DESIGN FORMULATION OF GOAT FEEDSTOCK FROM PALM KERNEL CAKE (PKC)

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ABSTRACT

The application of palm kernel cake (PKC) as the alternative feed has become crucially important for the livestock industry, yet the usage of PKC as the main protein sources has found the answer to the expensive price of the imported corn and soy meals. Several studies on the capability of PKC to substitute corn and soy meals as the main source of protein for the supplementary feed production has been done and the results obtained are positive. This research is aimed to formulate a supplementary goat feed using PKC and study the effect of the feed to the cost of production. There are three samples that are going to be formulated, as the ingredients for each sample are varies, especially the content of PKC and agricultural waste. The formulated supplementary goat feed is analyzed using Near Infrared Spectrometer (NIR), where the protein, fiber, ash, energy and several nutrient contents can be fully determined. Meanwhile, Atomic Absorption Spectroscopy (AAS) is used to determine the composition of metals inside the feed. The results obtained shows that all samples producing results that are likely within the range of the typical nutrient requirement, according to the standard nutrient requirement for goats. However, sample two is most likely preferable to be commercialized as its use the maximum amount of PKC and agricultural waste, thus, in term of cost analysis, the cost of production for this sample is the lowest and this sample is highly commercialization.

ABSTRAK

Penggunaan *palm kernel cake* (PKC) sebagai alternatif makanan tambahan menjadi semakin penting terutamanya dalam industri ternakan haiwan kerana penggunaan PKC, yang menjadi sumber utama protein boleh memberi jawapan kepada masalah harga import jagung dan soya yang tinggi. Beberapa kajian tentang keupayaan PKC ini sebagai sumber utama protein untuk makanan tambahan haiwan telah dijalankan dan hasil yang didapati adalah positif. Kajian ini dijalankan untuk merumuskan satu makanan tambahan untuk kambing dan mengkaji kesannya terhadap kos pembuatan. Terdapat tiga sampel yang akan dirumuskan, di mana setiap sampel terdiri daripada bahan campuran yang berlainan, terutamanya kandungan PKC dan hampas agrikultur. Makanan tambahan yang telah dirumus akan dianalisis menggunakan *Near Infrared Spectrometer* (NIR) di mana kandungan protein, fiber, debu, tenaga dan nutrisi lain dapat ditentukan sepenuhnya. Sementara itu, *Atomic Absorption Spectroscopy* (AAS) digunakan untuk mengkaji komposisi bahan logam dalam sampel. Keputusan yang didapati menunjukkan kesemua sampel menghasilkan kandungan nutrient dalam julat yang dikehendaki oleh standard. Walaupun begitu, sampel 2 adalah yang paling diterima untuk dikomersialkan, kerana penghasilannya menggunakan PKC dan hampas agrikultur yang maksimum, jadi dari sudut analisa kos, kos pembuatan untuk sampel ini adalah yang paling rendah dan disyorkan untuk tujuan pengindustrian.

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LIST OF SYMBOLS

cal	Calorie
^0C	Degree Celsius
g	Gram
h	Hour
kg	Kilogram
Km^2	Kilometer square
kWh	Kilowatt hour
RM	Malaysian Ringgit
Mcal	Mega Calorie
MJ	Mega Joule
mg	Milligram
mm	Millimeter
ml	Milliliter
ppm	Part per million
%	Percent
rpm	Revolution per minute
t	Tonne

GLOSSARY OF ABBREVIATIONS

CPO	Crude Palm Oil
EFB	Empty Fruit Bunches
EU	European Union
FFB	Fresh Fruit Bunch
IR	Infrared
NaCl	Sodium Chloride
NIR	Near Infrared Spectrometer
PKC	Palm Kernel Cake
PKO	Palm Kernel Oil
PKM	Palm Kernel Meal
POME	Palm Oil Mill Effluent
POS	Palm Oil Sludge
PPF	Palm Press Fiber
TDN	Total Digestible Nutrient
DM	Dry Matter
AAS	Atomic Absorption Spectroscopy
Ca	Calcium
P	Phosphorus
HNO_3	Nitric Acid
H_2O_2	Hydrogen Peroxide
Min	Minute
GE	Gross Energy
EE	Crude Fat
CF	Crude Fiber

