DESIGN FORMULATION OF RABBIT FEED BASED ON PALM KERNEL CAKE (PKC) AND OIL PALM FROND (OPF)

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ABSTRACT

Palm oil miling is a major industry in Malaysia. The total area under oil palm estates cover more than 2 million hectares. The industry, besides producing palm oil, also produces by-products such as palm kernel cake (PKC) and oil palm frond (OPF) which is usable as animal feed. Palm oil mills in Malaysia currently produces an annual quantity of 1.4 million tons of PKC. Moreover, OPF is one of the most abundant agricultural by-products in Malaysia. Almost all pruned fronds are discarded in the plantation, mainly for nutrient recycling and soil conservation. Rabbits are herbivores that feed by grazing on grass, straw and leafy weeds. In consequence, their diet contains large amounts of cellulose, which is hard to digest. The study focused on the suitability of PKC and OPF as a major source of crude protein, crude fiber and as well as minerals and vitamins in the formulation of rabbit feed. The nutritional compositions of these raw materials and a common animal feedstuffs, maize and soybean meal are analyzed using Near-Infrared Spectroscopy (NIRS). The results of crude protein (CP) content using NIRS analysis are 17.24 % in PKC, 0.00 % in OPF, 7.51 % in maize and 38.76 % in soybean meal. The result of crude fiber (CF) content in OPF is 32.99 %. These feed ingredients are then grinded and mixed on proper formulation using laboratory blender. Final product 1 analyzed using NIRS has 15.79 % crude protein (CP), 8.75 % crude fiber (CF) and 20.70 % acid detergent fiber (ADF) which represents high digestibility. Gross energy (GE) value is 4005.18 kcal/kg which resulted in a comparable appetite of rabbit with a commercial rabbit pellet. Final product 1 is considered suitable as a supplementary rabbit feed. Final product 2 and final product 3 are used as a comparison. At 40 % total formulation of PKC and OPF in the rabbit feed, the environmental problem of biomass from oil palm industry is solved.

ABSTRAK

Pengilangan minyak sawit merupakan industri yang utama di Malaysia. Jumlah kawasan estet kelapa sawit meliputi lebih daripada 2 juta hektar. Industri kelapa sawit, selain menghasilkan minyak sawit, turut menghasilkan produk-produk sampingan seperti hampas isirung sawit dan pelepah kelapa sawit yang digunakan sebagai makanan ternakan. Kilang-kilang minyak sawit di Malaysia menghasilkan 1.4 juta tan hampas isirung sawit pada setiap tahun. Tambahan pula, pelepah kelapa sawit merupakan antara produk sampingan pertanian yang banyak di Malaysia. Hampir kesemua pelepah kelapa sawit dibuang di kawasan tanaman dengan tujuan penggunaan semula nutrisi dan pemeliharaan tanah. Arnab merupakan sejenis herbivor yang makan rumput, jerami dan daun rumpai. Sebagai kesan, diet arnab mengandungi selulosa yang banyak dan sukar dihadamkan. Penyelidikan ini memfokuskan kesesuaian hampas isirung sawit dan pelepah kelapa sawit sebagai sumber utama protein mentah, serat mentah, mineral dan juga vitamin dalam formulasi makanan arnab. Kandungan-kandungan nutrisi bahan-bahan mentah tersebut dan juga ramuan makanan ternakan biasa, biji jagung dan serbuk kacang soya di analisis menggunakan spektroskop inframerah dekat. Keputusan-keputusan kandungan protein mentah di dalam hampas isirung sawit adalah 17.24 %, 0.00 % di dalam pelepah kelapa sawit, 7.51 % di dalam biji jagung dan 38.76 % di dalam sebuk kacang soya. Keputusan kandungan serat mentah di dalam pelepah kelapa sawit adalah 32.99 %. Ramuan-ramuan makanan arnab tersebut kemudian dikisar dan dicampur dalam formulasi tertentu dengan menggunakan mesin pengisar makmal. Produk akhir 1 yang dianalisis menggunakan spektroskop inframerah dekat mengandungi 15.79 % protein mentah, 8.75 % serat mentah dan 20.70 % serat peluntur asid menunjukkan penghadaman yang tinggi. Nilai tenaga kasar adalah 4005.18 kcal/kg menunjukkan keputusan selera makan arnab yang boleh dibandingkan dengan pellet arnab komersial. Produk akhir 1 dipertimbangkan sesuai sebagai makanan arnab tambahan. Produk akhir 2 dan produk akhir 3 digunakan sebagai perbandingan. Pada jumlah 40 % formulasi hampas isirung sawit dan pelepah kelapa sawit di dalam makanan arnab, masalah biomas daripada industri kelapa sawit adalah diselesaikan.

