UNIVERSITY OF CAPE COAST

PALM KERNEL OIL RESIDUE (PKOR) AS LIVESTOCK FEED IN GHANA: A CASE STUDY OF FOUR (4) DISTRICTS IN THE CENTRAL REGION

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BY

EBENEZER GYAMERA

Thesis submitted to the Department of Animal Science of the School of Agriculture, University of Cape Coast, in partial fulfillment of the requirements for award of Master of Philosophy Degree in Animal Science

MARCH 2010

Declaration

Candidate's Declaration

I hereby declare that this thesis is the result of my own original work and that no part of it has been presented for another degree in this university or elsewhere.

Candidate's Signature: …………………………….. Date: ……………

Name: Ebenezer Gyamera

Supervisors' Declaration

We hereby declare that the preparation and presentation of the thesis were supervised in accordance with the guidelines on supervision of thesis laid down by the University of Cape Coast.

Principal Supervisor's Signature: ………………… Date: ……………

Name: Professor F. N. A. Odoi

Co-Supervisor's Signature: ……………………….. Date: ……………

Name: Dr. K. S. Awuma

ABSTRACT

Feed costs amount to about 70 – 80% of the total production costs of meat production in intensively managed production systems. In Ghana, the major ingredients of such feeds are maize, wheat bran and protein based concentrates based on fishmeal. Agro Industrial By-Products especially Palm Kernel Oil Residue (PKOR) is potentially useful as an energy and/or protein source for feeding all species of livestock. The study was therefore designed to examine the extent of use of PKOR in four districts in the Central Region of Ghana. Primary data were collected using a set of structured and validated interview schedule from 60 poultry and livestock farmers, who were selected using multi-stage sampling technique. Data analysis was carried out using descriptive statistics (frequency counts and percentages) and inferential statistics (Pearson correlation). The results of the analysis showed that the poultry sub-sector was the main user of PKOR. A quarter (25.0%) of farmers sampled in the study use PKOR while 28.3% use a close variant of PKOR called Palm Kernel Cake. Farmers perceived that using PKOR reduces feed cost than using conventional feed ingredients only or commercially prepared feeds. Empirically, education and type of enterprise showed positive relationship with use of PKOR while years of experience showed negative relationship with use of PKOR. The major recommendations that emanated from the study are: information leaflets containing feed formulation using PKOR for different species of farm animals should be published by the Animal Production Directorate and distributed to farmers, and extension agents should train farmers on best ways of handling and using PKOR for feed.

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Thanks are also due to my lecturers Dr. (Mrs.) Irene Annor-Frempong and Dr. Baffour-Awuah for their constant encouragement and contribution to the research work. Special thanks go to Mr. Stephen Adu who assisted me in the laboratory analysis of samples.

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Also, I should thank my colleague, Theophilus Yangtul for his morale support and company during my entire studentship years at the University of Cape Coast.

Finally, I should like to thank my dad and siblings, as well as my fiancé for their encouragement, ‘open-handed generosity’, and for their prayer support without my even asking.

DEDICATION

To my dad, Mr. F. A. Gyamera, and my siblings; Mary, Joshua, Michael and Daniel.

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CHAPTER ONE

INTRODUCTION

Introduction

This chapter provides an introduction to the research undertaken. Among the topics discussed in the chapter are: background to the study, problem statement, general and specific objectives of the study. Also, the chapter includes the research hypotheses, significance of the study, limitation and delimitation, description of study area, and the organization of the report.

Background to the Study

Feed is the most important input factor in livestock production. This is especially so in intensive systems of management where livestock depend on what is provided to meet their needs for maintenance and production (Apantaku *et al*., 2006). Feed cost is about 70 to 80 percent of the production cost of eggs and meat (Nyanu, 1999; Flake and Ashitey, 2008). This implies that if cost of feed is lowered, the profit margin of livestock / poultry farmers would increase, and vice – versa. Furthermore, lowered feed cost could also reduce the prices of animal products such as meat and table eggs, thereby increasing per capita consumption of animal protein sources which is currently rated as low in Ghana (FAO, 2004).

Feed prices in Ghana have been increasing steadily in recent years; this has led to the steep decline in Ghana’s livestock industry, especially the poultry sector, since 2000 / 2001 (Flake and Ashitey, 2008). Controlling animal feed costs is critical to profitability in this industry, given that feed cost alone can represent as high as 80 percent of the variable production costs.

A study by Okantah *et al*. (2003) indicated that majority of peri – urban poultry farmers claimed to purchase commercially prepared feed while 34 percent mixed their own feed; the remainder did both. However, there has been mass out-cry recently by farmers on the high cost, poor quality and inconsistent weight of bags of commercially prepared feed. This results in high cost of production and hence lowered profit margins for farmers (Salami and Oyewole, 1999).

The increase in the price of livestock feed is partly attributed to the high cost of raw materials for feed production. Apantaku *et al*. (2006) explained that the problem of raw materials stemmed from the fact that livestock farmers have failed to harmonize crop and animal feeding in agricultural practices. The seasonality and frequent scarcity of raw materials have also led to another very serious problem facing livestock farmers – instability in feed prices (Tewe, 1996).

Undoubtedly, the use of non – conventional feedstuffs and formulation of balanced rations using the least cost ration approach will be a good avenue to reduce production costs (Nyanu, 1999). It is therefore not surprising for Flake and Ashitey (2008a) to report that farmers and feed manufacturers are switching to low-cost substitutes such as palm kernel cake and copra cake that are by – products of agro – processing. Indeed, palm kernel oil residue (PKOR), the solid waste obtained after locally extracting oil from the kernel of oil palm fruit, stands ideal as a low-cost livestock feed in Ghana.

Problem Statement

Palm kernel oil residue (PKOR) is the major (both in quantity and distribution) oil seed cake produced in Ghana, compared with copra cake and groundnut cake. Palm kernel cake (PKC), a close variant of PKOR, is an important livestock feed ingredient in many countries where it is produced. It also serves as a good feed source for ruminants in countries where it is not produced but imported. However, in Ghana, despite several feeding trials to prove its viability as a low-cost livestock feed ingredient, it appears that livestock farmers do not use it to any appreciable extent.

In recent times, when PKOR production has increased and feed prices have become high (with the possibility of further increases), the expectation would have been for farmers to extensively use PKOR in their rations. However, this is not so. In order for the livestock industry to be competitive and more profitable, livestock farmers need to use low cost feed ingredients.

Objectives of the Study

General objective

The main objective of this study was to investigate livestock farmers' perception and use of PKOR, and others such as PKC and PKM, as a feed ingredient in the Central Region of Ghana.

Specific objectives

The specific objectives of the study were:

(a) To determine the factors affecting the choice of feed ingredients by livestock farmers in the Central Region.

(b) To identify and rank, in terms of importance, factors affecting farmers' choice of feeds and/or feed ingredients in the Central Region

(c) To identify reasons why farmers incorporate PKOR or otherwise in the rations of their animals

(d) To identify the livestock sub-sectors which utilize PKOR most

(e) To ascertain the level of inclusion of PKOR in livestock rations on farms in the Central Region.

Hypotheses

The central hypothesis for this study was that: "Farmers using PKOR as feed ingredient are more knowledgeable about the potential of PKOR as livestock feed; they also live in areas where PKOR is easily available, when compared with their counterpart farmers not using PKOR".

To assess whether or not education or experience in keeping livestock has an effect on the utilization of PKOR. The study tested the following hypotheses:

1. H0: The educational levels of farmers do not significantly affect their use of PKOR as a major feed ingredient for livestock.

   H1: The educational levels of farmers significantly affect their use of PKOR as a major feed ingredient for livestock.

2. H0: The number of years of experience of livestock rearing has no significant influence on their use of PKOR as a feed ingredient.

   H1: The number of years of experience of livestock rearing had significant effect on their use of PKOR as a feed ingredient.

Significance

It is an undeniable fact that prices of feed and feed ingredients have increased markedly in recent years, resulting in high cost of production (Flake and Ashitey, 2008; FAO, 2006). This might, according to Adejumobi (1990) and Salami (1995), probably be due to several factors including competition between humans and livestock for feed ingredients such as cereal and legume grains, tubers and root crops; irregular and erratic supply of certain feed ingredients due to their seasonality e.g. cereals; excessive use of the scarce and expensive conventional ingredients such as grains, soybean meal and fish meal at the expense of cheaper substitutes in the manufacture of compound feeds; and inadequate local production of feed ingredients to meet local consumption by man and animal e.g. cereals and legumes.

To solve the problem of high cost of feeds, several authors, including Owusu-Dumfeh (1967), McDonald *et al.* (1998) and Odoi *et al.* (2006) have recommended the use of agro industrial by-products, of which the oil seed cakes are a good example. Palm kernel oil residue (PKOR), one of the oil seed cakes, is abundant in the Central region of Ghana but seems not to be utilized to any extent as a feed ingredient in livestock diets. Most researchers using PKOR in the diets of livestock have limited themselves to on-station trials and have not researched to see the exact needs of farmers as regards feeds and feeding; and subsequently, how PKOR is used by farmers. There is a general perception among researchers and international bodies that domestic consumption of by-products (including PKOR) is low in sub-Saharan Africa, but there is paucity of information on views of poultry and livestock farmers on use of PKOR.

This study will help to prove or disprove this perception and the preference of farmers for PKOR. As well, the factors affecting farmers' choice of feed ingredients and feeds will be examined. It is expected that by the end of this research, the real needs of livestock farmers as regards feeds and feeding, especially that regarding the use of PKOR, will be identified and possible interventions recommended for farmers and other stakeholders.

Limitations

The primary purpose for which this research was conducted was to fulfill academic requirements for a Master of Philosophy degree in Animal Science, which was time bound. That actually compelled the researcher to restrict himself to the use of a design that would permit the accomplishment of the broad aim of the study, within the stipulated period. This might affect the degree of control for some internal and external threats to validity. The whole study was expected to be completed and a report submitted within a maximum of twelve (12) months.

Also, since most farmers hardly keep records on their livestock management activities, the research relied on the respondents' power of recall and or perceptions to obtain some of the data required.

Lastly, due to limited financial resources, the study was limited to only four districts instead of the entire Central Region being studied.

Delimitations

This research concentrated on livestock farmers' perception and use of PKOR as a feed ingredient in the Central Region. Thus, the inferences made from the findings have been delimited only to the Region and not the entire country.

Again, in assessing the annual production levels of PKOR in Ghana, there was limited data available on PKOR production and so the data used were often secondary data from expeller-pressed PKC and not local processor groups.

CHAPTER TWO

LITERATURE REVIEW

Introduction

In this chapter, literature which was found relevant to the subject, have been reviewed and discussed.

Some Common Livestock Feed Ingredients/Feeds Used in Ghana

The traditional diets for monogastrics, especially poultry and pigs, in Ghana are based on maize as the main ingredient; wheat bran is also used in most diets. Okanta *et al*. (2005) reported that in addition, a large percentage of poultry farmers use a commercial concentrate. Thus, a simple diet given to poultry would contain 50 parts of maize, 25 parts of wheat bran and 25 parts of commercial concentrate (Okanta *et al*., 2005; Flake and Ashitey, 2008). Fish meal is also commonly used in rations for monogastrics. Fish meal is a readily available source of protein, and its excellent nutrient values also complement those of other feedstuffs very well, provided that the fish meal has been properly processed (Scott and Dean, 1991). Fish meal is commonly supplemented at levels of from 10-20% in poultry diets (Esminger, 1992 and McDonald *et al*., 1998).

Soybean meal is another emerging ingredient in poultry feed. Its inclusion in poultry feed is low due to high cost and the inclusion level of soybean meal ranges from as low as 10 percent to 18 percent of total ration for layers and 15 to 25 percent of feed formulation for broilers (Flake and

Ashitey, 2008). Soybean meal is an important source of dietary protein and energy for poultry throughout the world. However, not because much soybean is grown in Ghana, the price is generally too high to use extensively in animal feeds. The raw soybean seeds contain a number of natural anti-nutritional factors when fed to poultry, the most problematic being trypsin (protease) inhibitors. Thus, to increase the protein's nutritive value (Balloun, 1980), these anti-nutritional factors must be destroyed. Trypsin inhibitors disrupt protein digestion, which results in decreased release of free amino acids, and their presence is characterised by compensatory hypertrophy of the pancreas due to stimulation of pancreatic secretions. Fortunately, the heat treatment done during processing is usually enough to destroy trypsin inhibitors and other toxins such as lectins or haemagglutinins (Göhl, 1998). The growth depressant effects of lectins are believed to be due primarily to their damaging impact on intestinal enterocytes (Pustzai *et al*., 1979) and to appetite depression (Liener, 1986). Moreover, Coon *et al*. (1990) reported that the oligosaccharides, raffinose and stachyose, in soybean might be anti-nutritional factors. Soybean meal with added DL-methionine is equivalent to fish meal in protein quality, and economic savings from the replacement of fish meal can be up to 30%

Protein feedstuffs and other commercial concentrates provided by feed companies are usually expensive, can vary considerably in price, and price changes can occur unexpectedly (Flake and Ashitey, 2008; Apantaku *et al*., 2006 and Salami, 1995). Therefore, the use of by-products improve the stability of the production system.

To develop livestock production in the Central Region, and for that matter Ghana in a sustainable way, it is important to explore the possibilities of utilizing more of locally available agro-industrial by-products. Flake and Ashitey (2008) reported that the present increases in feed prices is causing feed manufacturers and many farmers to switch to low cost substitutes such as palm kernel cake, groundnut cake and copra cake that are by-products from agro-processing. The food trade and processing industry, as well as the manufacture of industrial products from agricultural raw materials offer a wider range of by-products other than those mentioned by Flake and Ashitey (2008). These include brewers spent grain, cocoa pod husk, coffe pulp, corn cob, sun dried poultry manure and kitchen waste (including plantain and cassava peels) (Tuah, 1999).

Ruminants feed predominantly on natural pastures. At present, no commercially prepared feed is produced for ruminants in Ghana.