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CHAPTER 1

INTRODUCTION

1.1 Background of Study

Since independent 1957, Malaysia has undergone tremendous growth in population and economics. The population in Malaysia in 2006 is over 24 million with a growth rate of 1.8% compare to over 23 million people in 2000. Because of this, economics have been major concern for Malaysia to gain profit. Malaysia has shifting the economics activities from labour intensive industries to energy and capital energy industries, particularly heavy industries. One of the major industries is the agriculture, which in agriculture, Malaysian natural resources that are popular are oil, gas,palm oil and rubber (*Jabatan Perangkaan Malaysia, 2006*).

Malaysia has a land area of 336,745 km^2 spreading over three main areas, namely Peninsular Malaysia (131,587 km^2), and Sabah (73,711 km^2) and Sarawak (123,466 km^2) . About four-fifths of the Malaysian Peninsular is covered by forests and swamps, features which are also common in East Malaysia. The inland belt between the coasts and the forested mountainous interior is the agricultural zone, where large areas of rubber and oil palm plantations are to be found, especially in West Malaysia.

The Malaysian economy expanded by 7.1% in the year 2004 exceeding the forecast of 6.0-6.5%. Agricultural sector, which was included as one of the influencing sector was also expanded. The sustain strong expansion of the agricultural sector was driven by higher production of crude palm oil and rubber, as well as food related crops in line with the government effort to revitalize the sector as an important engine of growth. Of importance, prices of agricultural products were significantly higher in 2004, creating a multiplier effect on the domestic economy since the sector is the larger employer of rural workplace (*MPOA, 2004*).

The expansion of the agricultural sector, especially in the palm oil production was driven by the availability of the crude oil palm in this country. The oil palm is said to be abundance especially in West Malaysia. The planted areas contitute about 63% of the total agricultural land all over the country (*MPOB, 2005*). Moreover, the influential growth of the oil palm is affected by the climate and the location of the country.

Malaysia is entirely equatorial. The ambient temperature remains uniformly high throughout the year, between 27 and 33 ^{0}C, with an average daily solar radiation of 4500kWh per square meter and an average daily sunshine duration of about 12 hours. Most locations have relative humidity of 80 to 88%, rising to nearly 90% in the highland areas and never falling below 60%. With this suitable climate and the availability of oil palm, Malaysia has made the sector of palm oil production as one of the profitable sector in the country. (*Jabatan Perangkaan Malaysia, 2006)*

Palm oil industry has been started early in 1970's and since then, Malaysia has become as one of the exporter and producer of palm oil products in the world. Palm oil milling is a major industry in Malaysia. Malaysia has relied on this industry to gain profit since 1996. The industry, besides producing palm oil, also produces by-products usable as animal feed. These are palm kernel cake, palm oil sludge (POS) and palm pressed fiber (PPF). The most useful is palm kernel cake, which the solid residue is left behind after the extraction of oil from the kernels of the palm fruits.

Malaysia is the world's largest producer and exporter of PKC. In 2005, Malaysia produced about 2.10 million of PKC (*MPOB 2006*). The PKC is now well entrenched as a major feed ingredient in beef and dairy feed in the country. The high protein contains in the PKC can be used to feed sheep and goats with suitable dosage. The protein content of PKC is considered sufficient to meet the requirements of most sheep and goats. (*A R Alimon, 2000*)

