UNIVERSITY OF EDUCATION, WINNEBA

COLLEGE OF TECHNOLOGY EDUCATION, KUMASI

AN ASSESSMENT OF TECHNOLOGIES USED IN THE SMALL SCALE PALM OIL PROCESSING INDUSTRY IN THE TANO NORTH AND SOUTH DISTRICTS OF THE BRONG AHAFO REGION OF GHANA

BY

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AUGUST, 2013

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DEPARTMENT OF MECHANICAL TECHNOLOGY

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AUGUST, 2013

DECLARATION

STUDENT'S DECLARATION

I, Alex Ampofo, declare that this Dissertation, with the exception of quotations and references contained in published works which have all been identified and duly, acknowledged, is entirely my own original work, and it has not been submitted, either in part or whole, for another degree elsewhere.

SIGNATURE: .....

DATE: .....

SUPERVISOR'S DECLARATION

I hereby declare that the preparation and presentation of this work was supervised in accordance with the guidelines for supervision of Dissertation as laid down by the University of Education, Winneba.

NAME OF SUPERVISOR: Prof. N. Kyei-Baffour

SIGNATURE: .....

DATE: .....

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DEDICATION

This work is dedicated to my beloved wife, Mrs. Rosemary Ampofo, who has been with me through thick and thin.

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ABSTRACT

This study assessed the technologies used in small scale palm oil processing industries in the Tano North and South Districts of the Brong Ahafo Region of Ghana. Questionnaire survey, focus group discussions and non-participant observations were used to collect data on the practices used by the processors and the types of equipment used. Processors in the two districts were found to have adopted the semi-mechanized technology aside the traditional processing technology. Four types of equipment were identified namely; mortar and pestle, digester with separate hand operated screw press, the flushing extractor and the digester with separate hand operated hydraulic press. The mortar and pestle was perceived to be the easiest to use and maintain as well as the most appropriate. On the other hand it was agreed to be the least effective and profitable among the four types of equipment. The digester with separate hand operated hydraulic press was agreed to be the most effective and profitable equipment but the most difficult to use and maintain. This implies that if processors who use the digester with separate hand operated hydraulic press are well trained in the use and maintenance of the equipment, a lot of benefits will be derived.

CHAPTER ONE

INTRODUCTION

This chapter gives introductory paragraphs that lead the reader to the selected topic, the problem area and the justification for choosing to research the problem area.

1.1 Background to the Study

Agriculture has been identified as one of the pillars of Ghana's economy. It is the third (22%) major component of Ghana's Gross Domestic Product (GDP) and supports about 50% of its workforce. Among the cultivated products in Ghana are the oil seed crops which are made up of groundnut, soya bean, coconut and oil palm (Business News, 2014). Oil palm due to its enormous benefits as stated by Asubonteng (2011) was selected by the government of Ghana in 2002 as one of the strategic pillars of agriculture and industrial growth. The demand for palm oil is growing due to its wide range of usage for various products and also as the most competitively priced vegetable oil accounting for more than half of the global import and export trade of all vegetable oils (Ministry of Food and Agriculture [MOFA], 2011).

Two kinds of oils which are of domestic and industrial importance (palm oil and palm kennel oil) are currently the major products processed from oil palm in Ghana. According to Cudjoe (2001), one area that serves as an important source of income for a large number of Ghanaians which are mostly women is the oil processing sector and more especially the small scale palm oil processing industry. Ghana had a total of 336000 hectares of oil palm and produced an estimated quantity of over 400000 metric tonnes of palm oil annually and more than 80% of the cultivated and processed oil palm is on small scale basis (MOFA, 2011).

Oil palm has been found to grow well in the forest belts of the rural communities of Ghana and currently, six out of the ten regions of Ghana namely; Ashanti, Brong Ahafo, Western, Eastern, Volta, and Central Regions have been identified as possessing lucrative and conducive environment for supporting the growth of oil palm (Kyei-Boateng, 2012).

Osei-Amponsah and Swanzy (2011) observed that the oil palm processing industry is made up of large, medium and small scale processors who use mechanized or traditional methods to produce palm oil from oil fruits. Orewa *et al* (2009) indicated that the major challenges in the palm produce industry are the low oil extraction rate and the high free fatty acids (FFA) content in the palm oil from small scale traditional processing methods and techniques. In an attempt to address the constraints, various improved and appropriate technologies have been developed and replicated for small scale palm oil processing in Ghana by institutions such as the Department of Agricultural Engineering (KNUST), Technology Consultancy Centre (TCC), GRATIS Foundation, Council for Scientific and Industrial Research (CSIR), SIS Engineering Limited and the Rural Technology facilities.

The technologies are selected based on their potential impact in overcoming excessive postharvest and processing losses, high labour input and poor product quality. The technologies also create opportunities to increase income of processors and free some of their time for other productive activities. Oil palm processing has been an indigenous practice among the communities of Tano North and South Districts of the Brong Ahafo Region of Ghana from time immemorial. However, the effectiveness, appropriateness and profitability of the technologies used have not been assessed especially at a period where oil palm has been identified as a commodity possessing enormous benefits for both

the local and international markets. This study therefore seeks to assess the existing methods and technologies applied on the small scale oil palm processing industry.