Factors Influencing Livestock Farmers Choice of Feeds

In livestock production, especially in intensive systems of management, feed is the most important factor (Apantaku *et al*., 2006). Therefore, it is important for livestock producers to familiarize themselves with the various types of feeds available in order to position themselves to make reasonable and responsible decisions about what feeds to include in their rations. In order to maximize production and profit, according to Esminger (1992), farmers must choose feeds that are most economical for the particular demands of the species or breed to be fed. Esminger (1992) noted that "a high-energy, high-protein feed that is fed to low-producing animals is unnecessarily expensive. Conversely, a low-cost but low-energy feed that is fed to animals at a high production level will depress potential for production and should be considered an expensive feed". It is important, therefore, that livestock producers know and follow good feed choice/buying practices. Likewise, farmers may consider the possibility of using commercial feeds, all or in part, or not at all.

Esminger (1992) and Apantaku *et al*. (2006) identified about eight factors that may influence farmers' choice of feeds. These were the quality of feed, technical ability and knowledge on feed processing methods and cost price of feed, storage capabilities of feed, transportation costs, long-term availability of feeds, government regulations and origin of feeds (farms or manufacturers).

Feed quality

Feed quality refers to the amount and types of nutrients an animal can derive from a particular feed (Tainton, 2000). Some feeds are more valuable than others; hence, measures of their relative usefulness are important. Although, Esminger (1992) noted that livestock producers are not expected to conduct experiments to evaluate the different feeds that they use, unless they are very large operators, it is important for the farmers to have a working knowledge of the value of different feeds from the standpoint of purchasing and utilizing them.

It is important for farmers to know what constitutes feed quality and how to recognize it, if they are to produce or buy superior feeds (Esminger, 1992). Farmers need to be familiar with the characteristics of feeds which indicate high palatability and nutrient content; and if in doubt, observation of the animals consuming the particular feed will inform them, as animals prefer and thrive on high-quality feed. Farmers may use physical evaluation, chemical analysis and/or biological tests to measure and compare the quality or value of different feeds, as some feeds are more valuable than others, and hence, their relative usefulness (Esminger, 1992).

Farmer's technical ability and knowledge on feed processing methods

The decision as to what type of feed to use will depend on the farmer's technical ability and knowledge on feed processing methods. Depending on the species being kept, farmers may choose between self-compounded or commercially-compounded feed, self cultivation of feed ingredients or purchase of the ingredients, among other options. Whichever programme is chosen must result in maximum returns for labour, management and capital. It is generally known that self-compounding is cheaper but the choice for this greatly depends on the farmers' technical ability and knowledge on feed processing, and also the size of the farm. Large farms will warrant the effort of self-compounding (Esminger, 1992). In choosing commercially compounded feeds, the farmer must recognize that there are differences in commercial feeds (Esminger, 1992). Efficient farmers will know how to determine what constitutes the best in commercial feeds for their specific needs. They will not rely solely on the appearance or aroma of the feed, nor on the salesperson, but will strongly consider the reputation of the manufacturer (i.e. conferring with other farmers who have used the particular product before and checking on whether or not the commercial feed under consideration has a good record for meeting its guarantees); specific needs of farm livestock (i.e., the class, age and productivity; and whether the animals are fed primarily for maintenance, growth or production); and finally, feed laws (Esminger, 1992).

The cost price of feed

This is a very important consideration as feed prices vary widely. Esminger (1992) recommended that for profitable production, feeds with similar nutritive properties should be interchanged as price relationships warrant. According to Salami (1995), choice of feed ingredients to formulate feeds is always influenced by the cost of the ingredients and availability in a locality. Furthermore, Salami (1995) stressed that increasing cost of feeding is the greatest problem facing livestock farmers, especially poultry farmers, because most layer and broiler farmers adopt intensive systems of management.

In studying the causes of high cost of feed in animal production, Adejumobi (1990) and Salami (1995) identified and reported the following as the chief causes:

(a) Competition between humans and poultry for the same feed ingredients e.g. cereal grains, legume grains, tubers and pulses.

(b) Importation of some conventional feed ingredients and imposition of custom duties on them e.g. fish meal, dicalcium phosphate (DCP) and feed grade synthetic amino acids.

(c) Irregular and erratic supply of certain feed ingredients due to their seasonality e.g. cereals.

(d) Excessive use of the scarce and expensive conventional ingredients such as cereal grains, soybean meal, fish meal and DCP at the expense of cheaper substitutes in the manufacture of compounded feeds.

(e) Inadequate local production of feed ingredients to meet local consumption by humans and livestock e.g. cereals and legumes.

It is for the majority of these reasons that there has been strong advocacy for the use of agro industrial by-products such as PKOR in the Central Region, in terms of abundance; in most cases, PKOR can be obtained free-of-charge.

It is evident from different literature (Fetuga *et al*., 1988; Esminger, 1992; Tainton, 2000 and Apantaku *et al*., 2006) that feed quality and feed cost are the two most important factors affecting farmers' choice of feed and that a relationship exists between the two (i.e. a high quality feed usually cost higher than a low quality feed). However, the significant role that feedstuffs play in livestock improvement programmes is grossly underrated and undermined due to poor feed quality seen in many developing countries (Apantaku *et al*., 2006). The rapid expansion and success of the livestock industry depend largely upon the availability of good quality and cheaper feed resources. Fetuga *et al*. (1998) confirmed this when they reported that there have been many dubious feed manufacturers in the livestock feed industry which has resulted in production of poor quality feeds.

It is for the above reasons that feeding livestock has become a sophisticated and complicated process. Therefore, the successful choice of a particular feed necessitates knowledge of all the factors that affect net returns. In this study, the factors that influence the choice of feeds by livestock farmers in the Central Region of Ghana are examined. The use of PKOR; one of the cheapest, commonest and high value feed resources in the Central Region of Ghana, among farmers is also studied.

Oil Palm – Origin, Cultivation and Contribution to Economy of Ghana

PKOR is a by-product obtained from the processing of the kernel of the fruit of the African oil palm. The African oil palm (*Elaeis guineensis*) is placed in the *Arecaceae* family, along with coconut and date palms. There are three naturally occurring forms or cultivars of the oil palm fruit, termed dura, tenera, and pisifera. Most cultivars are the tenera form which produces fruit with high oil content.

It is generally agreed that the Oil Palm (*Elaeis guineensis*) originated in the tropical rain forest region of West Africa (FAO, 2002). The main belt runs through the southern latitudes of Cameroon, Cote d'Ivoire, Ghana, Liberia, Nigeria, Sierra Leone, Togo and into the equatorial region of Angola and the Congo (FAO, 2002). According to FAO (2004), oil palm is produced in 42 countries worldwide on about 27 million acres (10,800,000 hectares) of land. Average yields are 4.4 tons/ha; per hectare yield of oil from the African oil palm is more than 4-fold that of any other oil crop. According to FAO (2004), the top 10 countries in terms of world production are Malaysia (44%), Indonesia (36%), Nigeria (6%), Thailand (3%), Colombia (2%), Cote d'Ivoire (1%), Ecuador (1%), Cameroon (1%), Congo (1%) and Ghana (1%).

In Ghana, more than 125,000 hectares of land is under oil palm cultivation; mostly under the nucleus estate model, typified by a large central plantation surrounded by smaller plantations established on local farmers' lands (CSIR, 2006). The three biggest nucleus estates are the Twifo Oil Palm Plantation located in the Central Region, Benso Oil Palm Plantation located in Western Region and Ghana Oil Palm Development Company's plantations at Kwae in the Eastern Region of Ghana (see Figure 1). However, oil palm cultivation is not limited to these three regions as smaller plantations are located in the Ashanti, Brong-Ahafo and Volta regions of Ghana.

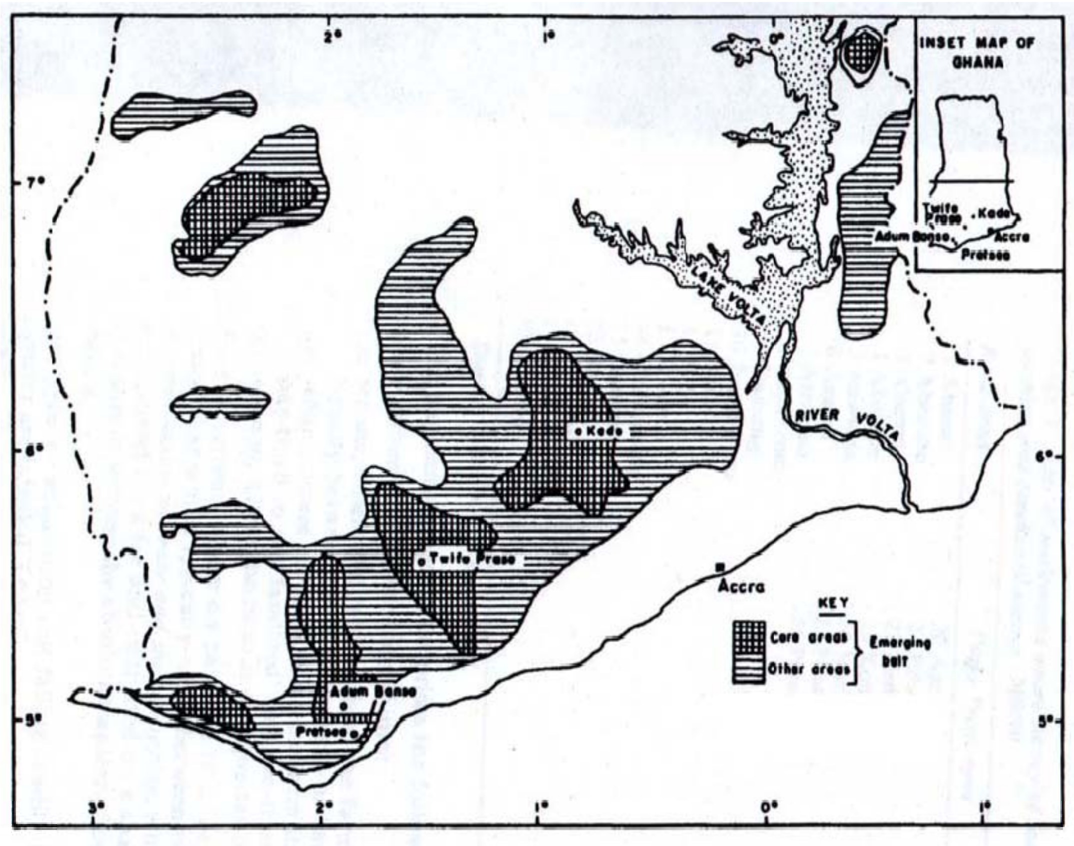

Figure 1: Oil Palm Belt in Ghana

Source: Gyasi, 1992

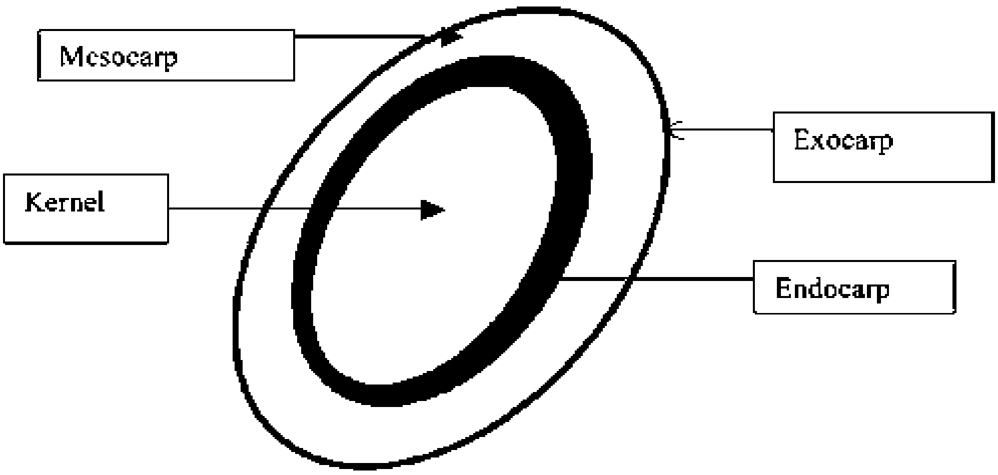

Figure 2: Structure of the palm fruit

Plate 1: Fresh fruit (on the left is a cut fruit)

Source: Field Data, 2008

Plate 2: Fresh fruit bunch (ffb)

Source: Field Data, 2008

Uses of Oil Palm

The products derived from the oil palm can be divided into three main categories: the oils derived from the fruit and seeds; the drinks from the ‘sap’ of the palm; and products that utilize the stem, leaf and foliage of the plant, example baskets and brooms.

Fruit and Seed Uses

Figure 2 shows the parts of the oil palm fruit (as also shown in Plate 1). Fruit and seed products have historically been the most important economic aspects of the plant because these are the products that have the most value on international markets. The edible palm oil comes from the red fleshy exocarp of the fruit; using traditional methods, this requires a labour-intensive process for extraction. The production of the oil probably came about from a local dish called palm nut soup. The oil extraction process may have been an extension of the palm nut soup preparation process.

The pericarp of the fruit, which consists of the shell and pulp, contains the palm oil. Palm oil is one of the main sources of the fats and oils components of many Ghanaian diets, and is a notable source of Vitamin A. Palm oil has industrial uses in the manufacture of soap and magarine. Upon the removal of these parts for oil extraction, producers are left with the endocarp, which consists of the kernel and its shell. The kernel shell contains no oil, but has uses as a fuel and component in building materials.

From the kernel, an entirely different oil, is extracted which is also used in cooking in certain areas in Ghana to a lesser extent than the red palm oil. Local uses of palm kernel oil are commonly limited to lamp oil (although petroleum kerosene is now more common) and an ingredient in the local soap industry. Industrial uses were discovered abroad and palm kernel oil was essential in the early days of margarine production. Since kernel oil's uses are primarily industrial, over 97% of total palm kernel oil production is sold (Anyane, 1966). With the advent of international trade, mechanized and more efficient methods were developed and continue to be improved for both palm oil and palm kernel oil extraction. Locally, the traditional methods, with some introduction of labour saving machinery, are still predominantly used in processing.

In traditional processing of the fruits of oil palm, not only are the oils marketed, but also nearly all of the by-products of the oil extraction are used. The fibres left from the fruits are dried and used as tinder for starting fires. The cracked shells of the kernels are used as fuel by blacksmiths, or can be mixed with mud and formed into blocks for the construction of traditional houses. The sediment of the red oil processing ('zomi') is eaten with some food products, example 'ampesi', 'gari', etc. The residue (sediment) of the kernel oil extraction process (referred to in this study as Palm Kernel Oil Residue or PKOR) is however often disposed of, although research has proven that it could be dried and fed to livestock or used as fuel (Odoi *et al*., 2006).

