-30.

Borden, N.H. (1965). Science in Marketing. In Schwartz, G, *the Concept of the Marketing Mix* (pp. 386-97). New York: John Wiley & Sons.

Chinajariyawong, C., & Muangkeow, N. (2011). Carcass yield and visceral organs of broiler chickens fed palm kernel meal or *Aspergillus wentii* TISTR 3075 fermented palm kernel meal. *Walailak Journal of Science and Technology*, 8(2): 175-185.

Collingwood, J.G. (1958). Processed Plant Protein Foodstuffs, *Palm Kernel Meal* (pp. 677-701). New York: Academic Press.

Davis, M. P., & Zainur, A. S. (1995). A Proposal to Establish Fully Integrated Prime Beef and Prime Lamb Feedlot Industries in Malaysia Using 100% PKC. *Proceeding of the 17th Malaysian Society of Animal Production Annual Conference* (pp 138-140). Pulau Pinang.

Department of Statistic Malaysia. (2017). Contribution of GDPby Kind of Economic Activity. Retrieve July 13, 2017, from https://newss.statistics.gov.my/newss-portalx/ep/epFreeDownloadContentSearch.seam?cid=3224

Department of Statistic Malaysia. (2017). Agriculture Sector Contribution to GDP. Retrieve July 13, 2017, from https://newss.statistics.gov.my/newss-portalx/ep/epFreeDownloadContentSearch.seam?cid= 3224

Department of Statistic Malaysia. (2017) Poultry Meat Industry. Retrieve August 13, 2017, from https://www.dosm.gov.my/v1/index.php?r=column/cthemeByCat&cat=405&bul_id=bEkvWDRrSWw4OGttVTduamVmWVN5UT09&menu_id=Z0VTZGU1UHBUT1VJMFlpaXRRR0xpdz09

Department of Statistic Malaysia. (2017). Export and Import by Commodity Animal Feed. Retrive August 17, 2017, from https://newss.statistics.gov.my/newss-portalx/ep/epFreeDownloadContentSearch.seam?cid=3324

Department of Statistic Malaysia. (2017). Current Malaysia Population. Retrieve August 30, 2017, from https://newss.statistics.gov.my/newss-portalx/ep/epDownloadContentSearch.seam?cid=5392

Department of Statistic Malaysia. (2016). Export and Import by Commodity Animal Feed. Retrive August 17, 2017, from https://newss.statistics.gov.my/newss-portalx/ep/epFreeDownloadContentSearch.seam?cid=3327

Department of Statistic Malaysia. (2015). Export and Import by Commodity Animal Feed. Retrive August 17, 2017, from https://newss.statistics.gov.my/newss-portalx/ep/epFreeDownloadContentSearch.seam?cid=3339

Department of Statistic Malaysia. (2014). Export and Import by Commodity Animal Feed. Retrive August 17, 2017, from https://newss.statistics.gov.my/newss-portalx/ep/epFreeDownloadContentSearch.seam?cid=3340

Department of Veterinary Services. (2017). Output of Livestock Products.Retrieve July 12, 2017, Retrieve from http://www.dvs.gov.my/dvs/resources/user_1/DVS%20 pdf/Perangkaan%202015%202016/page_6.pdf

Department of Veterinary Services. (2017). Per CapitaConsumption of Livestock Products. Retrieve July 10, 2017, from http://www.dvs.gov.my/dvs/resources/user_1/DVS%20p df/Perangkaan%202015%202016/page_10.pdf

Department of Veterinary Services. (2017). Self-sufficiency Level in Livestock Products Retrieve July 11, 2017, from http://www.dvs.gov.my/dvs/resources/user_1/DVS%20pdf/Perangkaan %202015%202016/page_12.pdf

Department of Veterinary Services, (2005). Composition of PKC, POS,PPF, Maize and Soybean Meal. Retrieve August 17, 2017, from http://www.dvs.gov.my/dvs/resources/auto%20downloa d%20images/560a42a080bb4.pdf

Department of Veterinary Services, (2005). Composition of Chicken Feed. Retrieve August 17, 2017, fromhttp://www.dvs.gov.my/dvs/resources/auto%20download%20imag es/560a42a080bb4.pdf

Department of Veterinary Services (2006). Guide to Broiler Chicken Farming. Retrive August 17, 2017, fromwww.dvs.gov.my/dvs/resources/auto%20download%20images/56 0a42ba49275.pdf