1.2 Statement of the Problem

One of the sources of food insecurity in Africa is postharvest crop losses. It has been estimated that at least 10% of the continents crop productivity is lost on and off farm. This is mainly because most subsistence farming communities do not have access to improved and appropriate technologies (African Ministerial Council on Science and Technology, 2003). Cudjoe (2001) observed that agro-processing is essential to the development of a nation's agricultural sector because they are primarily methods of transforming raw materials into finished products for consumption which goes a long way to avert food insecurity.

According to the European Food Information Council (2014), processed foods offer the following benefits:

- Extend the shelf – life of food and serve as the surge capacity in nature's seasonal cycles
- Increase the acceptability (flavour, colour, texture) and safety of food
- Provide nutritious foods enhancing good health, strengthening bodies and empowering minds

Palm oil is the most important single source of edible oil for most West Africans. It can be used for industrial purposes such as the manufacture of margarine, compound cooking

fats and soaps (Adjei- Nsiah *et al.* 2012). Baryeh (1990, 1992) has also shown that palm oil can be used as fuel blend for internal combustion engines.

A personal interview with Ofoase (December 6, 2012), an agricultural extension officer in the Tano South District revealed that, there was a massive oil palm cultivation of about 2,400 hectares from 2003-2010 under the Presidential Special Initiative (PSI) on oil palm in the Tano North and South Districts. According to him, most of the oil palm plantations have started bearing fruits and need to be processed to avert postharvest losses and also derive the full economic benefits of the commodity.

Currently, various oil palm processing technologies exist in the Tano North and South Districts of Ghana, but not much is encountered in local literature regarding the status of the technologies that are practiced by the oil palm processors and their effectiveness and economic benefits. It is against this background that this study is being conducted to assess the effectiveness of the technologies used by oil palm processors and also attempt to fill the identified literature gap.

1.3 Objectives of the Study

The main purpose of the study was to assess the technologies used in the small scale palm oil processing industries in the Tano North and South Districts of Ghana.

Specifically, the study sought to:

i. Examine the current technologies and processing practices of the small scale palm oil processors.

ii. Compare the technologies in terms of ease of use, ease of maintenance, effectiveness, appropriateness, durability, and their profitability.

iii. Identify the constraints of the acquisition and use of improved technologies.

1.4 Research Questions

The research questions that guided the study were as follows:

i. What are the current practices and technologies used in the small scale palm oil processing industry?

ii. How do the technologies in use differ in terms of ease of use, ease of maintenance, effectiveness, appropriateness, durability and profitability?

iii. What constraints exist in the acquisition and use of the various technologies?

1.5 Significance of the Study

Research work in oil palm would not be complete without looking into processing which adds value to the commodity. Processing demands various improved technologies to help reap the full benefits of the commodity. This study was intended to reveal the level of technologies currently used for the processing of palm oil. It is envisaged that the comparison of the existing technologies provide helpful information to prospective entrepreneurs, governmental and non-governmental organizations to make informed decisions on the choice of technology to invest in the oil palm processing industry. Again

engineers would use the results as the basis for further improvement in the design of oil palm processing equipment.

1.6 Limitations of the Study

Financial constraints and limited time at the disposal of the researcher rendered the resulting sample unrepresentative. Lack of co-operation from some of the respondents affected the total number of respondents interviewed and those issued with questionnaires. The quality of their responses also left much to be desired.

1.7 Delimitation

For a more complete assessment of technologies in palm oil processing, data from all stakeholders such as engineers, fabrication technicians, agricultural officers and processors should be gathered. On the other hand, this study was restricted to the processors, especially, the operators of the equipment used for processing due to limited finance and time constraints.

1.8 Definition of Terms

The terminologies used in the study have been defined to suit the context in which they were applied.

- **Traditional Technology**

  It is the typical indigenous methods and practices that are employed in palm oil processing.

- **Semi –Mechanized Technology**

  This describes the use of improved power operated machines at certain stages of the palm oil processing.

- **Fully-Mechanized Technology**

  It explains the use of power operated machines in almost all the stages of the palm oil processing.

- **Maintenance**

  It describes the ease with which spare parts can be obtained, the availability of local repairers and the cost of repairs.

- **Durability**

  This gives a description of whether parts of the machine have been replaced as a result of failure. It also describes the frequency of breakage, rust as well as wear and tear of components of machines or complete breakdown.

- **Effectiveness**

  It explains the ability of the machines to achieve maximum output with reduced labour and spillage.

- **Appropriateness**

  This is the suitability, convenience and conformity of the technology to social conventions such as consumer acceptance of final product.

- **Spillage**

  This refers to the quantity of palm oil that drops out of processing equipment and becomes waste.

- **Spoilage**

  The quantity of palm oil that go bad during and after processing and thereby become unusable.