Whereas utilization of similar product has long been adopted in oil palm plantation based industries in Malaysia (Tay, 1990), it appears livestock farmers in Ghana find no or very limited use for PKOR. Thus, it is not uncommon to see huge mounds of PKOR near processing sites; however, PKOR has great potential as livestock feed.

Other Uses of the Oil Palm Tree

Other products of the oil palm such as leaves and stem are of lesser relative economic importance when compared to the oils; but they are ubiquitous in the daily lives of most Ghanaians especially, among rural folks. Palm fronds are commonly used in making brooms for daily sweeping of houses, and this can be found in almost every household in Ghana. The fronds are also used as construction material for household and farm structures, either using entire fronds for shade structures or as rafters to which thatch roof is attached. Baskets are also woven from palm fronds, and these serve as containers used in the transportation of farm products in most farming communities.

The major product from the stem of the palm tree is a milky white, effervescent drink, called “palm wine”. This is sold fresh or is distilled into a much more potent drink known as “akpeteshi”. While palm wine is a notable source of vitamins (vitamin C and niacin) and minerals (primarily potassium) (Herzog *et al*., 1995), akpeteshi is reputed to have medicinal values, although it is most valued for its socio-cultural uses such as being used for libation to ancestral gods.

These other non-oil products of the oil palm are only mentioned parenthetically, as of “less economic value” (Anyane, 1966), or described, in the case of palm wine, as “entirely destructive to the crop” (Hartley, 1988). But Gerritsma and Wessel (1997) noticed that palm alcohol production is “becoming of increasing importance in Ghana”. The studies conducted by these authors fail to put any premium on the by-products obtained from the extraction of the oils, perhaps because the PKOR is dumped as waste. This study indicated that one of the by-products obtained from the extraction of oil from the kernel of the oil palm has great potential as feed for livestock even though much attention has not be given to palm kernel oil residue (PKOR). Local processor groups give no or limited value to PKOR even though when its use is fully exploited it could generate income for the local processor groups as well as reduce the cost of production of almost all species of farm animals.

Product Identification – What Exactly is PKOR?

Palm Kernel Oil Residue (PKOR) is the solid residue left behind after the extraction of oil from the kernel of the palm nut in small-scale cottage industries. Its colour varies from light to dark brown, and sometimes black, depending on the degree of heat applied during the extraction. It is fibrous in nature, comes out in big wet lumps and has a distinct pungent smell; although this smell reduces after drying for a period of time (Odoi *et al*. 2006). It is considered to be bitter, gritty and highly fibrous (Hutagalung, 1981; McDonald *et al*., 1988) compared to other oil seed cakes. The residue is thrown away, usually heaped at a spot close to the processing site.

Production of Palm Kernel Oil Residue (PKOR)

PKOR is obtained after two stages of oil extraction from the oil palm fruit. The first stage is the primary extraction of palm oil from the pericarp portion of the fruit, which also produces the kernel and other by-products namely, palm oil sludge (POS) and palm pressed fibre (PPF). The extraction of oil from the crushed kernel then results in the production of PKOR as a by-product. Two methods are commonly used for the extraction of oil from the crushed kernels. These are the “Traditional method” and the “Mechanical Extraction method”. A third method, namely the “Solvent Extraction method” exists, but is rarely used nowadays (Boateng *et al*., 2008). The characteristics of the residue from each of the above extraction methods vary.

(1) Traditional/Manual Method of Palm Kernel Oil Extraction

This method of palm kernel oil extraction is done by processor groups, mainly women. As groups of processors are not usually the same as those who extract the palm oil, they have to go around palm oil processors and sometime households (who use the oil palm fruits domestically) to purchase nuts in small quantities for drying until an appreciable quantity is obtained. The actual extraction process begins with the shelling of the palm nuts. This is done by a mechanical nut-cracker which delivers a mixture of kernels and shells that must be separated. The mixture is then poured into a clay-bath, which is a concentrated viscous mixture of red clay and water. The density of the bath is such that the shells sink while the lighter kernels float to the top of the mixture. The floating kernels are scooped in baskets, washed with clean water and dried. Periodically, the shells are scooped out of the bath and discarded or used as fuel. The dried kernels are then roasted with a little old oil. The roasted kernels are then sent to the mill to be ground into a paste. The paste is mixed with a small quantity of water and heated in drums or aluminium cooking pots to release the palm kernel oil. The released oil is periodically skimmed from the top; PKOR is the residue left after most of the oil has been scooped. It is usually discarded or left in the open to dry. The PKOR still contains a high level of residual oil and moisture (Odoi *et al*., 2006)

Presently, and since time immemorial, the kernel oil obtained is the only product of commercial interest. The by-product is dumped after oil extraction, close to the production sites. The environmental nuisance and dangers posed by the dumped by-product to both processors and neighbouring residents cannot be over-emphasized. Air pollution, soil pollution and water pollution, chocked drains and water ways, are some of the nuisance caused by the PKOR.

(2) Mechanical Extraction Method

The mechanical/expeller extraction method, according to Boateng *et al*. (2008), has been identified as the most common method of palm kernel oil extraction in Ghana. While this may be true in terms of volumes of palm kernel oil and for that matter PKOR produced, the number of people using the traditional extraction method might far out-number those using the mechanical extraction method.

The mechanical extraction method generally has four steps, namely; de-pericarping, nut cracking, kernel and shell separations and oil extraction.

De-pericarping

De-pericarping commonly refers to the process of removing fibre from the nuts. This is achieved through the use of a rotating drum fitted with baffles. The fibre-nut mixture is fed into the drum, rotating at about 15rpm. The baffles elevate the fibre-nut mixture and allow them to drop. As they fall, a current of air is passed through them which blows the partially dried fibre to the exit. The clean nuts may then be conveyed to a nut silo for drying. At the Ghana Oil Palm Development Company (GOPDC) for instance, nuts are dried to a moisture content of about 14% before they are fed into the cracker (Boateng *et al*., 2008). According to Hartley (1988), the moisture content of the nut must be less than 16% for the kernels to be sufficiently shrunk from the shells, in order to achieve good cracking.

Nut cracking

Cracking is achieved when the kernel passes through two rollers rotating in opposite directions. Movement of the rollers imposes pressure on the nut and causes the shell to break, releasing the kernel. In other mills, nuts are cracked by a centrifugal cracker. Nuts fed into the cracker are thrown out of slots and hurled against a cracking ring. The nutcase breaks upon impact to release the kernel. One disadvantage associated with the centrifugal cracker is that nuts with long fibres at the tail may not crack if the fibre side comes against the cracking ring.

Kernel and shell separation

Generally, there are two ways of achieving this, both of which mimic that of the traditional set up. These methods are known as dry/pneumatic and wet separation. In the dry separation, which is likened to winnowing in the local set up, fragments of light shells and those with long fibres that may have densities a little lower than that of the kernels are blown out of the separator. The second (wet) separation is achieved through the use of water in a hydrocyclone which replaces the clay bath. Through the activity of centrifugal force, a fast-moving water current is created within the cylinder-like hydrocyclone. The heavy particles, particularly the shells, are drawn towards the bottom of the hydrocyclone whilst the kernels remain afloat and are washed into a collecting chamber. After separation, the kernels are dried before being pressed for the oil. At one of the factories visited, it was a common practice to dry the kernels to a moisture content of 6%, as against the 5 – 7% reported by Asiedu (1989), before they are considered suitable for oil extraction.

Oil extraction

First, the kernels are fed into a grinder which breaks them into small fragments. The kernel fragments are put through a roller mill which presses the kernels into flakes. The flaked material is then subjected to steam conditioning, before it is finally conveyed into the expeller for the oil to be pressed out. On the other hand, the kernel flakes can be put through the press directly after flaking. This is normally followed by a second press to achieve maximum extraction. It must however, be appreciated that a great deal of heat evolves during the direct press and this goes to compensate for the steam conditioning in the earlier process (Boateng *et al*., 2008).

(3) Solvent Extraction Method

Solvent extraction processes can be divided into three main unit operations: kernel pre-treatment, oil extraction, and solvent recovery from the oil and meal. The solvent extraction process is an alternative for high capacity mills. In this method, solvents such as hexane are used. Studying the process, Odoi *et al*. (2006) report that the solvent percolates through a layer of the material being processed and is later recovered from the mixture by distillation and the cake steam purified. The crude palm kernel oil is purified using a settling tank or by centrifuging. Characteristically, the oil obtained using this method is bright yellow in colour, and rich in lauric acid, with a nutty smell and taste (Odoi *et al*., 2006). This extraction method is not currently used in Ghana and so it is only beneficial to mention it.

Nomenclature

As pointed out by Kayongo-Male *et al*. (1986), the use of different names by different researchers and authors constitute a problem which calls for the adoption of a standard system for describing the different grades of the major by-product from palm kernel oil extraction. Generally, three names are used in literature. These are palm kernel cake (PKC), palm kernel meal (PKM) and more recently, palm kernel oil residue (PKOR) by Odoi *et al*. (2006). The first two are however, already widely used. It seems the major difference between the products stems mainly from the oil content. PKM is usually adopted for the solvent extracted residue which has a relatively low oil content of about 0.5 – 3.0% (Chin, 1995), while PKC is adopted for the residue which has oil content of up to about 12%. Recently, the term PKOR has been used by Odoi *et al*. (2006) to describe the residue which contains very high oil content beyond 16%. It is worth mentioning that this system has not been standardized and adopted nationally or internationally; thus, PKC and PKM are sometimes used interchangeably. It must be noted, however, that the term PKOR has only been recently used; and refers to a product which contains high moisture and appears as a paste when fresh, unlike PKC and PKM which appear almost dry when fresh.

Also, in Ghana, the solvent extracted type (PKM) is almost completely not produced and some proximate analysis on the mechanically extracted type have shown oil content beyond 12%, even as high as 20% (Odoi *et al*., 2006).

Thus, using the method of extraction alone as a means of grading the by-product might lead to inappropriate conclusions. For nutritional purposes, it would be more appropriate to use the chemical as well as the physical properties.

There seems to be a dearth of literature on PKOR. However, from the forgoing discussion, it could be realized that PKC is a close variant of PKOR and there are several similarities chemically. Therefore, where there is no literature on PKOR, PKC will be reviewed. Some workers however, have used PKC to refer to PKOR (Boateng *et al*., 2008).

Differences Between By-Products From Different Extraction Methods

The by-products from the different extraction methods described are similar, but with varying degrees of differences in crude fat, fibre and moisture content. Other differences may be seen in the crude protein content.

The major difference in the by-products from the different extraction methods is the oil content or residual ether extract (Chin, 1995). Chin (1995) observed that the oil content of the solvent extracted by-product was low, about 0.5 – 3.0 percent, while that of the expeller pressed type was higher, ranging between 5 – 12 percent, depending on the extent of oil extraction.

Meanwhile, Odoi *et al*. (2006) reported levels of residual oil as high as over 20 percent in the by-product obtained from a factory in the Cape Coast Metropolis using the mechanical method. According to Odoi *et al*. (2006), the by-product obtained using the traditional method, though high in oil content, was not significantly higher than that obtained by the mechanical method from the factory in the Cape Coast Metropolis of Ghana.

Some differences are also physically observable between the by-products from different extraction methods when they are fresh. PKOR has high moisture content and looks more like a paste. However, PKC when fresh is solid and contains very low moisture content. Whereas PKC can be used in rations when fresh, it may not be possible to use PKOR when fresh. PKOR needs to be dried to lower moisture contents before it is utilized. The drying has two advantages. It reduces the moisture content to bearable levels and stabilizes the product from going rancid (Odoi *et al*., 2006)

Annual Production of PKOR and PKC in Ghana

Palm kernel from which palm kernel oil and palm kernel oil residue (PKOR) are obtained, usually forms about 5 percent of the total weight of fresh fruit bunches (see Plate 2) (FAO, 2004). There seems to be a dearth of literature on the total quantity of PKOR produced annually in Ghana.

Potential of PKOR/PKC

A review of the nutritional characteristics of PKOR vis-à-vis PKC reveals relatively high nutritive values, with generally no major nutritional limitations in livestock feeding (FAO, 1990). Consequently, many experiments have indicated its technical feasibility as a feed ingredient for a cross section of domesticated animal species.

Nutritional Merits of PKOR

Although, PKC supplies both protein and energy, it is looked upon more as a source of protein (Chin, 1995; McDonald *et al*., 1988). PKC also contains good levels of most major and minor minerals. The levels of some of the nutrients might vary widely, depending on the method of extraction and the source of the palm kernel from which the PKC is obtained.

The data presented in Table 1 compare the proximate analysis of PKOR and PKC by different researchers; while data presented in Table 2 show the metabolisable energy values of the rations different species of animals.

Table 1: Composition of PKC and PKOR on Dry Matter Basis

Fraction	Morrison, 1961 (PKC)	Nwokolo *et al*., 1976 (PKC)	Odoi *et al*., 2006 (PKC)	Anyang, 1999 (PKOR)	Odoi *et al*., 2006 (PKOR)
Dry matter	91.2	92.0	88.31	84.4	54.56
Crude protein	19.2	21.5	15.61	17.0	18.94
Lipid	6.7	7.8	23.05	12.8	13.27
Crude Fibre	11.9	17.5	20.31	23.4	18.30
Ash	3.7	5.0	7.50	6.6	3.67

Source: Different authors

Table 2: Metabolisable Energy Values of PKC in Rations for various Species of Livestock

	Metabolisable Energy, MJ/kg
Ruminants	10.5 – 11.5
Poultry	6.5 – 7.5
Swine	10.0 – 10.5

Source: Alimon, 2000

Crude Protein Content

Chin (1995) argues that PKC by itself is a source of medium-grade protein. This confirms earlier observations made by McDonald *et al*. (1988) and Mustaffa *et al*. (1987) that PKC has a comparatively low content of protein. Although, the authors above did not give much explanation to the reason underlying their observation, it could be due to the fact that certain essential amino acids especially the sulphur-containing ones, are limiting (Nwokolo *et al*. 1976). The crude protein content of PKOR ranges from 7.7 to 18.7 percent, depending on processing methods used and the degree of impurities such as shell content (Jalaludin, 1996). Also, observations made by Chin (1995) indicated that CP levels in the solvent-extracted PKC were more stable or constant (ranged between 15.0 and 15.3 percent) than the CP levels in the expeller-pressed PKC (where the CP content ranged between 14.6 and 16 percent). There do not appear therefore to be much differences between the two types; differences ranged from 0.4 to 0.7 percent, on a dry matter basis. Ffoulkes (2001) reports that the protein in PKC is of a good quality, confirming Devendra's (1977) results in which PKC ranked a little higher than copra cake, but lower than fish meal and groundnut cake, especially in its protein value.