1.2 Problem Statement

Rapid urbanization and income growth are making it difficult for many countries to meet consumer demand for animal-food products, let alone satisfy preferences. In livestock production, the major input is animal feed which accounts for 60-70% of operational expenses. Therefore, economizing on feed would lead to economies of production. The potential livestock such as goats need a balance diet in order to produce high quality of livestock to meet the current demand and Malaysia has imported over 2 million tonne per annum of energy feed as corn in the last three years and another 1 million tonne of protein supplement, mainly soya bean and fish meal for livestock feed (*Abu Hassan, O, 1996*). This expensive price of corns and soya beans has creates a very influential market for PKC to be used as an alternative animal feedstock. However, there is also an issue arise for the inconsistency supplies of these imported feeds. It is maybe due to the problems of the transportation and climate changes. Meanwhile, the abundance of oil palm biomass can increase the production of PKC in the country. The oil palm biomass is a waste generated from the milling palm oil, and it is harmful to the environment. However, since 2001, Malaysia has exported too much of PKC to the European countries to gain profit *(MPOB 2000)*. Thus, utilization of PKC is very feasible as it has offering both dietary benefits to animals and substantial cost savings to farmers. The excellence source of energy and high protein as well as its availability makes the PKC a very reliable animal feeding stuff to fattening goats.

1.3 Research Objectives

The main concentration of this research is to estimate the potential of palm kernel cake (PKC) used as feed in feeding goats in Malaysia, therefore, the objectives of this research are:

i. To determine the percentage of protein and other nutrients inside PKC
ii. To analyze the percentage of calcium, phosphorus and fiber inside PKC
iii. To formulate a goat feedstuff by adding PKC as the main protein sources instead of soy meal and corn meal.
iv. To study the effect of using local PKC and other raw materials to the cost of production of supplementary feed.
v. To analyze the new formulated product and how close its follows the standard feed quality.

1.4 Scopes of Study

The scopes of this research are:

i. Analyze the nutrients inside PKC
ii. Preparation of the feed
iii. Analyze the feed
iv. Cost analysis of the products
v. Identification of the process equipments involved in the production of the feed.

1.5 Significance of the Study

This research is constructed in order to formulate a goat feed using available local PKC as the main source of protein. This feed is then to be compared by the standard nutrient composition needed by goats, where the conventional one uses imported raw materials as the protein sources. As a result, a healthy fat goat can be observed. The expensive price of the conventional animal feedstock such as corn and soya bean has creates a very influential market for the PKC. PKC has a strong chemical and nutrient profile. It is high in the phosphorus to calcium ratio, as well as level of magnesium, iodine, zinc, essential amino acids; fiber (useful for goats) and fat (for energy). PKC boosts energy when fed to goats. A feed concentrate with 60% of PKC has been found to increase milk production of the goats by 55%. Moreover, the availability of oil palm in this country makes the production of PKC relevant. In addition, it is low cost in production, whereby most of the raw materials added to produce the feed can be found locally. In these ways, PKC represents a viable choice as an alternative feed for goats.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Palm kernel cake (PKC) (Figure 2.1) is a by-product produced from the milling of palm oil. It is a solid residue that is left behind after the extraction of oil from the kernel of the palm fruit. PKC is known as an alternative animal feedstuff after corn and soya bean. It contains high nutritive value, including protein, minerals and energy. The high nutrients content inside it has made it well entrenched as a major feed ingredient in beef and dairy feed in the country. PKC always comes in the form of pellet (figure 2.2) when it is needed to feed animals.

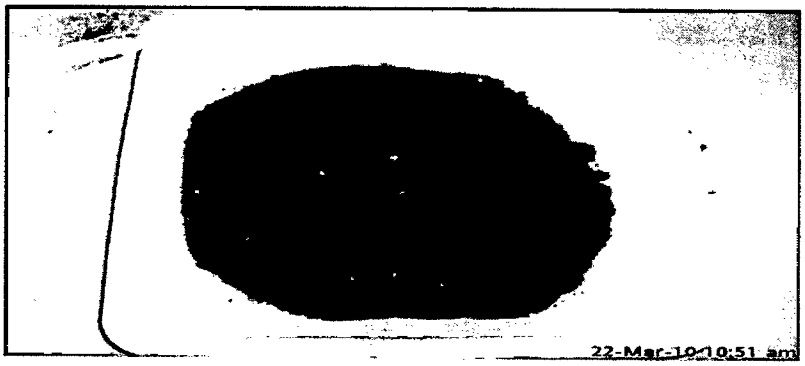

Figure 2.1: Palm kernel cake (PKC)