Department of Veterinary Services. (2016). Common ingredients in Broiler Chicken Feed Formulation. Retrieve November 15, 2016, fromhttp://www.doa.gov.my/index/resources/aktiviti_sumber/sumber_a wam/penerbitan/kertas_pembentangan/kertas_kerja5.pdf

De Toledo, T. C. F., Canniatti-Brazaca, S. G., Spoto, M. H.E., & Arthur, V. (2005). Sensory evaluation of chicken breast under gamma irradiation at commercial doses. *Journal of Food Science*, 70: 8–12.

De Vellis, R.F. *(1991). Scale Development: theory and applications (Applied Social Research Methods Series, Vol. 26).* Newbury Park: Sage.

Fadil, M., Alimon, A. R., Meng, G. Y., Ebrahimi, M., & Farjam, A. S. (2014). Palm kernel cake as a potential ingredient in Muscovy ducks diet. *Italian Journal of Animal Science*, 13(1): 112-115.

Fanatico, A. C., Pillai, P. B., Emmert, J. L., Gbur, E. E., Meullenet, J. f., & Owens, C. M. (2007). Sensory attributes of slow- and fast-growing chicken genotypes raised indoors or with outdoor access. *Poultry Science*, 86: 2441–2449.

Fetuga, B. L., Babatunde,G. M., & Oyenuga, V. A. (1977). The value of palm kernel meal in finishing diet for pigs. The effect of varying palm kernel meal on performance and carcass quality of finishing pigs. *Journal of Agricultural Science Cambridge*, 88 (3): 655-661.

Fiorentini, M., Kinchla, A.J., & Nolden, A.A. (2020) Role of Sensory Evaluation in Consumer Acceptance of Plant-Based Meat Analogs and Meat Extenders: A Scoping Review. *Foods 2020*, *9*:1334.

Harp, S. S., Hoover, L. C., Crockett, K. L., & Wu, C. K. (1998). Development of a beef appetizer concept for casual dining restaurants: application of focus group interviews and consumer sensory evaluation. *Journal of Hospitality and Tourism Research*, 21(3):43-60.

Haščík, P., Ibrahim O. E. E., Garlík, J., Bobko, M., & Kročko, M. (2013). Sensory evaluation of broiler meat after addition slovak bee pollen in their feed mixture. *Scientific Journal for Food Industry*, 7: 107-110.

Hassan Usman Zamani, Teck Chwen Loh, Hooi Ling Foo, Samsudin A. A., & Alshelmani M. I. (2016). Effects of feeding palm kernel cake with crude enzyme supplementation on growth performance and meat quality of broiler chicken. *International Journal of Microbiology and Biotechnology*, 2(1): 22-28.

Hoffmann, R. (2000).Country of origin – a consumer perception perspective of fresh meat. *British Food Journal*, 102 (3): 211 – 229.

Horsted, K., Bodil H Allesen-Holm, Hermansena, J. E., & Kongsteda, A.G. (2012). Sensory profiles of breast meat from broilers reared in an organic niche production system and conventional standard broilers. *Journal of the Science of Food and Agriculture,* 92: 258–265.

Hutagulung, R.I., Mahyuddin, M.D., & Jalaludin, S. (1982). Feeds for Farm Animals from the Oil Palm. In Pushparajah, P and Chew (P S Eds.), *Proceeding of the Oil Palm in the Eighties* (pp 609-622).

Inmyxai, S., & Takahashi, Y. (2010). The effect of firm resources on business performance of male- and female-headed firms in the case of Lao Micro-, Small-, and medium-sized enterprises (MSMEs). *International Journal of Business and Information,* 5(1): 63-90.

Kotler, P. (2005). *Marketing: an introduction*. New Jersey: Pearson Education.

Kotler, P. & Armstrong, G. (2006). *Principles of Marketing 10th Edition*. New Jersey: Pearson Education.

Kperegbeyi J. I., & Ikperite S. E. (2011). The effectiveness of replacing maize with palm kernel cake in broilers' starter diet. *Journal of Environmental Issues and Agriculture in Developing Countries*, 3 (1): 145-149.