Amino Acid Availability

Reports by Yeong *et al*. (1983) and Hutagalung *et al.* (1982) suggest that the amino acid composition of palm kernel cake (PKC) is not very good (Table 3). However, the availability of the amino acids in PKC have been rated by other authors to be very high. For example, Nwokolo *et al*. (1976) had estimates for all the essential amino acids and indicated their availabilities to be in excess of 85%, except for valine which was only 68.4% available. It could also be seen from Table 3 that cystine was absent from the analysis of Hutagalung *et al*. (1982) and very little in that of Yeong *et al*. (1983).

Table 3: Amino acid composition of some commonly used feed ingredients in Ghana (%)

Amino Acid	PKC[1]	PKC[2]	Maize[3]	Wheatbran[3]	SBM[3]
Arginine	2.18	2.40	0.46	1.02	4.24
Cystine	0.20	-	0.21	0.34	0.95
Glycine	0.82	0.84	0.32	0.80	1.05
Histidine	0.29	0.34	0.24	0.39	1.36
Isoleucine	0.62	0.61	0.29	0.54	2.55
Leucine	1.11	1.14	1.03	0.98	4.63
Lysine	0.59	0.61	0.27	0.66	3.19
Methionine	0.30	0.34	0.10	0.22	0.77
Phenylalanine	0.73	0.74	0.41	0.79	2.85
Serine	0.69	0.77	0.38	0.64	2.75
Threonine	0.55	0.60	0.28	0.48	2.09
Tryptophan	0.17	0.19	-	-	-
Tyrosine	0.38	0.47	0.34	0.46	2.10

PKC[1] – Source: Yeong *et al*., 1983

PKC[2] – Source: Hutagalung *et al*., 1982

[3] – Source: Donkoh and Atto-Kotoku, undated

Furthermore, comparing the amino acid composition in PKC to some commonly used ingredients in livestock and poultry rations in Ghana, it could be seen from Table 3 that PKC compares well with wheatbran, which is also viewed sometimes as a medium grade protein source and used often to increase the crude fibre content of compounded feeds. PKC is superior to wheat bran in all the essential amino acids except cystine, histidine, lysine and phenylalanine. PKC is superior to maize in all amino acids but lower in all amino acids compared to soya bean meal. This observation suggests that, all other factors being held constant, PKC can conveniently replace wheat bran in most compounded livestock feeds in Ghana.

Fat Content

The high fat content makes PKC an energy source (Hishamuddin, 2001). The ether extract content ranges from 0.5 – 3 % in the solvent extracted PKC and 5 – 12 % in the expeller pressed PKC (Chin, 1995). However, Odoi *et al*. (2006) have reported oil content of about 23% in the expeller-pressed PKC obtained from a factory in the Cape Coast metropolis (Table 1). PKOR has an average of about 13% fat content, which compares quite well with the fat content of the expeller-pressed PKC. The oil is mostly saturated (Hutagalung, 1982). However, studies by Rhule (1998) have shown that this property is not all bad as palm kernel cake with high level of residual fat induced higher average daily gain, better feed conversion efficiency with reduced leanness, in pigs.

Crude Fibre

Another property of PKOR that is worth mentioning is the fibre content. It could be seen from Table 1 that PKOR contains between 20.30% (Odoi *et al*., 2006) and 23.4% (Anyan, 1999). This is quite high compared with the crude fibre content of PKC (18.3%) obtained by Odoi *et al*. (2006) and that of other authors (Table 1). Further, crude fibre content of as low as

3.9 % on dry matter basis has been reported (FAO, 1998) for PKC of Malaysian origin. Fibre is considered an essential nutrient for ruminants, especially dairy cattle, since cattle fed insufficient fibre often develop digestive problems (Miller and O'Dell, 1969). About 17% CF, on dry matter basis, is enough to prevent adverse effects for lactating cows (NRC, 1978). With this observation, it should be possible to feed PKOR to cattle without any cause for alarm. However, feeding PKOR/PKC to monogastrics will have to be done with much caution, as have been recommended by several authors.

Mineral Elements

PKOR is very rich in both macro and micro nutrients. Table 4 shows the mineral content in PKC. Although marked differences might exist in the levels of other nutrients, especially crude protein and fat content, the values obtained for the mineral elements are fairly stable and similar for the by-product obtained from different extraction methods.

Table 4: Mineral Element Composition of PKC

Mineral	Yeong *et al*. (1983)	Chin (1991)
Calcium, %	0.29	0.25
Phosphorus, %	0.79	0.52
Magnesium, %	0.27	0.16
Iron, $mgkg^{-1}$	4.05	4.05
Copper, $mgkg^{-1}$	28.5	28.5
Zinc, $mgkg^{-1}$	77.0	77.0
Manganese, $mgkg^{-1}$	225.0	225.0

Source: Different authors

The results obtained by Chin (1991), are very similar to what Yeong *et al*. (1983) had reported earlier. From Table 4, with the exception of calcium, phosphorus and magnesium, the composition by all other essential mineral elements were equal in analysis by the two sources.

The high phosphorus to calcium ratio in the PKC makes it a good choice for dairy cattle feed. It is therefore, no exaggeration for Osman (1986) to report that almost all exported Malaysian PKC is used in dairy cow feed. PKC is used as a common ingredient in German and Dutch dairy rations, with approximately 10% of the cake in the ration; whereas in Malaysia, dairy farmers include more than 50% (Osman and Hishamuddin, 1991). Phosphorus and calcium elements are critical nutrients in the feed, not only as the major elements forming the mineral basis of bones and teeth, but also as the key minerals required in biochemical energy transformation in all body cells (Hishamuddin, 2001).

Nutritional Limitations of PKOR

Despite the high quality of the protein, and the relatively satisfactory calcium and phosphorus balance and energy, PKOR is not without problems when used as animal feed. There are two intrinsic problems in the utilization of PKOR, namely, the high oil residue and the copper content (Jalaludin, 1996); others include the high fibre content (McDonald *et al*., 1988). It is however worth noting that these properties might not be bad in themselves, unless viewed vis-à-vis different animal species, age and physiological state of the animal, as well as the methods of handling and storage.

High Oil Content and Rancidity

The oil content in certain cases can be as high as 23% (Odoi *et al*., 2006), especially for the expeller pressed by-product. The disadvantage is the high susceptibility to developing rancidity in storage. Once rancid, animals fed with it will reject it. Odoi *et al*. (2006), therefore observed and consequently suggested quick drying as an ideal remedy to this problem. Ffoulkes (2001) observed that unpalatability of the feed increased with an increase in the oil content.

Rancidity comes about when the carbon-carbon double bonds in polyunsaturated fatty acids are broken down due to atmospheric oxidation (auto-oxidation). The process of rancidity is accelerated by exposure to heat, light and moisture. Rancidity leads to the emission of unpleasant odours. Even though palm kernel oil is high in saturated fatty acids, there is also a considerable proportion of unsaturated fatty acids present, making PKOR liable to rancidity. The rate of rancidity becomes accelerated in PKOR when it is left in mounds (in the open) near production sites. PKOR therefore, has a sour taste as well as a very strong and pungent smell, upon exposure to light, heat and moisture. These changes in taste, colour and odour as a result of oxidative rancidity contribute to make the fats less palatable and even unsafe for feeding to farm animals. However, even though rancid feeds are potentially toxic, their unpleasant odour and taste generally discourage animals from eating them (Odoi *et al*., 2006). Rancidity therefore tends to reduce feed intake drastically; this adversely affects performance and growth in animals (Tung & Wood, 1975).

High Copper Content

The high copper content can cause toxicity in small ruminants, particularly sheep (Jalaludin, 1996). The same author observed that, to a certain extent, copper toxicity can be alleviated by the addition of zinc molybdate. The extent of copper toxicity in larger ruminants is somewhat unclear because feeding PKC over a long period to either cattle or buffaloes has not resulted in retarded growth or maturity. Furthermore, Jalaludin's (1996) results showed that steers fed high level of PKC were found to have normal concentrations of rumen metabolites, glucose, urea, alkaline phosphate and glutamate oxaloacetate transaminase. Studies by Hair-Bejo *et al.* (1995) also showed that buffaloes fed 100% PKC had twice as much copper and zinc in the liver and adrenal cortex compared to buffaloes fed a normal diet. However, high mineral contents in these two organs did not cause any mortality.

High Crude Fibre Content

Whereas this property may not pose a problem when ruminants are concerned, it becomes an issue of much importance when one desires to feed PKC to monogastrics. The high crude fibre content (of about 16% in some cases) reduces its apparent digestibility for such animals (McDonald *et al*., 1988). This has led to several authors recommending the highest level of PKC inclusion in the diet of simple-stomached animals at not more than 20% (McDonald *et al*., 1988). However, good and comparable results, with a control soyabean meal based diet, have been reported when 30% PKC was included in the diet of rabbits (Orunmuyi *et al*., 2006).

Furthermore, the product is gritty and therefore not readily eaten; it is therefore appropriate to use it in mixtures along with more acceptable feeds.

Presence of Anti-nutritional Factors

Ariff-Omer *et al*. (1998) reported PKC to contain 30% *B*-Mannan, a powerful anti-nutritional factor which can cause depression in feed conversion ratio and reduce weight gains by 20-25% in poultry. According to the same report, PKC feed value is further reduced by the presence of high shell content that accompanies local processing. Palm shells have no nutritive value and are undigestible (Awaludin, undated).

Suggested Solutions to Problems of Using PKOR in Rations for Farm Livestock

In addition to the solutions suggested under each of the problems listed above, these general solutions may be considered to correct or minimize the effects of the problems. These are processing, supplementation, and conditioning of animals.

Processing

Sun-drying may be the simplest form of processing PKOR as feed for farm animals. Apart from reducing the moisture content in fresh PKOR, sun-drying also reduces the pungeant smell (Odoi *et al*., 2006).

Another processing method is pelleting. Pelleting of PKOR may have the advantage of improving the flavour of PKOR and thereby increasing its acceptability by animals. Although it is commonly believed that flavour of a feed is an important factor affecting its voluntary intake, there is little evidence in support of this (Whittemore and Elsley, 1976). The same authors observed that sugar is important in determining ruminant food preferences and molasses can sometimes be used to encourage the eating of food that cattle may be reluctant to consume normally. Similarly, the authors also reported that, sugar is used in diets for piglets to promote the eating of creep feed. In view of the above observations, processing PKOR, which is generally unpalatable, into pellets and consequently coating the pellets with sugar may increase its acceptability and high consumption. Furthermore, mixing PKOR with slight amounts of sugar (if it has to be fed to animals for the first time) might increase its intake.

Supplementation

Taking cognizance of the fact that some amino acids are limiting together with a relatively low energy content, using PKOR as a supplement rather than the main diet might be more ideal, as has been done in most trials using PKOR or its close derivatives. Though, it is generally recommended that the level of its inclusion in diets for simple-stomached animals should not exceed 20% of the feed, several authors (Chin, 1995; Mustaffa *et al*., 1987) have achieved reasonably good results with inclusion rates of up to about 30% for monogastrics and 50% for ruminants, mainly dairy cattle. Surprisingly, Chin (1995) has reported instances where dairy cattle were fed 100% PKC in commercial feedlot programmes in Malaysia with no adverse effects; only minerals and vitamin supplements were given.

Enzyme Supplementation

As earlier stated, PKC has been reported to contain *B*-mannan which has anti-nutritional properties that hinders the full utilization of nutrients in PKC especially by monogastric animals. To address this problem, studies on the effect of enzyme supplementation of PKC in monogastric animal feeding have been carried out by many researchers. According to David *et al.* (1997), the degradation of *B*-mannan in PKC by an appropriate enzyme to mannose will release the sugar and other digestible sugars that can be absorbed and metabolized by monogastric animals. Oluwafemi (2009) also reported that addition of enzymes to the diets of chicks up to 42 days reduced the viscosity of the digesta with a resultant improvement in the feed conversion ratio and fat digestibility in birds. A similar study on the effect of enzyme supplementation on Palm Kernel Cake-based diets on broiler performance was carried out by Akpodiete *et al* (2006), the result of which is in agreement with Nwokolo *et al* (1977) which suggested that up to 30% level of PKM incorporation in broiler starter rations are acceptable.

Conditioning of Animals

Conditioning animals to PKOR diets over a period by gradually mixing more and more of the PKOR in the usual diet the animals in question are used to, can help to obtain higher success rates. Adaptation / acceptability by the animal can be quicker if the animals were introduced to PKOR early in life as the flavour of PKOR in the milk of their mother – dam is known to improve acceptance later in life.

Other Problems with Cottage Industry-Produced PKOR

Apart from the above-mentioned limitations that may be encountered when feeding PKOR to farm animals, PKOR in several instances (due the way PKOR is disposed of) serves as an environmental pollutant. PKOR from cottage extraction of palm kernel oil at present pollutes water bodies, the soil, vegetation and air (Odoi *et al*., 2006). When this results, it makes the environment harmful to both animal and plant life in the community where it is produced. Residual oil from PKOR may run into streams, groundwater or other water bodies through runoffs or infiltration from rain; this is especially so when it is dumped near these sources. Such pollution is unhealthy for both animal life in the water, and animals that drink from these sources. The water also becomes unsuitable for domestic use, unless it is treated at great cost. Water bodies into which PKOR is dumped may be choked by the fibre in the residue, making them stagnant, with several attendant negative effects. Soils on which PKOR is dumped eventually become marginal land, with vegetation unable to survive on it. Similarly, air pollution results from dumping of PKOR in the open which turns rancid. Very unpleasant smells or stench diffuse, making the air unpleasant to breathe.