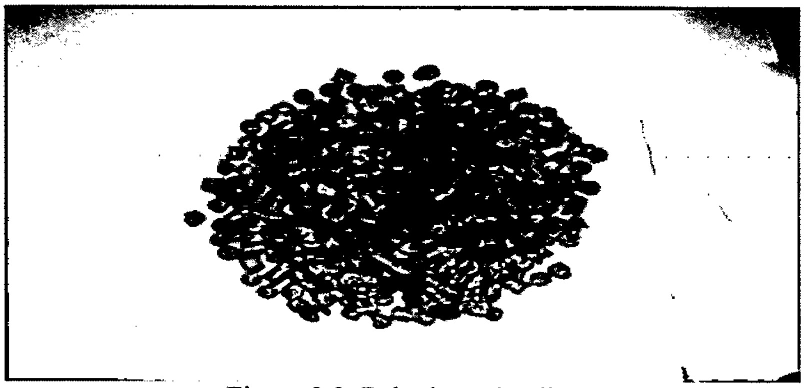

Figure 2.2: Palm kernel pellet

2.2 Background of Palm Oil Sector in Malaysia

Since the 1970's, Malaysia has been active in producing and exporting palm oil products and up until now, Malaysia has known as one of the largest producer and exporter of the palm oil products in the world. In the year 2000, Malaysia produced 10.84 million tonnes of palm oil which accounted for 49.9% of the world palm oil production or about 9.4% of world total production of oil and its products. Malaysia exported 9.08 million tonnes of palm oil during the year 2000. Malaysia is also the largest producer and exporter of palm kernel products, especially palm kernel oil and palm kernel cake (PKC). PKC is the by-product from milling palm kernel oil and usually being used as animal feeding stuff. In the year 2000, Malaysia produced 1.38 million tonnes of palm kernel oil and 1.64 million tonnes of PKC. Of these, only 0.52 million tonnes of palm kernel oil and 1.35 million of PKC have been exported. Since 1996, Malaysia has been producing more than 1.3 million tonnes of PKC annually (table 1) (*Hishamuddin .M.A 1999*).

Table 2.1: Malaysia annual production of palm kernel and PKC (tonnes)

TABLE 1. MALAYSIA: ANNUAL PRODUCTION OF PALM KERNEL AND PKC (t)

Year	Palm kernel	PKC
1975	232 821	n.a
1980	557 066	278 559
1985	1 211 887	633 316
1990	1 844 737	1 038 221
1995	2 395 588	1 293 144
1996	2 488 750	1 383 034
1997	2 636 000	1 435 104
1998	2 429 468	1 345 277
1999	3 025 690	1 624 134
2000	3 162 760	1 639 227
2001*	1 366 360	729 197

Notes: n.a - not available.

Sources: Malaysian Department of Statistics (1985); PORLA (1999).MPOB (2000).

2.3 Production of PKC in Malaysia

The palm kernels are crushed to yield palm kernel oil and PKC. Normally, the percentage of yielded PKC is 50%. Since 1996, Malaysia has produced more than 1.3 million tonnes of PKC annually (table 1). Most of the PKC produced are exported to other countries, especially in Europe for the ingredient animal feed formulations. The European Union (EU) absorbs more than 85% Malaysian PKC annually and the Netherlands is the biggest importer of Malaysian PKC among the EU countries (table 2). Asian countries are also imported Malaysian PKC and they are South Korea and Japan. In 2000, approximately, about 1.1 million tonnes or 90% of Malaysia PKC exports to EU were taken by the Netherlands (table 3).