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LIST OF ABBREVIATIONS

PKC	Palm kernel cake
PKM	Palm kernel meal
PKE	Palm kernel expeller
OPF	Oil palm frond
NIRS	Near-infrared spectroscopy
CP	Crude protein
CF	Crude fiber
ADF	Acid detergent fiber
ADP	Acid detergent fiber-protein
ADL	Acid detergent lignin
NDF	Neutral detergent fiber
DM	Dry matter
EE	Ether extract
GE	Gross energy
DE	Digestible energy
MARDI	Malaysian Agriculture Research and Development Institute

CHAPTER 1

INTRODUCTION

1.1 Background of the study

The oil palms (*Elaeis*) comprise two species of the *Arecaceae*, or palm family. They are used in commercial agriculture for the production of palm oil. The African Oil Palm *Elaeis guineensis* is native to west Africa, occurring between Angola and Gambia, while the American Oil Palm *Elaeis oleifera* is native to tropical Central America and South America. The generic name is derived from the Greek for oil, *elaion*, while the species name refers to its country of origin.

The oil palm industry had a humble beginning. From a mere four original palms introduced from West Africa to the Bogor Botanical Gardens, Indonesia in 1848, their seeds soon arrived on Malaysian shores in 1871. The research and development (R&D) undertaken soon showed the potential of the new crop. Following this, the first commercial planting was done in 1911 at Tenammaran Estate, Kuala Selangor (Yusof Basiron *et al*., 2004). The tropical climate and temperature range from 20°C to 30°C on an average had expanded the area of oil palm planting. The growth in area during the various decades of the last century in Malaysia is shown in *Table 1.1*.

Table 1.1: Area of oil palm planting and growth in the decades of the last century

Years in decades	Hectares	% Growth
1870 - 1910	< 350	-
1920	400	14.2
1930	20 600	5 050.0
1940	31 400	52.4
1950	38 800	23.5
1960	54 638	40.8
1970	261 199	378.0
1980	1 023 306	291.8
1990	2 029 464	98.3
2000	3 376 664	66.3

Source: Malaysian Oil Palm Statistics (2001)

At the end of 2000, the area stood at 3.376 million hectares, producing 10.842 million tonnes of palm oil, 3.162 million tonnes of palm kernel, 1.384 million tonnes of palm kernel oil and 1.639 million tonnes of palm kernel meal (Chan *et al*., 2004).

Due to the tremendous growth of oil palm planting and palm oil production, numerous efforts have been made to conserve the environment by identifying and converting the by-products into a value-added products. For example, Waste to Wealth (W2W) is an international event which conferred and exhibited annually. It offer an opportunity for participants from the academia, research institutes, industries and government agencies to share and exchange information on research and development results and industrial practices as well as to interact and identify opportunities for cooperation in related field.

Rabbits are one of *mammalia* class in the *animalia* kingdom, found in several parts of the world. There are many other species of rabbit, and these, along with pikas and hares, make up the order *Lagomorpha*. Rabbit meat is considered a leaner and healthier meat than beef, lamb or pork, due to its lower fat and cholesterol content (Enser, Hallet, Hewitt, Fursey & Wood, 1996), (Lee, & Ahn, 1977) and (Lukefahr, Nwosu, & Rao, 1989). One of the most interesting aspects of a rabbit's body is his digestive system.

As herbivore, a rabbit needs a diet consisting almost entirely of vegetable matter. The diet should contain a full range of proteins, fibers, fats, and carbohydrates, together with vitamins and minerals, but the proteins and fats will be those of vegetable origin, which the oil palm industry is an abundant source.