Kum, H. K., & Wan Zahari, M. (2011). Utilization of Oil Palm By- products as Ruminant feed in Malaysia. *Journal of Oil Palm Research*, 23: 1029-1035.

Lawless, H.T. & Heymann, H. (2010). *Sensory Evaluation of Food*. Berlin/Heidelberg, Germany: Springer Science and Business Media LLC.

Lawlor, J. B., Sheehan, E. M., Delahunty, C. M., Kerry, J. P., & Morrissey, P. A. (2003). Sensory characteristics and consumer preference for cooked chicken breasts from organic, corn-fed, free-range and conventionally reared animals. *International Journal of Poultry Science*, 2 (6): 409-416.

Laupa, J. (2016, August 8). Merintis projek tanam jagung bijirin. Utusan Online. Retrive from http://www.utusan.com.my/sains-teknologi/pertanian/merintis-projek-tanam-jagung-bijirin-1.367805.

Malaysia Palm Oil Board. (2017). Oil Palm Industry Production of CPO and By-Products. Retrieve August 17, 2017,from http://bepi.mpob.gov.my/index.php/en/statistics/producti on/177-production-2017/791-production-of-oil-palm products-2017.html

Malaysia Palm Oil Board. (2016). Oil Palm Industry Production of CPO and By-Products. Retrieve August 17, 2017,from http://bepi.mpob.gov.my/index.php/en/statistics/production/168-production-2016/747-production-of-oil-palm-products-2016.html

Malaysia Palm Oil Board (2015). Oil Palm Industry Production of CPO and By-Products. Retrieve August 17, 2017,from http://bepi.mpob.gov.my/index.php/en/statistics/production/159-production-2015/685-production-of-oil-palm-products-2015.html

Malaysia Palm Oil Board (2014). Oil Palm Industry Production of CPO and By-Products. Retrieve August 17, 2017,from http://bepi.mpob.gov.my/index.php/en/statistics/production/146-production-2014/625-production-of-oil-palm-products-2013.html

Malaysia Palm Oil Board (2013). Oil Palm Industry Production of CPO and By-Products. Retrieve August 17, 2017,from http://bepi.mpob.gov.my/index.php/en/statistics/production/133-production-2013/532-production-of-oil-palm-products-2013.html

Mardhati, M.,Wong, H. K., & Noraini, S. (2011). Growth performance and carcass quality of broilers fed with palm kernel meal-based rations. Journal of tropical Agriculture and Food Science, 39(2): 157–166.

Melovic, B., Cirovic, D., Dudic, B., Vulic, T.B., & Gregus, M. (2020). The Analysis of Marketing Factors Influencing Consumers' Preferences and Acceptance of Organic Food Products Recommendations for the Optimization of the Offer in a Developing Market. Foods *2020*, *9*: 259.

Miezeliene, A., Alencikiene, G., Gruzauskas, R., & Barstys, T. (2011). The effect of dietary selenium supplementation on meat quality of broiler chickens. *Biotechnology, Agronomy, Society and Environment*, 15(1): 61-69.

Ministry of Agriculture and Agro-based Industry Malaysia. (2017). Import Maize. Retrive November 17 2017, from http://www.doa.gov.my/index/resources/aktiviti_sumbersumber_awam/penerbitan/kertas_pembentangan/kertas_kerja1.pdf

Mirnawati, Rizal, Y., Marlida, Y., & Kompiang, I. P. (2011). Evaluation of palm kernel cake fermented by *Aspergillus niger* as substitute for soybean meal protein in the diet of broiler. *International Journal of Poultry Science*, 10 (7): 537-541.

Mohammed Rafiq & Pervaiz K. Ahmed, (1995). Using the 7Ps as a generic marketing mix. *Marketing Intelligence and Planning*, 13 (9): 4–15.

Muhamad Akhmal, H. R., Norhani, A., Nur Zurawdhah A. M., Mohd Izuan E. H.,Zulkifli Idrus, & Shuhaimi Mustafa (2017). Optimisation of extrusion for enhancing the nutritive value of palm kernel cake using response surface methodology. *BioResources*, 12(3): 6679-6697.

Muhamad Akhmal, H. R., Norhani Abdullah, & Shuhaimi Mustafa. (2015). Removal of shells in palm kernel cake via static cling and electrostatic separation. *Journal of Biochemistry, Microbiology and Biotechnology*, 3(1): 1-6.