Table 2.2: Malaysian export of PKC (tonnes)

TABLE 2. MALAYSIAN EXPORT OF PKC (t)

	1997	1998	1999	2000	2001*
EU	998 749	965 070	1 062 986	1 214 698	615 404
Japan	7 004	7 363	13 732	13 113	3 398
South Korea	81 979	179 909	123 434	106 730	100 090
Singapore	-	-	0	6 715	0
Other countries	-	-	6 017	8 676	25 863
Total	1 087 732	1 152 342	1 206 169	1 349 932	744 839

Note: *January - May.
Sources: PORLA (1999); MPOB (2000).

Table 2.3: Malaysian export of PKC to EU countries (tonnes)

TABLE 3. MALAYSIAN EXPORT OF PKC TO EU COUNTRIES (t)

	1997	1998	1999	2000	2001*
Belgium	0	0	0	3 304	0
Germany	29 762	44 910	28 610	104 083	33 542
Ireland	16 795	0	0	0	0
Italy	0	4 199	0	0	5 000
Netherlands	863 986	895 714	1 034 376	1 097 933	535 728
Portugal	0	5 882	0	0	0
Spain	0	0	0	9 377	35 128
U. Kingdom	88 207	14 365	0	0	6 005
Total	998 749	965 070	1 062 986	1 214 698	615 404

Note: *January - May.
Sources: PORLA (1999); MPOB (2000).

2.4 Palm Kernel Cake (PKC) Extraction

Palm kernel cake (PKC) is obtained out from two stages of oil extraction from the palm oil fruit. The first stage is the primary extraction of the palm oil from the pericap (figure 2.1) portion of the fruit, which also produces the kernel and by-products palm oil sludge (POS) and palm press fiber (PPF). The extraction of oil from crushed kernel is then results in the production of PKC as the by-product. Two methods are used for the extraction of oil from the crushed kernel. These are the conventional mechanical screw press method that results in the expeller pressed palm kernel cake and the solvent (usually hexane) extraction method that results in the solvent extracted type (*F.Y.Chin, 1991*).

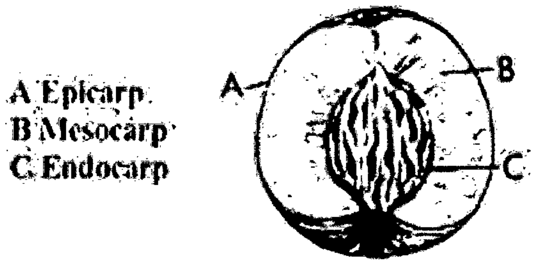

Figure 2.3: Pericap portion of fruit oil palm

Generally in Malaysia, mechanical extraction by screw press is widely used (figure 2.5). The solvent extraction method is not used currently due to its higher costs.