Palm kernel cake (PKC) or palm kernel meal (PKM) is produced as a by-product of palm kernel oil extraction process. It is also termed palm kernel expeller (PKE) due to the screw presses mechanism. PKC is considered a medium grade protein feed, containing 14.6 % to 16.0 % crude protein, useful for fattening cattle either as a single feed, with only minerals and vitamins supplementation, or mixed with other feedstuffs (Chin, 2001).

Oil palm frond (OPF) is obtained as a by-product during harvesting of the fruits. Compound feeds based on OPF and PKC have been successfully processed as pellets and cubes. OPF alone is a good source of fibre with as much as 45 % crude fiber content with a nutritive value generally between straw and hay (M. Wan Zahari *et al*., 2004).

Generically, feeds are natural materials and elaborative products of any origin that, either alone or suitably mixed, are able to provide adequate animal nutrition. The main quality factors of feeds are the energy value, the amount of crude fibre (CF), which is very important in regard to digestibility, crude protein (CP) whose contents are important for the balance and digestibility of essential amino acids and the ether extract (EE), together with the different additives that may be present (I. Gonzàles-Martin *et al*., 2006).

1.2 Problem statement

A common rabbits feed contains primarily grass or hay, merely found in their original habitat. The favorable taste of rabbit meat and potential as livestock, is currently distributed around the world at scale production. Rabbit meat consumption is important in the Mediterranean area, especially in France, Italy and Spain (Lebas & Colin, 1992).

Livestock continue to play a vital rule in the nutritions of humans worldwide. Maize and soybean meal are the major imported ingredients for animal feed. Malaysia suffers from a severe shortage of animal feed ingredients so it has to import such products to keep its livestock industry fully operational. Locally available raw materials contribute about 30 % of the total feed ingredients in Malaysia (Loh, 2004). In commercial rabbit meat production, feed consumption is one of the critical points when feed costs represent over 70 % of rabbit meat production (Moura et al., 1997).

The utilization of palm kernel cake (PKC) and oil palm frond (OPF) as a main ingredients in an animal feed have been proved by many research through formulations of proper feed for various species of animals. Crude protein and crude fiber contents in a palm kernel cake are well accepted to provide a nutritional feed for ruminants, poultry and aquaculture. Certain commercial rabbit pellets do not contain enough long fiber which usually found in straw and hay. Naturally occured cellulose or long fiber is important in maintaining a good rabbit's health. Consequently, the opportunity to substitute PKC and OPF nutritions in the rabbit feed are large.

1.3 Research objectives

1. To determine the nutritional values of palm kernel cake (PKC), oil palm frond (OPF), maize and soybean meal.
2. To produce rabbit feed based on palm kernel cake (PKC) and oil palm frond (OPF).
3. To solve the environmental problem of biomass from oil palm industry.

1.4 Scopes of the study

To achieve the research objectives, scopes have been identified in this study. The scopes of the study are listed as below:-

1. To determine the nutritional values of raw materials using near-infrared spectroscopy (NIRS) analysis.
2. To ensure the nutritional values of final products using near-infrared spectroscopy (NIRS) analysis.
3. To compare the appetite of rabbit between PKC and OPF based feed and normal diet (commercial rabbit pellet).

1.5 Significance of the study

Palm kernel cake (PKC) is identified as the most useful by-product among the many residues produced in the palm oil industry in Malaysia, being traded very economically both at local and international markets. Malaysia currently produces an annual quantity of 1.4 million tonnes PKC as a by-product and has been the largest PKC exporter in the world, with the European Union countries importing more than 85 % of Malaysian PKC annually, the other importers are the Netherlands, United Kingdom, Germany, Ireland, and Asian countries like South Korea and Japan (Saw *et al*., 2008).

Although PKC supplies both protein and energy, it is looked upon more as a source of protein. PKC by itself is a medium grade protein feed and with its high fibre content it is often consider as suitable for feeding of ruminants. Suitability of PKC as feed for cattle has been much proven. Invariably, it has become the basic feed in most rations for fattening cattle in feedlots. It is also the primary constituent supplementary feed for dairy cattle, mixed together with other ingredients such as ground maize and soybean meal (Chin, 2009).

Utilization of palm kernel meal in rabbit diets has not been extensively investigated. (Aduku *et al.,* 1988) compared palm kernel cake with peanut meal and sun flower meal in diets of weaner rabbits. (Imasuen *et al*., 2003) also replaced maize with palm kernel meal in the diets of weaned rabbits.