While it may be difficult to modify the way of disposal in order to mitigate the adverse effects of PKOR, it may be expedient to seriously consider widespread utilization of PKOR in feeding farm animals. Research has proven that PKOR can be conveniently used as livestock feed.

Processing of PKOR for Use as Animal Feed

Unlike PKM and PKC, due to the high moisture, and lumpy nature of fresh PKOR, it must undergo some processing in order to be made suitable for use as feed. According to Odoi *et al*. (2006), the large wet lumps should be spread out in the sun to dry (over a period of 5-7 days, depending on intensity of sun); spreading it out on iron or aluminium sheets, or on a hot concrete surface speeds up the drying process. Whilst drying, the lumps should be broken up to speed up the process; any foreign material still present (e.g. cracked shells, small stones and other inert materials) should be removed by hand or sieved out. It is important whilst drying, to protect PKOR against rain and overnight dew. The dried product, which is more stable, can be stored in sacks until ready for use. Odoi *et al*. (2006) observed and suggested that contents of sacks should be spread out to air from time to time (at least one day in a week), else it can lead to mould formation and rancidity. Drying may also be achieved using mechanical means (example kiln or oven), but sun-drying is cheaper.

Feeding Trials with PKOR in Different Species of Farm Livestock

Reports in the literature investigating the use of PKOR in ruminants particularly cattle (Witt, 1952; Osman, 1986; McDonald *et al*., 1988; Chin, 1995 and Ffoulkes, 2001), chickens (Onwudike, 1986; Osei *et al*., 1987; Onifade *et al*., 1998; Garcia *et al*., 1999; Akande *et al*., 2007; Eziesh *et al*., 2004; Odoi *et al*., 2006), pigs (Jegede *et al*., 1994; Kim *et al*., 2001) and rabbits (Orunmuyi *et al*., 2006) are well documented. Recently, there have been reports of the use of PKC in feeding fish in aquaculture (Malaysia Palm Oil Council, 2008).

Monogastrics

The first use of PKM in poultry diets was reported by Temperton and Dudly (1939) cited by Morrison (1956), who found that PKM was a satisfactory dietary substitute for wheat middling in layer diets. Nwokolo *et al*. (1976) studied the availability of amino acids in PKM, soybean meal (SBM), cottonseed meal (CSM), and rapeseed meal (RSM) for growing chicks. They found that the amino acid availability in PKM ranged from 63.3% in glycine to 93.2% in arginine, with an average of 84.5%, compared with an amino acid availability of 97.3% in SBM, 92.5% in CSM, and 91.9% in RSM. They suggested that PKM is a reasonable source of protein for poultry. McDonald *et al*. (1982) suggested that PKM should be limited to 20% in broiler diets. Osei and Amo (1987) fed broilers with different levels of PKM in isonitrogenous diets and found no significant differences in body weight and feed consumption up to 8 weeks of age. However, feed conversion efficiency significantly declined as PKM levels reached 12.5% of the diet. Yeong *et al*. (1983) fed growing chickens various levels of PKM in isonitrogenous and isocaloric diets. They found no significant differences in daily feed intake and daily weight gain. However, the feed conversion ratio significantly improved when diets containing lower levels of PKM were fed.

Unlike poultry, utilization of palm kernel oil residue or its close derivatives in rations for rabbits 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. The results obtained by Imasuen *et al*. (2003) and Orunmuyi *et al*. (2006) both showed no significant differences (P>0.05) in the final live weight of animals fed on diets with palm kernel cake (at 10, 20, 30 and 40% of total feed). All the PKC based diets were however significantly different from the control diet of soyabean meal.

Ruminants

Fibre is considered an essential nutrient for ruminants, since ruminants fed insufficient fibre often develop metabolic or digestive problems (Miller and O'Dell, 1969). Thus, it is not surprising that PKC has gained popularity in ruminant production, especially with dairy cattle, than in any other species. According to a report by the National Research Council (1978) in the USA, about 17% crude fibre, on dry matter basis, is enough to prevent adverse effects of a deficiency for lactating cows. Thus, PKOR having a crude fibre content of 16% averagely (with higher levels reported) stands ideal to be used for feeding dairy cattle, and consequently other ruminants, without much problems, all other things being equal.

Osman (1986) reported that almost all exported Malaysian PKC (about 1.4 million tones in 2000) was used in dairy cow feed. PKC is used as a common ingredient in dairy rations; approximately 10% of the cake in the ration in Germany and the Netherlands; whereas in Malaysia, dairy farmers use more than 50% (Osman and Hishamuddin, 1991).

According to Devendra (1978), the biological value of PKC is 61 – 80% for sheep. Work by Witt (1952) and Morrison (1956) demonstrated that feeding palm kernel-based diets to dairy cows increased the milk fat content, enhanced the firmness of butter and produced good quality meat. This finding was confirmed by Gohl (1981) who further suggested that 2-3kg of PKC rations could be fed to adult cattle satisfactorily. Gohl (1981) further reported that a ration with 2-3kg of PKC daily is satisfactory for adult cattle. The quantity suggested by Gohl (1981) corresponds to about 50% of the daily dietary requirement of dairy cattle. It is similar to the recommendation made by Ffoulkes (2001), that ruminants, specifically goats should not be fed more that 50% of the ration as PKC. Possible reasons for Ffoulkes' (2001) recommendation might be due to the resultant substitution effect which might arise at higher levels.

Several authors, including McDonald *et al*. (1988), recommended that PKC, should not exceed 20% of the diet when used as a supplement. The reports above in which PKC formed 50% of rations and which obtained reasonably good results tend to render such recommendations by McDonald *et al*. (1988) and other authors no more binding, especially in countries where breeds have low productivity. But it is important when viewing these results to do so with the environment under which the research was carried out in view. It is amazing when one even considers the results obtained by some authors who have fed cattle with 100% PKC with only vitamins and minerals as supplements (Chin, 1995). Results of weight gain performance of various breeds of cattle fed PKC and PKC based diets in different trials and observations undertaken by various workers have been cited by Hawari and Chin (1985) and Mustaffa (1987). In their works, average daily live weight gains ranged from a low 0.39kg achieved by Kedah-Kelantan cattle fed a 100% expeller pressed PKC diet, while 0.83kg weight gain was obtained by Droughtmaster cattle fed a mixed ration comprising 60% solvent extracted

PKC and 40% Palm Oil Mill Effluent (POME), also a by-product from palm oil processing.

The performance of Sahiwal-Friesian cows fed with conventional dairy concentrate mixture without PKC was compared with those fed with identical amounts of solvent-extracted PKC diet (Ganabathi, 1983). Cows fed PKC performed similarly to those fed with the conventional ration giving 7.7kg of milk daily over a 200-day period compared with the 8.4kg of daily milk production for the conventional ration, the difference was not significant

In the same trial, solvent-extracted PKC diet was compared with expeller pressed PKC diet for milk production. The results showed that solvent extracted PKC diet gave significantly better milk production than the expeller pressed PKC diet. Over a 170-day milking period, cows fed solvent extracted PKC diet produced 7.9kg milk daily while those fed with expeller pressed type produced only 4.8kg milk daily.

Further work by Mustaffa *et al*. (1991) showed that switching over from a grass-based diet to 100% PKC diet can be done overnight without any observed ill effects. Mustaffa *et al*. (1991) however, recommended a one week change period in which the normal feed is gradually reduced, until withdrawn completely. In order to coax the animal to eat the PKC, the same authors recommended that molasses be added to the diet. This agrees with work done by Whittemore *et al*. (1976).

Summary of Literature Review

To summarize, feed costs (using conventional feedstuffs or commercially compounded feeds) have become very high. Livestock farmers, in order to maximize profits, have sought for and continue to seek for and choose feeds that are most economical. In order to make the best choice, feed quality and costs, as well as technical ability and knowledge on feed processing methods are primary factors to consider. PKOR is the by-product obtained from the extraction of palm kernel oil from cottage industries. It is available in somewhat large quantities all around the country and has a great potential as feed for farm animals. Although fresh PKOR is prone to spoilage due to high moisture content (>50%) (Odoi *et al*, 2006) and residual fat content (>13%), and the fact that it is usually produced under high environmental conditions, effective drying can help to stabilize PKOR by slowing down any chemical deterioration that promotes rancidity and shortens shelf-life, thereby making it more suitable for use as feed for livestock in Ghana.

CHAPTER THREE

METHODOLOGY

Introduction

The chapter explains the methodology used to conduct the research. The chapter covers research design, study population, source and type of data, instrumentation, sampling procedure and sample size, pre – testing of instrument, field data collection procedure and data analysis.

Study Area

The area of study consisted of four districts in the Central Region of Ghana, namely; the Cape Coast Metropolis, Mfantseman West District, Abura-Asebu-Kwamankese District and Komenda-Edina-Eguafo-Abrem District. These districts were selected on the distribution of commercial livestock farmers based on the national livestock census data of 2000 obtained from the regional veterinary office. Further, in each of these four selected districts, there were a large number of palm kernel oil processor groups or mills which made PKOR easily accessible to farmers.

Description of the Study Area

The Central Region is one of Ghana's ten administrative regions. It is bordered by the Ashanti and Eastern regions to the north, Western Region to the west, Greater Accra Region to the east, and to the south by the Atlantic Ocean. There are seventeen (17) districts in the region.

The Central Region of Ghana has a rich supply of land suitable for oil palm cultivation in a belt stretching from Dunkwa-on-Offin in the north-west, to the Assin Fosu and Abura-Asebu-Kwamankese, Ajumako-Enyan-Essiam and finally the Asikuma-Odoben-Brakwa Districts in the east. There are approximately 11,480 hectares of oil palm under cultivation in the region. Nearly 2,000 farmers are engaged in oil palm production, with the largest holding of almost 9,268.8 hectares being found in the Twifo-Hemang Lower Denkyira District (CEDECOM, 2008). The Twifo Oil Palm Plantation Limited (TOPP) is the largest single holder with 4,280 hectares. As part of their out-growers' scheme, about 5,000 hectares of existing farms will be cultivated in the near future. About 70% of the existing plantations in the region are still very young, with some being only in their second and third years of production. Peak production is expected around the tenth year of production. The annual output from the Central Region is estimated at 64,548 tonnes of fresh fruit bunches. The mill at TOPP is the largest in the West Africa sub-region and has a processing capacity of 20 tonnes of fresh fruits bunches an hour (TOPP, 2008).

There are also small scale oil extraction enterprises dotted all over all the oil palm production districts in the region. These small-scale enterprises produce mainly for the local market, for both domestic and industrial consumption.

Oil palm is a crop that provides multiple outputs and it is the only plant whose fruit produces two types of oil- palm oil and palm kernel oil. It is the production of the palm kernel oil that results in the production of PKOR as a by-product. The production of the latter however, is not limited to oil palm growing areas alone, but takes place also in towns and villages where oil palm fruits are consumed domestically.

Study Population

The population for the study was all commercial livestock farmers captured in the census book of the Central Regional Veterinary Office. However, particular attention was given to those farmers who regularly sought the guidance of the Regional Veterinary Officers. The majority however, happened to be poultry farmers, with a few cattle and pig farmers.

Sampling and Sample Size

The study was carried out in the Central Region of the Republic of Ghana. The study area consisted of four out of the seventeen administrative districts in the region. These were the Cape Coast Metropolis, Mfantseman West District, Komenda-Edina-Eguafo-Abrem District, Abura-Asebu-Kwamankese District. The sampling method used was the multi-stage sampling technique. The first stage involved purposively sampling for four districts based on the population of commercial livestock farms and the existence of at least one cottage industry involved in the extraction of palm kernel oil, the process that leads to the production of PKOR as by-product. The second stage involved purposively selecting three (3) towns from each of the selected metropolis and districts. The final stage involved a simple random selection of five (5) farmers from each town, using a list of commercial farmers obtained from the 2000 livestock census from the Regional Veterinary Office. A total of sixty (60) respondents were selected for the study.

Responses from all 60 respondents were found to be useful for the data analysis.

The Districts with towns selected were; the Cape Coast Metropolis (Cape Coast, Esuakyir, UCC); Komenda-Edina-Eguafo-Abrem District (Elmina, Komenda and Ankaful); Mfantseman West (Anomabo, Saltpond and Egyaa); and Abura-Asebu-Kwamankese District (Abura Dunkwa, Batanyaa and Gagem).

Data Collection

Data were collected through the use of tested, validated and structured interview schedules for commercial livestock farmers, between September and December, 2008. The instrument was considered most suitable for the research survey based on the following reasons: (i) it provided uniform information which ensured comparability of data and (ii) it could easily be used to collect information from any respondent, whether literate or illiterate (Kumar, 1999). Also, observations were made to obtain information on issues such as sample of PKOR used for compounding feeds, sanitary conditions of farms and extraction method for PKOR. The observed information was used to support and explain some of the results obtained. The instrument had a reliability test coefficient of 0.84.

Primary data were collected on socio-economic/demographic characteristics, preference and use of feeds and feed ingredients, level of inclusion of PKOR in rations, observation of farmers on the effects of using PKOR, factors affecting farmers' choice of feeds and feed ingredients.

Secondary data were collected from documents, records and reports of Palm Kernel milling companies and processor groups, and libraries.

Data Analysis

Descriptive statistics (frequency counts and percentages) and inferential statistics (Pearson correlation) were used to analyze the data collected. The Statistical Package for Social Sciences (SPSS, 2007) was used in running the tests.

CHAPTER FOUR

RESULTS AND DISCUSSION

Introduction

This chapter is devoted to the results that were obtained from the survey. Preliminary analyses of the results were made using descriptive statistics (frequencies and percentages). Inferential statistics (correlations and t-tests) was then used to test the hypotheses. The discussion on the results is also included in this chapter. The arrangement of the results and discussion is divided into three main thematic areas, namely; socio-economic and demographic characteristics, factors influencing choice of feeds and use of Palm Kernel Oil Residue (PKOR).

(A) Socio-Economic or Demographic Characteristics

The major enterprises respondents were engaged in are shown in Table 5.