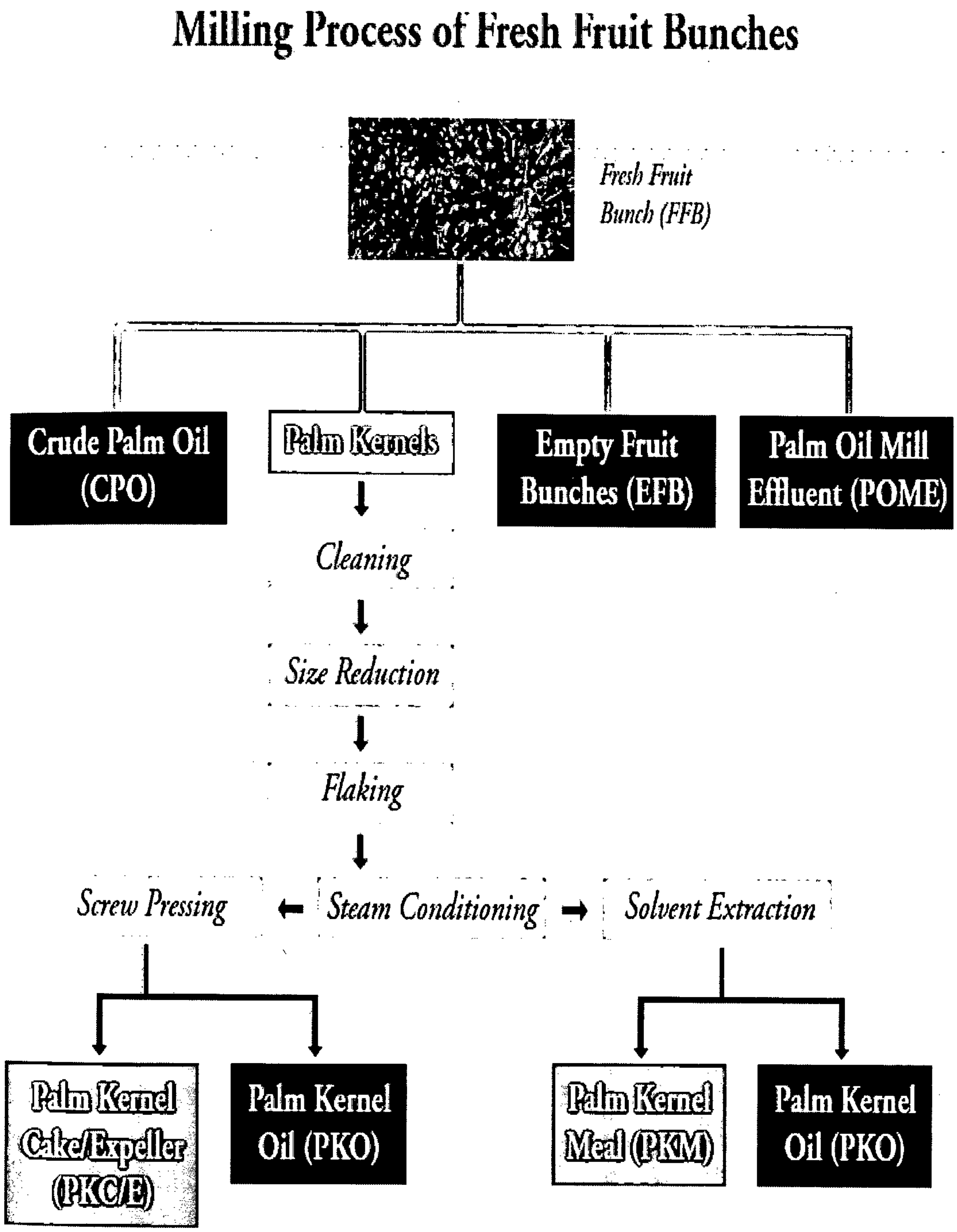

Figure 2.4: Extractions of palm kernel oil

2.4.1 Mechanical Extraction

Mechanical extraction processes are suitable for both small and large capacity operations. The three basic steps of these processes are (a) kernel pre treatment, (b) screw pressing and (c) oil clarification (figure 2.5).