Oil palm frond (OPF) consists primarily of celluloses, hemicelluloses and lignin, and lesser amounts of protein, oil and ash that make up the remaining fraction of the lignocelluloses biomass. Much research has been carried out by MARDI and JIRCAS on use of OPF for animal feeding, either fresh, or processed as silage or pellet (Abu Hassan, Ishida and Mohd Sukri, 1995).

The combination of palm kernel cake (PKC) and oil palm frond (OPF) in the present research study is a main factor in formulation a reliable, sustainable and economic rabbit feed. As country developed, Malaysian citizens need a high quality livestock supplied by its variety of feed resources and utilization of these biomass from oil palm industry can significantly minimize the rabbit feed cost.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The purpose of this chapter is to provide a review of past research efforts related to nutritional components of rabbits feed. The review is detailed so that the present research effort can be properly tailored as well as to justify the scope and direction of the present research effort. A review from other relevant research studies are also provided.

Bustanul Ariffin *et al*., (2009) claimed that interest in alternative plant protein sources has grown due to the increasing demand in food and non-food industries. Since the soy protein, legume protein and wheat gluten protein are comparative attractive in food industry, the protein extraction from agriculture by-product has received a lot of researchers attention in order to fulfill the demand of industries. There is a potential for conversion of agriculture by-products into useful products or even as raw material for other industries. The utilization of agriculture by-products as a source of functional ingredients is a talented field which indirectly solve the environment problems caused by disposal of agricultural by-products.

2.2 Types of rabbit breeds

2.2.1 Heavy breeds

Rabbits are used for their wool, fur and meat. Adult weight of heavy breeds exceeds 5 kg. The Bouscat Giant White, (French) Belier, Flemish Giant and French Giant Papillon are examples. The fur of the (French) Belier varies greatly in colour and can be white, agouti, iron grey or black. Its body build would make it a good meat rabbit. However, it is bred for show and therefore found only in small units, at least in France.

2.2.2 Average breeds

Adult weight of average breeds varies from 3.5 kg to 4.5 kg. English Silver, German Silver, Argenté de Champagne, Fauve de Bourgogne, The New Zealand Red, The Californian, The New Zealand White and The Large Chinchilla are examples of those average breeds. The Californian is a synthetic American breed. It was presented for the first time in 1928 in California by its breeder, whose objective was a meat animal with very good fur.

2.2.3 Lightweight breeds

These breeds have an adult weight of 2.5 to 3 kg. They include the Small Himalayan, the Small Chinchilla, the Dutch and the French Havana. The lightweight breeds usually develop very quickly and make excellent mothers. They eat less than the medium and large breeds and could be crossed or used pure in developing countries to produce a light, meaty carcass of 1 to 1.2 kg.

2.2.4 Small breeds

These breeds weigh about 1 kg at maturity. They are represented chiefly by the Polish rabbit, with its many variations of coat colour. Selection for small size has led to very low fertility and a marked decrease in growth rate. These breeds cannot be used for meat production. They are bred for show, for the laboratory and as pets.

2.3 Nutritional components of rabbits feed

2.3.1 Energy

The energy requirements for various productive function (growth, lactation, gestation) have received little attention. Assuming that rabbits, like most animals, voluntarily adjust their feed intake to meet their energy needs, the lack of precise data on energy requirements is perhaps of less concern in rabbit diet formulation than the lack of data on requirements of most other nutrients.

Lebas (1975) has studied the performance of growing rabbits fed diets differing in energy content. Approximately 9.5 kcal of digestible energy (DE) was required per gram of body weight gain, regardless of energy content of the diet. The data suggest that a level of 2,500 kcal of DE per kg of diet will satisfy the energy needs for rapid growth, but, at energy levels lower than this, the rabbit may not be able to consume sufficient feed to meet its energy requirements for maximum growth.

2.3.2 Carbohydrates

The fiber fraction of feeds corresponds to the structural carbohydrates of plant material. In the past, this was measured as crude fiber. In recent years, the terms “cell wall constituents” (CWC) and “acid-detergent fiber” (ADF) have become widely used, CWC consists of hemicellulose, cellulose, lignin and silica, while ADF consists of cellulose, lignin and silica. Schurg *et al.* (1976) found digestibility coefficients of 25.0 and 36.7 percent for ADF and CWC, respectively, of a whole-plant corn pellets.