Table 5: Farmers' Major Enterprise (Species Raised)

Species	Frequency	Percentage	Std. Deviation
Layers	38	63.3	
Broilers	12	20.0	
Large Ruminant (Dairy)	1	1.7	1.482
Large Ruminant (Beef)	2	3.3	
Small Ruminant	4	6.7	
Pigs	3	5.0	
Total	60	100.0	

Source: Field Data (2008)

The study revealed that the majority (83.3%) of commercial farmers in the Central Region of Ghana kept poultry, of which broilers formed a quarter, with the remaining being layers. Other species kept by farmers were small ruminants (6.7%), pigs (5.0%), beef cattle (3.3%) and dairy cattle (1.7%).

The study focused on the major species being kept by the respondents for two primary reasons – to find out which species were most kept on commercial basis by farmers in the Central Region; and which livestock enterprises most utilized PKOR in feed formulation.

It was observed that many of the poultry farms visited were in the small-scale category of 50 – 5,000 birds. This agrees well with the observation by Flake *et al*. (2008) that the small-scale (50 – 5,000 birds) and medium-scale (5001 – 10,000 birds) of farms form about 80 percent of the poultry sector in Ghana. These relied on commercial feedmill operators for their feeds; the two categories also produced mainly table eggs. Those poultry farms raising broilers were mainly backyard poultry producers who raised broilers primarily for festive occasions such as Christmas, New Year and Easter.

The results clearly underscore the importance of small-scale poultry production in the Central Region of Ghana. In order to ascertain the reasons for the small flock sizes, farmers were asked why they kept such low number of birds. Over a third (78.2%) attributed this to a lack of funds for expansion, as their main source of funding was from private/personal sources. This majority were willing to increase their flock sizes with the availability of funds – whether from private sources or in the form of low interest loans. Lowering interest rates on agricultural loans by commercial banks may motivate poultry farmers to borrow more money to increase their flock sizes. Furthermore, giving poultry farmers an economic stimulus in the form of capital from the central government will help them to increase production.

The fact that keepers of laying birds formed the majority (75%) of poultry producers agrees with the observation made by Okantah *et al*. (2005) when they studied poultry production in the Greater-Accra and Ashanti Regions of Ghana. Farmers who kept layers generally agreed that the ease of selling eggs was an important consideration in influencing their decision to keep layers. On the contrary, broiler producers were of the opinion that they could only market their product easily during festive seasons but faced a challenge of fierce competition from imported broiler meat during other times of the year. To mitigate the aforementioned marketing challenges, farmers could slaughter and sell their birds as frozen meat instead of lives birds. They could also produce broilers only at the periods where they are assured of ready market. On the other hand, the Central Regional Coordinating Council could, through its revenue agencies, impose high tax rates on imported poultry products entering the region so that domestic broiler production could be increased.

Thus, layer production appears to be the core poultry activity and a long-term, steady business where the product can be marketed with ease and reasonable assurance of making profit.

From Table 5, it could be seen that only 11.7 percent of farmers kept ruminants on commercial basis. These also sought regular technical support from the Veterinary Service offices. This low interest is probably due to the fact that the indigenous ruminant species take a long time to reach saleable size and therefore, many farmers were reluctant to invest fully in ruminant production. All farmers who kept ruminants kept other livestock species in addition or were engaged in other businesses to maximize returns or reduce risks.

The small percentage (11.7%) of farmers keeping ruminants is quite alarming with regards to the utilization of PKOR as livestock feed. This is because several authors (McDonald *et al*., 1998; Chin, 1995 and Odoi *et al*., 2006) have highly recommended PKOR as suitable particularly for feeding ruminants even though the potential also exists for feeding PKOR to poultry and other species of livestock. The recommendation of these authors is justified when one considers the fact that PKOR is high (an average of about 18.3%) in crude fiber. Intensifying farmer education through on-farm feeding trials using PKOR could help ruminant livestock keepers to adopt the use of PKOR.

Table 6 shows the status of respondents regarding ownership or operations on their farms.

Table 6: Status of Respondents Regarding Ownership of Farms

Status	Frequency	Percentage (%)	Std. Deviation
Owner	46	76.7	
Farm Supervisor	6	10.0	0.761
Caretaker	7	11.7	
Farm Manager	1	1.7	
Total	60	100.0	

Source: Field Data (2008)

Over a third (76.6%) of the respondents interviewed were the real owners of the farms (Table 6) and therefore could make major decisions concerning operations of the farm, including feeds and feeding. The high level of owners involved in direct operations of the farms was expected to enhance innovativeness and fast adoption of low-cost inputs such as feed ingredients in contrast to absentee owners. Though decision making is faster with the majority of farmers, there is also a higher risk of making errors than in instances where decision making is by a board. From an economic perspective, the high rate of farmers being the real owners of their farms could be attributed to the fact that the small farm sizes do not warrant the employment of farm hands or managers to take care of the farm. It is also possible that most farmers are able to use family labour and therefore do not need to employ other workers who may have to be paid.

The education level of respondents in this work is presented in Table 7.

Table 7: Educational Level of Respondents

	Frequency	Percentage (%)	Std. Deviation
No formal education	6	10.0	
Basic school	11	18.3	
MSLC	15	25.0	
Secondary School	14	23.3	1.429
Tertiary (Polytechnic / University)	9	15.0	
Other education (vocational / technical / commercial)	5	8.3	
Total	60	100.0	

Source: Field Data (2008)

The study revealed that there was high level of formal education among the respondents; 94.0% had one form or the other formal education ranging from basic education to tertiary education. This showed that majority of the respondents are literate. Even those who had no formal education (6.0%) indicated they had received one training or the other from veterinary officers or colleague farmers which had enhanced their knowledge in livestock rearing. The relative high level of literacy is expected to enhance innovativeness of farmers because literate farmers can read articles on livestock management and adopt those practices on their farms. It is however, worth-mentioning that the high level of education among respondents was not necessarily in animal husbandry, feed formulation and production. This could affect their actual practices on farms, in one way or the other.

Most of the farmers, except for those raising ruminants and pigs, relied mainly on commercially compounded feeds for their animals. However, with the rising cost of commercially compounded feeds, farmers were being forced to find alternatives. So, especially for those raising broilers, farmers were increasingly compounding their own feed, especially for birds at the finisher stage. But since the majority (90%) of the farmers had no formal training in feed formulations, they indicated that they depended on formulations provided them by either friends (colleague farmers) or veterinary officers. Farmers should request for advice on feed formulation and compounding from nutritionists and other knowledgeable personnel. This would enable them formulate and compound quality feeds for various categories of poultry and livestock they keep. The best source should have been the Animal Production Directorate because the Directorate has personnel who have been trained as Nutritionist and specialists in feed formulation and production.

The high level of literacy among the respondents suggests that they could read and make good use of any information provided in writing such as bulletins or publications on feed formulations using PKOR and other locally available feed ingredients. But such publications were non-existent. Therefore, if such publications could be produced and distributed to farmers on regular basis, farmers would be better positioned to utilize PKOR and other locally available feed ingredients in rations for their stock.

Results in Table 8 represents years of experience of farmers since establishment of their farm.

Table 8: Years of Experience (since Establishment of Farm)

	Frequency	Percentage (%)	Std. Deviation
up to 5 years	13	21.7	
6 - 10 years	20	33.3	
11 - 15 years	19	31.7	1.141
16 - 20 years	3	5.0	
above 20 years	5	8.3	
Total	60	100.0	

Source: Field Data (2008)

The majority (78.3%) of farmers in the Central Region of Ghana were not novices in the animal rearing business, with many having been in the business for over 5 years. Therefore, they should have experience the rising cost of feed and as a result be expected to be resorting to alternative feed ingredients to produce quality least cost rations. Only 21.7 percent had less than 5 years experience in livestock rearing (Table 8). A Pearsons correlation test (where years of experience of farmer and likely use of PKOR were pooled) showed no significance ($r = 0.05$, $P > 0.05$). It was ordinarily expected that the number of years a farmer had been in production would have exposed him/her to several innovations such as the potential benefits in the PKOR, but the results obtained showed otherwise. Although, the correlation was positive ($r = 0.05$, $P > 0.05$), it did not show any significant difference. The best way of getting farmers informed therefore, could be through regular education through extension agents or animal production personnel. The results obtained from the correlation also suggest that research findings were not within the reach of the ordinary farmer. Forming strong linkages between research institutions and extension services department would help transfer research findings to farmers for their benefit.

Level of Awareness of PKOR as Feed Ingredient

Farmers were asked to indicate their awareness of PKOR as a potential feed ingredient. The results of the analysis showed that farmers have high awareness of PKOR as feed ingredient as 78.3% indicated they were aware of PKOR's potential as feed ingredient. Although there was high awareness among farmers, of PKOR as feed ingredient, only about half (53.3%) of the respondents had used it in their rations at one time or the other. A quarter (25.0%) of the respondents were aware but had never used PKOR in their rations. This observation is in agreement with earlier results of Roger *et al*. (1977) who cautioned on the use of awareness to determine adoption of innovation, in that it is not always certain that farmers who are aware of innovation will adopt them. According to Roger (1995), potential adopters of a technology progress over time through five stages in the diffusion process. First, they must learn about the innovation (knowledge); second, they must be persuaded of the value of the innovation (persuasion); they then must decide to adopt it (decision); the innovation must then be implemented (implementation); and finally, the decision must be reaffirmed or rejected (confirmation). The focus is on the user or adopter. It is only individuals who are risk takers or otherwise innovative who will adopt an innovation earlier in the continuum of adoption/diffusion (Rogers, 1995). The result obtained in this study is in agreement with Roger's (1995) diffusion process. Only a part (53.3%) of respondents had used PKOR in feeding their livestock although 78.3 percent of the respondents had knowledge on the usefulness of PKOR as feed ingredient. The major reason given by respondents who had knowledge on PKOR's potential as feed ingredient but were not using it in their rations was that they did not want to take any risk of using an ingredient they were not sure of the real value. There is therefore the need for personnel of Animal Production Department and Extension Agents to have on-farm trials or demonstrations to persuade farmers with the value of using PKOR. With that done, farmers may then decide to adopt PKOR as an ingredient in their rations.

About a fifth (21.7%) of the respondents were not aware that PKOR could be used as a feed ingredient. It was rather those keeping ruminants who seemed not to be aware of the potential of PKOR as a feed ingredient. This latter observation is quite worrying since greater potential exists for PKOR to be fed to ruminants than any other livestock species (McDonald *et al.*, 1988 and Odoi *et al.*, 2006). Perhaps, it could be that ruminant keepers have not been hit hardest by the rising feed cost because their animals are kept mainly on the extensive or semi-intensive management systems; also, that there is not much pressure on the ruminant farmers to finish their animals within specific time limits. This shows the level of laxity in the ruminant sub-sector in the Central Region of Ghana. If such trends continue, it will be difficult for the region to produce enough animal protein to meet the demands of the ever increasing population. Ordinarily, one would have expected that ruminant farmers would use PKOR to supplement forages, and more especially, during the dry seasons when fresh forages are inadequate in both quality and availability.

To enable farmers take full advantage of the potential and benefits of PKOR, extension agents as well as personnel from the Animal Production Directorate of the Ministry of Food and Agriculture (MOFA), should create awareness among livestock keepers and educate them on PKOR usage in feeds or as supplements through workshops, open days, information leaflets publications, etc.

The main sources of information on PKOR available to farmers were studied and the findings are presented in Table 9.

Table 9: Main Source of Information on PKOR

Source	Frequency	Percentage (%)
Veterinary Officers	5	15.6
Workshops/Seminars	7	21.9
Journals	1	3.1
Friends/Colleague Farmers	19	59.4
Total	32	100

Source: Field Data, 2008

The findings of this study revealed that farmers obtained information on PKOR use from various sources, ranging from interpersonal to mass media. Over half (59.4%) of the sampled farmers indicated friends (who were also livestock farmers) as their source of information on PKOR's potential as livestock feed. This was followed by workshops/seminars (21.9%), veterinary workers (15.6%) and journals (3.1%). From this, it could be inferred that friends served as the main source of information (on feeds and feeding) to the farmers. This finding is contrary to that of Adekoya *et al*. (2000) who reported that extension agents were the major source of information used by farmers. This observation is very alarming, if livestock farmers in the Central Region of Ghana should continue to use friends/other farmers as their major source of information, without any intervention. Since communication with their peers seems to be the major source of information at the disposal of livestock farmers in the Central Region, it is important that initial efforts are made by extension agents or veterinary workers to reach more farmers to ensure that proper information is transferred through the "snowball effect" (Training of trainers approach).

Also, it appears from Table 7 (Education of sampled farmers) that the majority (90%) of the sampled farmers had one form or the other of formal education and therefore literate. It is thus, perceived that one of the better ways to help livestock farmers manage the risk of obtaining incomplete or inadequate information from colleague farmers will be their access to printed materials like periodic newsletters, fact sheets, and other practical materials on feed formulations using PKOR and/or other agro industrial by-products. Malaysia has achieved great results using periodic newsletters, *Product Series*, to educate farmers on Palm Kernel Cake as Animal Feed (MPOC, 2008)

(B) Factors Influencing Choice of Feed/Feedstuffs

Factors that influence the choice of feed ingredients in the Central Region are presented in Table 10.

Table 10: Factors Influencing Choice of Feed

Factors	Very Important	Important	Not Important	Rank
Quality of feed	11 (18.3)	44 (73.3)	5 (8.3)	2nd
Ease of Processing	9 (15.0)	39 (65.0)	12 (20.0)	3rd
Cost price of feed	51 (85.0)	8 (13.3)	1 (1.7)	1st
Storage capabilities	5 (8.3)	9 (15.0)	46 (76.7)	5th
Proximity	8 (13.3)	32 (53.3)	20 (33.3)	4th
Preference for brand	6 (10.0)	3 (5.0)	51 (85.0)	6th

Source: Field Data (2008); (Parentheses indicates percentages)

Sampled farmers were asked to rate the factors that influence their choice of feeds/feedstuffs on a 3 point scale of importance; very important – 3, important – 2 and not important – 1. Results of analysis of data showed that cost price of feed/feedstuff, quality of feed and ease of processing were the most important factors that influenced farmer's choice between one feed or the other, with 85.0% and 15.0% of the farmers, respectively ranking the three factors mentioned above as very important. Other factors that farmers considered as important in influencing their choice of feed/feedstuffs were proximity to source (13.3%), storage capabilities and preference for a particular brand, in that order.