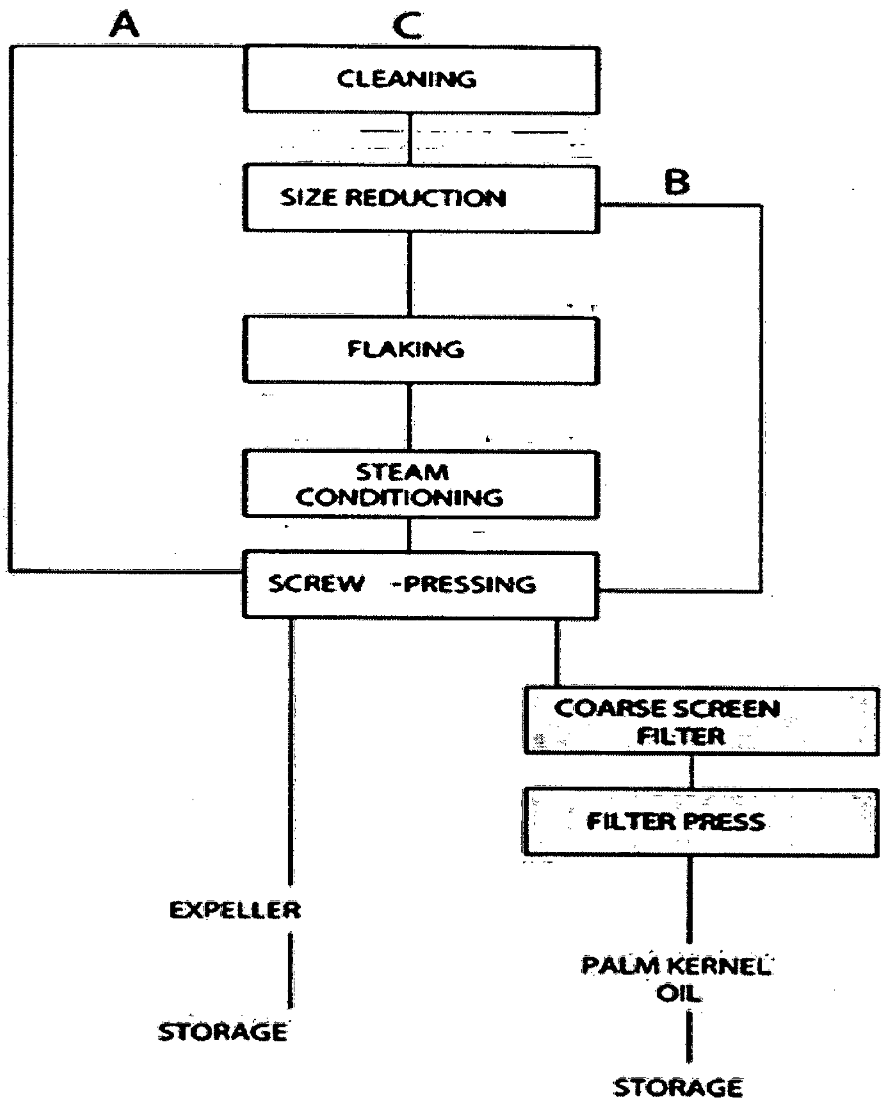

Figure 2.5: Mechanical extraction of palm kernel oil

Line (A) is for direct screw-pressing without kernel pre-treatment; Line (B) is for partial kernel pre-treatment followed by screw-pressing; and Line C is for complete pre-treatment followed by screw-pressing.

2.4.1.1 Kernel Pre-Treatment

Proper kernel pre-treatment is necessary to efficiently extract the oil from the kernels. The feed kernels must first be cleaned of foreign materials that may cause damage to the screw-presses, increasing maintenance costs and down time, and contamination of products. Magnetic separators commonly are installed to remove metal debris, while vibrating screens are used to sieve sand, stones or other undesirable materials.

A swinging hammer grinder, breaker rolls or a combination of both then breaks the kernels into small fragments. This process increases the surface area of the kernels, thus facilitating flaking. The kernel fragments subsequently are subjected to flaking in a roller mill. A large roller mill can consist of up to five rollers mounted vertically above one another, each revolving at 200-300 rpm. The thickness of kernel cakes is progressively reduced as it travels from the top roller to the bottom. This progressive rolling initiates rupturing of cell walls. The flakes that leave the bottom nip are from 0.25 to 0.4 mm thick. The kernel flakes are then conveyed to a stack cooker for steam conditioning, the purpose of which is to:

- Adjust the moisture content of the meal to an optimum level
- rupture cell walls (initiated by rolling);
- reduce viscosity of oil;
- coagulate the protein in the meal to facilitate separation of the oil from protein materials