Nantachai, K., Hongphan, N., & S. Tamangklang, S. (2007). Sensory characteristics and preference mapping of breast and thigh chicken meat from commercial broiler and crossbred chickens. *Proceeding of the Summer Program in Sensory Evaluation 2007* (pp 58-69). Vietnam National University, Hochiminh City, Vietnam.

Nazlin Imram, (1999). The role of visual cues in consumerperception and acceptance of a food product. *Nutrition and Food Science*. 99(5): 224–230.

Ng, W. K. (2004). Researching the use of palm kernel cake in aquaculture feeds. *Palm Oil Developments*, 41: 19-21.

Ng, W. K., Lim, H. K., Lim, S. W. and Ibrahim, O. (2002). Nutritive value of palm kernel meal pretreated with enzyme or fermented with *Trichoderma koningii* (Oudemans) as a dietary ingredient for red hybrid tilapia (*Oreochromis* sp.). *Aquaculture Research*, 33: 1119- 1207.

Norshamliza Chamhuri, P. J. B. (2015). Consumer perceptions of food quality in Malaysia. *British Food Journal*, 117 (3): 1168 – 1187.

Nunnally, J.C., & Bernstein, I.H. (1994). *Psychometric Theory*. New York: McGraw-Hill.

Okeudo, N. J., Onyike, I. L., Okoli, C. V., Chielo, I. L. (2006). Production performance, meat quality and feed cost implications of utilizing high levels of palm kernel cake in broiler finisher diets. *International Journal of Poultry Science*, 5(12): 1160-1163.

Okeudo, N. J., Eboh, K. V., Ndidi V. Izugboekwe & Akanno, E. C. (2005). Growth rate, carcass characteristics and organoleptic quality of broiler fed graded levels of palm kernel cake. *International Journal of Poultry Science*, 4 (5): 330-333.

Okon, B. I., & Ausaji, A. A. (2007). Effects of dietary supplementation of periwinkle (Pachymelania aurita) flesh on meat quality of broilers fed palm kernel cake based diets. *Journal of Food, Agriculture and Environment*, 5 (3&4): 330-333.

Oladokun, A. A., Wahab, A. R., & Suparjo, N. M. (2016). Prospect of maximising palm kernel cake utilization for livestock and poultry in Malaysia: A review. *Journal of Biology, Agriculture and Healthcare*, 6(13): 107-113.

Oluwafemi. R. (2008). Palm kernel cake (PKC) utilization in monogastric animal feeding - implications for sustainable livestock development. *The Internet Journalof Veterinary Medicine*, 6(2).

Owomoyela, S. K., Ola, O. S., & Oyeniyi, K. O. (2013). Investigating the impact of marketing mix elements on consumer loyalty: An empirical study on Nigerian. *Interdisciplinary Journal of Contemporary Research in Business*, 4(11): 485-496.

Pavelková, A., Kačániová, M., Hleba, L. Petrová, J., Pochop, J & Čuboň, J.(2013). Sensory evaluation of chicken breast treated with oregano essential oil. *Animal Science and Biotechnologies*, 46 (2): 379-383.

Peter, J. P. (1979). Reliability: A review of psychometric basics and recent marketing practices. *Journal of Marketing Research*, 16(1): 6-17.

Pogorelova, E. V., Yakhneeva, I. V., Agafonova, A. N., & Prokubovskaya, A.O. (2016). Marketing mix for ecommerce. *International Journal of Environmental & Science Education*, 11(14): 6744-6759.

Ramin, M, Alimon, A. R., & Ivan, M. (2010) Effects of fungal treatment on the *in vitro* digestion of palm kernel cake. *Livestock Research for Rural Development, Vol 22 Iss: 82.*
*Doi:*http://www.lrrd.org/lrrd22/4/rami22082.htm

Rapp, E., Öström, A., Bosander, F., & Gustafsson, I. B. (2007). The sensory effect of butter in culinary sauces. *Journal of Foodservice*, 18: 31–42.

Ribeiro, R. D. X., Oliveira, R. L., Macome, F. M., Bagaldo, A.R., Silva, M. C. A., Ribeiro, C. V. D. M., Carvalho, G. G. P., & Lanna, D. P. D. (2011). Meat Quality of lambs fed on palm kernel meal, a by-product of biodiesel production. A*sian-Australasian Journal of Animal Sciences*, 24 (10): 1399-1406.