Hoover and Heitmann (1972) studied utilization of ADF by rabbits. Growth was significantly lower with a dietary level of 29.4 percent ADF than with 14.7 ADF. Lebas (1975) obtained a similar growth rate with diets containing 10 and 18 percent crude fiber.

Compared to other animals studied, the rabbit is unique in that the flora of the large intestine is almost entirely bacteroides (Smith, 1963). Fuller and Moore (1971) also noted that bacteroide species were the dominant organism in rabbit large intestine. Gouet and Fonty (1973) reported a similar finding. Many bacteroides are cellulose digesters (Hall, 1952; Hungate, 1966) so it is likely that the rabbit does have a population of cellulolytic organism.

2.3.3 Protein and amino acids

The importance of protein quality in rabbit nutrition is well recognized. For rapid growth, rabbits are dependent upon adequate quantities of dietary essential amino acids. Dependence on dietary essential amino acids implies that non-protein nitrogen sources would not be useful to rabbits. Numerous studies have indicated this to be true. Olcese and Pearson (1948) found that supplementation of a low-protein diet with urea did not allow for growth. King (1971) reported that substitution of part of the plant protein in a grower diet with urea resulted in decreased growth. Cheeke (1972) observed that neither urea, biuret, nor diammonium citrate improved groth when added to a low-protein diet. These reports provide abundant evidence that non-protein nitrogen sources cannot be employed usefully in grower diets.

The value of various protein supplements for rabbits have been studied. Cheeke and Amberg (1972) found that, at equal protein levels, soybean meal promoted growth rates of 34 g per day, while growth with cottonseed meal was 25 g per day. Supplementation of cottonseed meal with lysine and methionine increased growth rate to the level obtained with the other two supplements. Lebas (1973) found soybean meal supported a higher growth rate than obtained with sesame meal. Colin and Lebas (1976) have found rapeseed meal, horsebeans and peas to be acceptable protein supplements after supplementation with methionine. The various responses to different protein supplements are largely a consequence of their amino acids composition.

2.3.4 Lipids

Thacker (1956) fed diets containing 5, 10, 15, 20 and 25 percent fat in the form of vegetable oils found that gains of 4 to 5 week old Dutch rabbits were greater with fat levels of 10 to 25 percent than with the 5 percent level. Arrington *et al.* (1974) also observed better performance with fat levels of 11 and 14 percent than with 2.4 and 3.6 percent. It appears that there are no special problems associated with feeding of fat to rabbits; level used in feeds is thus dictated by the prevailing economic relationship between fat sources and grains. Arrington *et al.* (1974) observed digestibility coefficients of 83.6 and 90.7 percent for the ether extract fraction, largely consisiting of corn oil.

Essential fatty acid deficiency in rabbits has been demonstrated (Ahluwalia *et al.,* 1967). Signs include reduced growth, loss of hair, and changes in the male reproductive system including degenerative changes in the seminiferous tubulus, impaired sperm development, and decreased accessory gland weights.

2.3.5 Mineral elements

2.3.5.1 Calcium and phosphorus

Calcium and phosphorus are major constituents of bone; in addition, calcium has metabolic roles in blood clotting, in controlling excitability of nerve and muscle tissue and in the maintenance of acid-base equilibrium, while phosphorus is a component of such vital cellular constituents as ATP, DNA, RNA and phospholipids.

Rabbits are tolerant of high dietary calcium levels. Chapin and Smith (1967) found that diets containing as much as 4.5 percent calcium and a calcium : phosphorus ratio of 12 : 1 did not depress growth and resulted in normal bone ash. High (1 percent) levels of phosphorus are unpalatable, causing feed rejection (Chapin and Smith, 1967).

2.3.5.2 Potassium

Hove and Herndon (1955) found that potassium defficiency in rabbits resulted in a severe and rapidly progressing muscular dystrophy. They estimated the potassium requirement for growth to be at least 0.6 percent of the diet. A defficiency is unlikely, except perhaps with prolonged feeding of a high-grain diet. Alfafa and other forages are rich in potassium. It has been reported that high levels of potassium (0.8 – 1.0 percent) may induce nephritis in rabbits (Surdeau *et al*., 1976).