Predictably, a majority (85.0%) of respondents mentioned cost price of feed or feedstuffs as the most influential factor in their choice of feed. This is probably because the main aim of every commercial farmer is to make profit and therefore will buy and use feeds that cost less, in order to increase profit.

However, it will be dangerous to base one's choice on cost price alone since the cost of feed may not always be commensurate to the quality of the feed/feedstuff. The use of cost price as the major factor in determining which feed/feedstuff to use in rations might probably explain why some (53.3%) farmers have at some point in time used PKOR in their rations since PKOR might be obtained at a far cheaper cost or in some instances free-of-charge. It will be expedient to consider cost in relation to quality of the feed/feedstuff, its processing, storage capabilities and availability among others.

(C) **Use of Palm Kernel Oil Residue and Its Effects on Livestock Production**

The use of palm kernel oil residue in the Central Region and the effect of the use of PKOR on performance, growth and profitability are discussed in the sections that follow. Table 11 shows the type of residue used, the main sources from which PKOR/PKC is obtained, the form in which PKOR is obtained, processing of PKOR before usage and other uses of PKOR apart from its use as feed ingredient.

Table 11: Use of PKOR

	Frequency	Percentage (%)
Type of Residue Used		
PKOR	15	46.9
PKC	17	53.1
Main Sources from which PKOR/PKC is Obtained		
Ameen Sangari (PKC)	14	43.8
Local Processors (PKOR)	15	46.9
Other Sources (PKC)	3	9.3
Form Obtained		
Fresh (PKOR)	12	37.5
Semi-Dried (from dump site)	3	9.4
Dried (PKC)	17	53.1
Processing before Usage		
Air-Drying	15	46.9
Grinding	1	3.1
No further processing	16	53.1
Other Uses of PKOR		
As Fuel for tripod	5	8.3
As Dewormer	1	1.7
As Mulch	2	3.3
As Treatment against termites	1	1.7

Source: Field Data (2008)

This study showed that more than half (53.3%) of livestock farmers in the Central Region of Ghana have at one time or the other used PKOR/PKC in rations for their livestock; out of this proportion, 46.9% used PKOR while the remaining (53.1%) used PKC. Local availability as well as the low cost price of these vegetable protein sources might have been responsible for the high patronage by livestock farmers. However, it is thought that it is more likely the unprecedented high feed prices in recent times that have caused livestock farmers to resort to the use of other feeds especially, PKOR. Hitherto, the common belief amongst researchers was that PKOR was not utilized by farmers but its wide use from this study refutes that assertion.

Sources of PKOR Used

Table 11 shows that 46.9 percent of respondents who used the residue obtained their by-product from local processors producing PKOR. The rest obtained it from the Ameen Sangari Company and as far away as Takoradi (other sources) producing PKC. The high percentage (46.9% of farmers who used the residue or 25% of all sampled farmers) of respondents using PKOR was quite unpredictable. Many earlier works (for example, Okanta *et al*., 2005) have observed that locally available sources of vegetable protein have infrequently been used by farmers. Respondents using PKOR found commercially prepared feed to be expensive or to rapidly escalate in price and therefore, their resorting to locally available and cheaper sources of vegetable protein.

Forms of PKOR Used

Respondents who used PKOR, obtained it in two main forms: fresh/“muddy” (37.5%) and semi-dried (9.4%). It was only the respondents who used PKC (53.1%) that obtained it in the dry state. Fresh PKOR contains high levels of moisture and is not fed to farm animals due to pungeant smell (Odoi *et al.,* 2006). To be made suitable for use as feed, respondents spread the PKOR in the sun, for about a week, to dry. This agrees with the processing style described by Odoi *et al*. (2006). Those who obtained PKOR in the semi-dried form also dried it further in the sun for 2 to 3 days before using it in the ration for their animals. Sun-drying was the major process the PKOR was subjected to before using it in the ration for livestock. It is not advisable to collect semi-dried form of PKOR from dumping sites because it might have grown rancid. Once rancid, animals fed with it will reject it having adverse effects on performance and growth in animals (Tung & Wood, 1975).

Table 12: Duration of Use of PKOR

	Frequency	Percentage (%)	Std. Deviation
Have stopped using PKOR	10	31.2	
below 1 year	4	12.5	
1-3 years	6	18.8	
4-6 years	4	12.5	1.900
7-9 years	3	9.4	
10 and above years	5	15.6	
Total	32	100.0	

Source: Field Data (2008)

Results of analysis of data showed that more than half (53.3%) of the farmers have used PKOR as an ingredient in their feeds before. However, about a third (31.2%) of the farmers (Table 7), who have used PKOR before, had stopped using it due to adverse effects on their production.

Data collected from the respondents indicated that 31.3% of the farmers using PKOR were new entrants (i.e., have used PKOR for below 4 years) to the use of PKOR while 15.6% had successfully used PKOR for more than 10 years.

Inclusion level of PKOR in rations as practiced by respondents in the study is present in Figure 3.

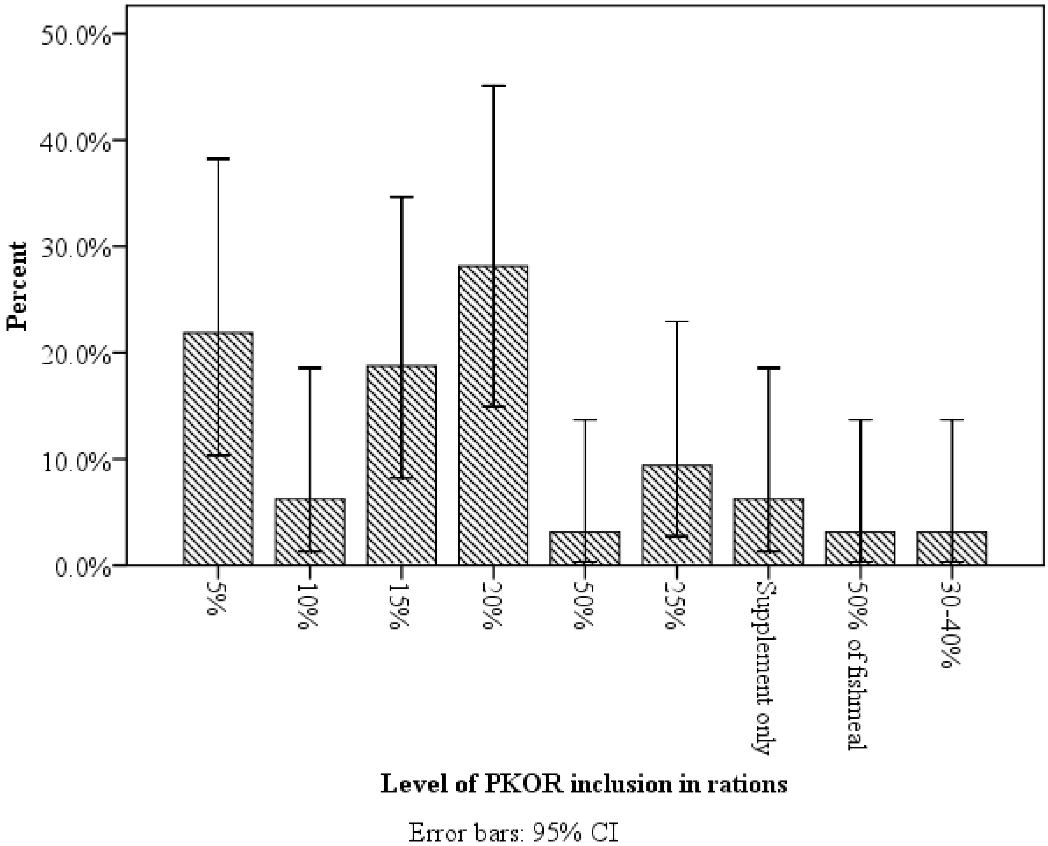

Figure 3: Inclusion Level of PKOR in Rations

Data presented in Figure 3 shows how much PKOR respondents included in their rations; this ranged from as little as 5% to as high as 50% of the entire ration.

Most respondents, who used PKOR in their rations, were not sure of exactly what ingredient(s) PKOR replaced. However, 7 out of 11 respondents replaced wheat bran (especially during periods when wheat bran was scarce) with up to about 40% of PKOR. One respondent replaced fishmeal (in broiler finisher diet) with up to 50% PKOR, with no apparent marked adverse effect on production. The major reason for this 'unusual move' was primarily that of reducing production cost. The major observed effect with this inclusion level was high fat deposit in the meat of broilers. According to him, some consumers preferred this type of meat to the conventional low level fat carcasses; even though there are serious health implications to consumers. However, as there was a ready market for such type of birds, it made economic sense.

The quantities of feed eaten by poultry are inversely related to the concentration of energy in their diets (McDonald *et al*., 1998). Thus, if the energy concentration of their diet is increased without a change in the concentration of the protein and other nutrients, and birds begin to eat less of the diet, then although their energy intake may remain approximately the same, their intake of protein will fall (McDonald *et al*., 1998). The birds may then be deficient in protein. However, since the birds in question in this survey were fed for only a short period of time (2–3 weeks) on the aforementioned PKOR diet where 50% fishmeal is replaced with PKOR, the effects of protein deficiency may not have become marked before the birds were slaughtered for sale. It is envisaged that such high replacement level may reduce cost of feed significantly since fishmeal takes a relatively high amount of the cost of feed. The respondent could however, not provide the exact amount of savings made on using PKOR. This is something worth following up research-wise.

Similarly, the replacement of fishmeal with PKOR has serious implication on the amino acid balance of the feed and consequently, the nutrition of the birds. This is because the amino acids balance present in fishmeal is significantly different from that in PKOR. The replacement of up to 50% fishmeal with PKOR thus will alter the amino acid mixtures provided by the diet out of proportion and might cause inefficient utilization of the acids and feed in general. This is so because reports by Yeong *et al*. (1983) and Hutagalung *et al*. (1982) suggest that the amino acid composition of palm kernel cake is not very good. Cystine, a very important amino acid was absent from the analysis of Hutagalung *et al*. (1982) and very little in that of Yeong *et al*. (1983).

Nearly all (90.6%) the farmers who used PKOR in their rations were poultry farmers. This is probably due to the fact that it is mainly poultry farmers who keep their stock under the intensive system and therefore tend to be hit most by high feed cost. It was observed that the percentage of farmers who used 25% - 50% of PKOR in rations were all keeping broilers; and they used PKOR only at the finisher stage of production which extends for only a short period of 3 – 5 weeks. The success of this group of farmers could be due to the fact that they do not feed the birds for a long time, enough for any likely deleterious effects of such high inclusion levels to show up. They have mentioned weightier birds and reduced cost of production as some of the major benefits of feeding PKOR-based broiler finisher diets. Again, it must be emphasized that wide variations in the optimum inclusion level of PKOR have been reported (Rhule, 1998) depending on variations in the oil and shell content of the PKOR used. Usually, the mechanically extracted type (PKC), have higher shell content and is likely to be higher in fiber content than the traditionally extracted type (PKOR). This is confirmed by Onwudike's (1988) findings that reduced body weight and egg production were observed only at levels greater than 40% PKOR (mechanically extracted) inclusion. Figure 3 shows that the majority (75.0%) of respondents used between 5 and 20 percent PKOR in their feeds. This range is considered by several authors (Yeong, 1980; McDonald *et al*., 1988; and Onifade *et al*., 1999) as the optimum level for poultry. This observation probably might mean that most farmers using PKOR are knowledgeable to some extent on the proper use of it, or that the farmers might have obtained their formulations from expert sources, or arrived at these through experience (trial-and-error).

Finally, Figure 3 showed that a few (6.2%) of the farmers used PKOR for supplementary feeding of small ruminant. The dried PKOR was mixed with wheat bran or 'corn mill waste' in the ratio 1:1 and fed to the flock every other day. Particular attention was given to pregnant ewes, lactating ewes as well as lambs. It was however, realized that many farmers keeping ruminants had no knowledge that PKOR could be successfully used to supplement ruminant feeds, which are predominantly grasses. This lack of knowledge could probably be attributed to the fact that ruminants in Ghana are able to survive dry seasons (when feed is scarce) and still maintain themselves to grow speedily with the onset of the rainy season due to the principle of compensatory growth (Manteca *et al*., 2004). Ruminant growth in Ghana is influenced much by the weather. More commonly, ruminants graze on standing hay (with almost no supplementation) during the dry season. The animals often lose weight during the dry season and gain weight rapidly when the grass grows again during the rainy season (Manteca *et al*., 2004). This uneven growth pattern usually accounts for, in part, the delayed reaching of the saleable weight or size. If ruminant keepers could supplement the predominantly grass diet with PKOR, they could achieve better nutrition and possibly reach saleable sizes earlier.

However, it can be inferred that ruminant farmers are not the hardest hit by increasing cost of feed, and therefore, have not had to seriously look for other alternatives as being done by poultry and pig farmers. Nevertheless, ruminant farmers could still benefit from improved productivity as a result of better nutrition at cheap cost if they considered use of PKOR.

Reasons for Using PKOR

The main reason farmers gave for their use of PKOR/PKC in rations for their farm animals was to reduce the cost of feeding. Farmers argued that recent high cost of feed ingredients and especially commercially compounded feeds has led to high costs of production and thus, they were making all efforts to reduce the cost of production. Although, none of the farmers using PKOR/PKC could indicate by what margin using PKOR reduced their cost of feeding, they were of the general opinion that using PKOR reduced the cost of feeding or increase profits.

PKC (a close variant of PKOR), according to MOPC (2008), could be cost effective and a practical ingredient to be utilized in ration formulations for various livestock species. In general, respondents were of the opinion that using PKOR reduced the cost of feeding and thus, increased their profits. Surprisingly though, none of the farmers was able to provide, by what margin using PKOR reduced their cost of feed. The fact that using PKOR reduces feed cost may be undoubtedly true because, most farmers obtained PKOR free-of-charge from the processors or paid as little as one Ghana Cedi for a bag (about 40 kilogram). Those who used PKC paid four Ghana Cedis for a 40 kilogram bag of the by-product. Comparing this with the prices of wheat bran and other conventional feed ingredients, PKOR is cheap.