Rosli, A. (2001). Feeding Trials in Malaysia: Palm Kernel Cake as a Feedstuff for Cattle. *Palm Oil Developments*, 34: 7-10.

Sadeghi, S., Tolide-ie, H., & Ghaderi, F. (2012). The relationship between heart rate as an indicator of work hardness and results of dynamometry. *Work*, 41: 5677- 5680.

Sharmila, A., Alimon, A. R., Azhar, K., Noor, H. M. & Samsudin, A. A. (2014). Improving nutritional values of palm kernel cake (PKC) as poultry feeds: A review. *Malaysian Journal of Animal Science*, 17(1): 1-18.

Sethi, I., & Chawla, A. S. (2014). Influence of cultural, social and marketing factors on the buying behavior of Telecom users: A comparative study of rural, semi-urban and urban areas in and around Chandigarh. *Journal of Marketing Management*, 2 (1): 97-110.

Sidel, J. L., & Stone, H. (1993). The role of sensory evaluation in the food industry. *Food Quality & Preference,* 4: 65-73.

Siti Nasihah, I. (2014). *Consumers'preference towards sensory characteristics among different types of chicken*. (Master thesis). Universiti Putra Malaysia, Serdang.

Soltan, M. A. (2009). Growth performance, immune response and carcass traits of broiler chicks fed on graded levels of palm kernel cake without or with enzyme supplementation. *Livestock Research for Rural Development, Vol 21 Iss: 37. Doi:* http://www.lrrd.org/lrrd21/3/solt21037.htm

Sow, T. M. A., & Grongnet, J. F. (2010). Sensory characteristics and consumer preference for chicken meat in Guinea. *Poultry Science*, 89: 2281–2292.

Subramaniam, V., May, C. Y., Halimah, M., Zulkifli, H., Tan, Y. A., & Wei, P. C. (2010). Life cycle assesmentof: the production of crude palm kernel oil part 3a. *Journal of Oil Palm Research*, 22: 904-912.

Sue, T. T. (2001). Quality and Characteristics of Malaysian Palm Kernel Cakes/Expellers. *Palm Oil Developments,* 34: 1-3.

Suriya Kumari Ramiah, Norhani Abdullah, Muhammad Akhmal, Saminathan Mookiah, Abdoreza Soleimani Farjam, Chen Wei Li, Liang Juan Boo & Zulkifli Idrus (2019) Effect of feeding less shell, extruded and enzymatically treated palm kernel cake on expression of growth related genes in broiler chickens. *Italian Journal of Animal Science*, 18:1, 997-1004.

Sundu, B., Kumar, A., & Dingle, J. (2006). Palm kernel meal in broiler diets: Effect on chicken performance and health. *World's Poultry Science Journal*, 62: 316-325.

Tabe, K., Kim, Y. J., Ohnuma, S., Ogoshi, H., Atsushi Suzuki, A., & Nishiumia, T. (2013). Improvement of texture and palatability of chicken breast: Effect of high hydrostatic pressure and sodium hydrogen carbonate. *High Pressure Research*, 33 (2): 348-353.

Thompson, S. A. & Weber, C. W. (1981). Effects of dietary fibre sources on tissue mineral level in chicks. *Poultry Science*, 60: 840 - 845.

Tuorila, H (2015). From sensory evaluation to sensory and consumer research of food: An autobiographical perspective. *Food Quality and Preference,* 40: 255–262

Tuorila, H., & Monteleone, E. (2009). Sensory food science in the changing society: Opportunities, needs, and challenges. *Trends in Food Science and Technology*, 20: 54–62.

Wan Zahari, M. & Alimon, A. R. (2004). Use of palm kernel cake and oil palm by-products in feed compounds. *Palm Oil Developments*. 40: 5-9.

Watchravesringkan, K.T., Ruoh-Nan Yan, & Yurchisin, J. (2008). Cross-cultural invariance of consumers' price perception measures. *International Journal of Retail and Distribution Management*, 36 (10): 759 – 779.

Yeong, S.W., Mukherjee, T.K., & Hutagulung, R.I. (1983). The nutritive value of palm kernel cake as a feedstuff for poultry. *Proceeding of the National Workshop on Oil Palm By-products Utilization* (pp 100-107).