2.3.5.3 Sodium and chlorine

Addition of 0.5 percent salt to the diet, or provision of salt blocks for free-choice consumption, are adequate means of providing these elements. Disadvantages of salt blocks include greater cost, greater labor requirements and cage corrosion in moist climates.

2.3.5.4 Magnesium

Kunkel and Pearson (1948) characterized magnesium deficiency as causing poor growth and hyperexcitability with resulting convulsions. They estimated the magnesium requirement for growth as 30 – 40 mg per 100 g of diet. There is evidence that inadequate magnesium may result in fur chewing (Gaman *et al*., 1970). Woodward and Reed (1969) noted alopecia, blanching of the ears and alteration of fur texture and luster in rabbits fed a diet containing 5.6 mg of magnesium per kg of diet. Cheeke and Amberg (1973) found that the major route for magnesium excretion in rabbits is the urine, a pattern which is similar to the unusually high urinary calcium excretion.

2.3.5.5 Iron

Iron deficiency in rabbits produces microcytic, hypochronic anemia (Smith *et al*., 1944). At birth, rabbits have a very large iron reserve (Tarvydas *et al*., 1968), so the newborn are not dependent on a supply of iron in the milk. Rabbit liver has a high iron storage capacity. Iron from transferrins in the blood is incorporated into ferritin in the liver, which in the rabbit is the immediate precursor of hemosiderin (Underwood, 1971).

In view of the generous distribution of iron in feedstuffs, iron deficiency in rabbits is unlikely to be encountered under practical conditions. Because of the iron reserve at birth, the rabbit is not susceptible to iron-deficiency anemia in the preweaning phase.

2.3.5.6 Copper

A deficiency of copper results in anemia and graying of the hair (Smith and Ellis, 1947). Bone abnormalities associated with copper deficiency have been reported (Hunt *et al*., 1970); the deficiency signs were accentuated by supplementation of the low copper diet with 1 percent ascorbic acid. A dietary level of 3 mg of copper per kg of diet has been suggested as approximately the requirement (Hunt and Carlton, 1965). King (1975) reported that 200 ppm added copper stimulated growth rate of young rabbits.

2.3.5.7 Selenium

The nutritional essentiality of selenium has been demonstrated for numerous species of animals. This element has been shown to be a constituent of the enzyme glutathione peroxidase, which is involved in the disposal of peroxides in tissues. The metabolism of selenium is inextricably involved with that of vitamin E, which functions in preventing peroxide formation. Although selenium has not been demonstrated to be a nutritional essential for the rabbit, protection against peroxide damage appears to be more dependent on vitamin E than on selenium in the rabbit.

2.3.5.8 Molybdenum

An excess of molybdenum induces copper deficiency, anemia and other signs of toxicity (Arrington and Davis, 1953). Neither an excess nor deficiency of molybdenum in rabbits under practical conditions is unlikely.

2.3.5.9 Zinc

In young female rabbits fed a diet containing 0.2 ppm zinc, Shaw *et al*. (1972, 1974) observed the following deficiency signs; reduced feed consumption, lowered hematocrit, weight loss, graying of the dark hair, alopecia, dermatitis and reproductive failure. Unreceptiveness to the male, apparent failure of ovulation and a pale, inactive endometrium were factors in the lack of fertility. Since lost of appetite was pronounced, all of the above signs may be at least partially a result of reduced intake of other nutrients. In similar study, Apgar (1971) noted sparce hair, dermatitis, weight loss, appetite depression, sores around the mouth and wet matted hair on the lower jaw and ruff when female rabbits were fed a diet containing less than 3 ppm zinc.

2.3.5.10 Cobalt

Cobalt is required for the synthesis of vitamin B12 by microorganisms in the digestive tract. Utilization of cobalt by the bacterial flora is much more efficient in the rabbits than in ruminants (Simnett and Spray, 1965). After 51 weeks on a diet containing less than 0.03 ppm cobalt, no deficiency signs in rabbits were observed. Absorption of vitamin B12 is more efficient in the rabbit than in man, the rat, or sheep (Simnett and Spray, 1965). In view of these results, cobalt deficiency in rabbits under natural conditions is extremely unlikely.