Adverse Effects of PKOR-Based Diets on Production

When asked about effects of using PKOR/PKC in rations, 37.5% (i.e. 12 out of 32 respondents) of the respondents, who had at one time or the other used PKOR/PKC claimed that they had observed some adverse effects after using the by-product. Sixty-two and half percent had not observed any adverse effect from using PKOR in rations.

Respondents had used PKOR in rations at one time or the other were asked to describe adverse effects they had observed as a result of using PKOR in rations. The results obtained are presented in Table 13.

Table 13: Some Observed Adverse Effects of Using PKOR in Ration

	Frequency	Percentage (%)	Valid Percentage (%)
Dull and Unthrifty	3	15.8	25.0
High Fat Deposit in Meat	7	36.8	58.3
Oil on (boiled) eggs**	1	5.3	8.3
Taint in milk	1	5.3	8.3
Reduced Lay	3	15.8	25.0
Low Feed Intake	4	21	33.3

Valid percentage is frequency/yes responses. Meaning some respondents selected >1 effect.

Source: Field Data, 2008

Adverse effects observed by some of the farmers after using PKOR-based diets included effects on the product and effects on production. Among the product effects was high fat deposit in the meat of poultry birds. This was expected because of the high fat content in PKOR. Also, it could be that PKOR-based diets prepared by farmers were excessively high in energy content due to the high fat content and thus, contributing to the fat build-up in the meat of birds. Another effect of PKOR-based diets on product quality is tainted milk. This happened on a dairy farm where milk is the main product. This off-flavour in milk makes PKOR undesirable for inclusion in the ration of dairy cows. However, there is need to investigate the quantities that were fed because from all indications, PKOR is best suited for ruminants of which diary cattle are part. Further, PKC, a close variant of PKOR has been successfully used on dairy farms in Malaysia and many parts of Europe (Chin, 1995) without it imparting off-flavour to the milk.

Other effects observed by farmers who used PKOR-based diets were reduced lay and low feed intake. Normally, low feed intake would lead to reduced lay. The low feed intake could be attributed two main reasons: either at the time of introducing the PKOR-based diets, the birds were not familiar with it or that the high caloric nature of PKOR diets led to the low feed intake in terms of volume. If the former was the case, then there is need to condition animals by introducing PKOR in smaller bits over a period of time. Also, introducing PKOR based diets earlier in the life of layer birds (for example, at the grower stage) will get birds to become used to the PKOR so that by the time birds are into lay there would not be a problem. Secondly, when fed free-choice, birds tend to eat to satisfy their energy requirements (Esminger, 1992). Many small-scale farmers in the Central Region did not consider the energy content of the diet in their formulation. Apparently, when birds eat to satisfy their energy requirements, it will mean that other nutrients such as protein and some minerals would be deficient and the imbalance would lead to reduction in lay.

Willingness of Respondents to Recommend PKOR Use to Other Farmers

Majority (68.75%) of the farmers who used PKOR were willing to recommend it to other farmers. This implies that more farmers would continue to be roped into use of PKOR in the diets of their animals. Therefore, as we anticipate an expansion in the use in PKOR-based diets, there is need to educate livestock farmers on best ways of incorporating PKOR to reduce the potential risk on productivity.

Farmers’ Readiness to Acquire Technical Knowledge on Use of PKOR

Almost all (98.3%) respondents expressed interest in knowing more about how to properly use PKOR as livestock feed. This result tends to refute the general perception among researchers that farmers are usually unwilling to learn or adopt new technologies. On the other hand, this result could also show the extent to which farmers are hard hit by rising feed prices, since they would ordinarily be reluctant to readily adopt new technologies.

Relationship Between Selected Variables and Use of PKOR

Hypothesis was set based on the objectives of the study to test relationship between selected variables and use of PKOR in rations for livestock. This was carried out using Pearson correlation. Preliminary analyses were performed to ensure no violation of the assumptions of normality, linearity and homoscendasticity. Further, tests ran to ascertain the relationship between selected variables and use of PKOR in rations for livestock gave the following results: Educational background ($r = 0.08$, $p>0.05$), Years of experience of farmer ($r = -0.22$, $p>0.05$).

The results of the analysis showed that educational background was positively related with use of PKOR/PKC while years of experience of farmers was negatively related to use of PKOR. Both variables tested had small strength of correlation and showed no significant differences.

Relationship Between Education and Use of PKOR

The trend observed was for farmers who had higher educational qualifications to be more likely to use PKOR in rations for their livestock.

Though the relationship was not significant, the nature of the relationship was expected because highly educated farmers ordinarily should read more widely than their counterparts who are not. Also, farmers with high educational qualification will be able to formulate own rations more successfully than their counterparts who are not educated.

Relationship Between Years of Experience and Use of PKOR

The fact that a person has been in farming for a long time does not mean that he/she will be predisposed to the use of new technology. This shows that farmers might be quite resistant to changes in the technologies they use perhaps for fear of risk. Farmers would want to consider the risk involved in changing to a new technology before trying it. This also means that the respondents are rational.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Introduction

This chapter consists of three sections. The first section summarizes the results of research carried out in connection with the use of PKOR as livestock feed ingredient in the Central Region of Ghana. The second section draws conclusions on the use of PKOR as livestock feed ingredient and its effects on production and profitability of farmers. The third section presents recommendations and policy prescriptions proposed based on findings from the study.

Summary

Feed cost has been high in Ghana for some time now affecting livestock and poultry production in the Central Region and in Ghana as a whole; improvement could result from reduced cost of feed. The high cost of feed resources has forced most farmers, especially poultry farmers, to leave the business or to look for other non-conventional feed ingredients that cost less. The use of AIBPs has been suggested by many animal researchers and several studies have proved the suitability and viability of using many of these AIBPs as feed ingredients.

PKOR is one such AIBP that is produced in large quantities in the Central Region. It is suitable for use as livestock feed after it has been dried in the sun for a period of between 5 – 7 days (Odoi *et al*., 2006). Its nutritional properties are good and could be used to feed a cross section of farm animals including ruminants and poultry. However, due to the high crude fibre content, it tends to be more suitable for ruminant livestock.

Thus, the study was conducted to assess the extent of use of PKOR in livestock and poultry production in the Central Region of Ghana. Specifically, it determined the factors affecting the choice of feeds by livestock farmers in the Central Region, identified reasons why farmers incorporated PKOR in the rations of their animals, identified the livestock sub-sectors which utilize PKOR most, and ascertained the level of inclusion of PKOR in livestock rations on farms in the Central Region of Ghana.

The results revealed the following findings:

(a) Majority (83.3%) of commercial farmers in the Central Region of Ghana kept poultry, of which broilers formed a quarter with the remaining being layers.

(b) Most farms are on small-scale being operated by the owners (76.7%).

(c) Almost all the respondents (94.0%) had one form or the other of formal education and could read and write using the English Language.

(d) The main source of information for most farmers was friends/colleague farmers. Information transmitted through this channel formed 59.4%.

(e) The cost price of feed, quality of feed, and ease of processing are the major factors that farmers consider in choosing between feeds and/or feedstuffs.

(f) A quarter (25.0%) of farmers sampled in this study use PKOR as feed ingredient while 28.3% use a close variant of PKOR called PKC.

(g) Poultry farmers perceive that using PKOR reduces feed cost than using the conventional feed ingredients only or buying commercially compounded feeds.

(h) Some farmers who used PKOR in their rations have observed adverse effects such as taint in milk, low feed intake and reduced lay.

(i) The results of the analysis showed that educational background of farmer and type of enterprise were positively related with the use of PKOR with none being significant. Conversely, years of experience of farmer was negatively related to use of PKOR as feed ingredient.

(j) Majority (98.3%) are willing to learn more about the use of PKOR as feed ingredient.

Conclusions

(1) Factors that affect the choice of feed ingredients by livestock farmers in the Central Region are cost price, quality of feed and ease of processing, in order of importance.

(2) Livestock farmers in the Central Region, who use PKOR in rations for their livestock, use it with the aim of reducing cost of production.

(3) Within the livestock sector, the poultry sub-sector utilizes PKOR most in the Central Region.

(4) Livestock farmers in the Central Region use a wide range of levels of PKOR in rations for their livestock. Inclusion levels range from as little 5% to 40% of wheat bran, 50% of fishmeal and supplementary purposes.

Recommendations

Based on the conclusions of the study, the following recommendations were made:

(1) The Animal Production Directorate in collaboration with the CSIR research institutions and universities should publish feed composition tables (including locally available feeds and AIBPs) and distribute to farmers. Feed composition tables serve as a basis for ration formulation.

(2) The Animal Production Directorate (the government agency responsible for animal production in Ghana), concerned and interested non-governmental agencies, research institutes and universities should organize, publish and distribute to farmers frequently, information leaflets containing different examples of PKOR and other feedstuffs in animal feed formulations for the different animal species in the Central Region of Ghana.

(3) The extension agents/agencies should identify and mobilize key farmers to train them on best and effective ways of handling and using PKOR as feed ingredient for different species of farm animals, so that they could in turn train other farmers in their vicinity on using PKOR. This is important since the major source of farmers' information was found to be through other farmers.

(4) Further experiments could be conducted to determine the extent to which PKOR can contribute to the total supply of nutrients for different species of animal in the Central Region of Ghana.

(5) Further studies should be carried out to determine the quantity and time period during which PKOR is available and storage properties of PKOR.

(6) Development of the livestock industry is one of the important tools in the Central Region of Ghana to improve farmers´ incomes. Hence, on-farm applied research should be conducted to evaluate PKOR under practical conditions.

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APPENDIX

Questionnaire Used for Survey

UNIVERSITY OF CAPE COAST

ANIMAL SCIENCE DEPARTMENT OF THE SCHOOL OF AGRICULTURE

POSTGRADUATE RESEARCH QUESTIONNAIRE

TOPIC: Exploratory Study Of The Key Variables Affecting The Utilization Of Palm Kernel Oil Residue (PKOR) As A Major Animal Feed Ingredient In Ghana

Confidential Statement

This survey is purely for academic purposes. Your comments / answers to this survey are confidential and will not be attributed to you or your organization in my thesis or any report.

Introduction

Palm Kernel Oil Residue (PKOR) is the solid residue left behind after the extraction of oil from the kernel of the palm fruits, using the traditional extraction method. Its close variants are Palm kernel cake (PKC) and Palm kernel meal (PKM)

SECTION ONE: Perception and Knowledge of PKOR as Livestock Feed

1. Does your farm use PKOR in feeding its livestock?

   Yes [ ] - Please proceed to Question 2

   No [ ] - Please proceed to Question 18

2. Since when (date of first use) have you been using PKOR in your rations?

   Below 1 year [ ]

   1 - 3 years [ ]

   3 – 5 years [ ]

   5 – 8 years [ ]

   8 – 10 years [ ]

   Other (specify):

3. How much PKOR do you include in your feed / rations?

   5 % [ ]

   10 % [ ]

   15 % [ ]

   20 % [ ]

   Supplement only [ ]

   Other (specify):

4. Where do you obtain your PKOR? (Name and location of source).

5. Do you pay for it?

   Yes [ ]

   No [ ]

6. How much (in Gh¢) do you pay per kilogram of PKOR?

7. In what form do you obtain the PKOR?

Fresh [ ]

Dried [ ]

Semi-dried [ ]

8. Do you further process the PKOR before feeding it to your livestock?

Yes [ ]

No [ ]

9. If yes (to question 8, above) mention all the processes

10. Are there any problems associated with the supply of PKOR?

Yes [ ]

No [ ]

11. Mention them

12. How did you learn of PKOR as a feed ingredient?

Personal Communication [ ]

Workshop / Seminar [ ]

Journal [ ]

Television / Radio Programme [ ]

Other (specify):

13. Please mention the reasons why you include PKOR in your rations

14. Do you have any problems associated with use of PKOR?

Yes [ ]

No [ ]

15. If yes (to question 14, above), provide some details.

16. Do you intend to continue using PKOR in your rations as far as it remains available?

Yes [ ]

No [ ]

17. Would you recommend the use of PKOR as livestock feed to other farmers?

Yes [ ]

No [ ]

18. You answered No on Question 1. Please could you specify the reasons as to why you do no use PKOR in your rations? *(Tick as many that apply to you)*

Have not considered it	[ ]
Don't know much about it	[ ]
Not readily available	[ ]
Would cost too much to transport to farm	[ ]
I don't want to take the risk	[ ]

Other (specify):

19. Do you know of any other uses of PKOR?

Yes [ ]

No [ ]

20. If yes (to question 19, above), mention them.

21. Would your company be interested in taking part in a programme to improve knowledge on the use of PKOR as livestock feed?

Yes [ ]

No [ ]

SECTION TWO: Factors influencing your choice of feeds and feed ingredients

22. What are the major feed ingredients you use in your feeds / rations? (include energy, protein and fibre sources, only).

INGREDIENT	MAJOR NUTRIENT (if known)
………………………….	………………………………
………………………….	………………………………
………………………….	………………………………
………………………….	………………………………
………………………….	………………………………
………………………….	………………………………
………………………….	………………………………
…………………………..	………………………………
…………………………..	………………………………

23. Check all the factors that influence your choice of the ingredients mentioned above.

Price	[ ]
Origin of feedstuff	[ ]
Long-term availability	[ ]
Storage capabilities	[ ]
Quality of nutrients contained in the feedstuff	[ ]
Government regulations	[ ]
Ease of processing	[ ]
Other (specify) ……………………………..	[ ]
…………………………….	[ ]

24. Rank the above-listed factors in order of importance (beginning with the most important). Indicate by writing the appropriate figure in the space provided.

Very important = 1, Important = 2, Not important = 3

Price	[ ]
Origin of feedstuff	[ ]
Long-term availability	[ ]
Storage capabilities	[ ]
Quality of nutrients contained in the feedstuff	[ ]
Government regulations	[ ]
Ease of processing	[ ]
Farmers' preference	[ ]
Other (specify) ……………………………..	[ ]
…………………………….	[ ]

25. Mention any problems associated with the supply of any of the ingredients you usually use in your feeds?

SECTION THREE: Demographic Data

1. Occupation or Rank:
2. Educational / Professional Qualifications:
3. Experience (since when have you been working in your present capacity?):
4. Organisation:
5. Location of Organisation (state the town):