CHAPTER TWO

LITERATURE REVIEW

This section deals with the result of other studies that are closely related to the topic under study. It provides a framework for establishing the importance of the study. Again it serves as a benchmark for comparing the results of the study with other findings and provides justification for methods used in the collection and analysis of data collected.

2.1 Oil Palm Cultivation

The oil palm tree *(Elaeis guineensis Jacq.)* is generally accepted to have originated from the tropical rain forest region of West Africa (Poku, 2002). Food and Agricultural Organization [FAO] (2004) reported that Oil palm is produced in 42 countries worldwide on about 10,800,000 ha. The notable top 10 countries that produce oil palm are Malaysia, Indonesia, Nigeria, Thailand, Colombia, Cote d'Ivoire, Ecuador, Cameroon, Congo and Ghana.

According to MoFA (2011), Ghana had its first international commercial trade in oil palm in 1820. It started from wild palm harvesting and developed into an agricultural crop and plantations in 1850. The total area under oil palm in Ghana more than doubled from 142,000 ha in 1960 to about 336,000 ha by 2010.The President's Special Initiative (PSI) added about 20,000 ha to the national stock between 2004 and 2010. Of the 336,000ha under oil palm in Ghana, Eastern Region accounts for the highest area of 32%, followed closely by Western Region with 28%, Central Region with 16% and the rest are

the Brong Ahafo and Ashanti Regions with 10% each and the least development with 4% is found in the mid Volta Region (MASDAR, 2011).

Oil palm is a monoecious crop as it bears both male and female flowers on the same tree. Each tree produces compact bunches weighing between 10-25kg with 1000 to 3000 fruitlets per bunch. Each fruitlet is almost spherical or elongated in shape. Generally the fruitlet is dark purple, almost black and the colour turns orange red when ripe. Each fruitlet consists of hard kernel (seed) enclosed in a shell (endocarp) which is surrounded by a fleshly mesocarp.

Palm tree may grow up to 18.3m and more in height. The trunks of young and mature trees are wrapped in fronds which give them a rather rough appearance. The older trees have smoother trunks apart from the scars left by the fronds which have withered and fallen off. Oil palm tree will start bearing fruits after 30 months of field planting and will continue to be productive for the next 20 to 30 years, thus ensuring a consistent supply of oils. Each ripe bunch is commonly known as fresh fruit bunch (FFB) (Malaysian Palm Oil Council [MPOC], 2012). Poku (2002) indicated that, the wild oil palm grooves of West Africa consist mainly of a thick – shelled variety with a thin mesocarp, called dura. A breeding work of a crossing of dura and a shell-less variety (Pisifera), has resulted in a hybrid with a much thicker mesocarp and a thinner shell called Tenera.

A recent research work (MASDAR, 2011) revealed that, about 93% of oil palm cultivators in Ghana have preference for the tenera variety. This is mainly due to the fact that the tenera palm fruits yields more when processed. It again showed that, oil palm cultivation is a major occupation for five regions of Ghana, specifically, Brong Ahafo,

Eastern, Western, Ashanti, and Central Regions because it serves as an alternate source of income. Over 636,000 households are believed to be engaged in oil palm cultivation and more importantly in the rural communities of Ghana which has great economic impact (Osei-Amponsah and Swanzy, 2011).

2.2 Characteristics of Small-Scale Palm Oil Processors

Research studies on palm oil processing in West Africa have revealed that palm oil processing is widely associated with women but with the emergence of the improved technologies, there has been a shift to a few men who are able to operate this equipment. This makes the jobs of most of the women threatened. To enable the women stay in business, various recommendations have been made to design equipment that will be women friendly (Wiemer & Altes, 1989, p.37). Taiwo *et al*. (2000) also reported that, females dominate in palm oil processing while their male counterparts only offer assistance by operating machines and take up strenuous tasks. It was further mentioned that none of the machine operators that were interviewed have had any formal training in machine operation and maintenance and the need to organize training programmes for them is important. Adjei-Nsiah *et al.* (2012) in their study also found men to be predominant owners and operators of most improved small-scale palm fruit processing mills.

2.3 Uses of Palm Oil

Inyan (cited in Adjei-Nsiah *et al*, 2012) found palm oil as an important domestic and industrial commodity used in the food and cosmetic industry worldwide. Its consumption is also said to have increased in recent years worldwide especially in Europe, China and India partly because of the expansion of the bio-fuel industry and the need for cheaper sources of oleo chemicals. Palm oil has also been identified to be a source of raw material for several industries which lie within the scope of domestic manufacturing including soaps and detergents, bakery and confectionary fats and margarine and therefore replete with linkage effects (Oladipo, 2008).

FAO (2004) explaining palm oil's contribution to diet stated that 90% of the palm oil produced finds its way into food products, with industrial uses accounting for the remaining. It is found to be a replacement for cocoa butter fats, and in ice cream and mayonnaise. Kyei-Baffour and Manu (2011) have also stated that palm oil is a rich source of vitamins A, D and E which are indispensable in the pharmaceutical industry.

Osei-Amponsah and Swanzy (2011) illustrated the oil palm value chain as shown in Figure 1 which includes the uses of palm oil.

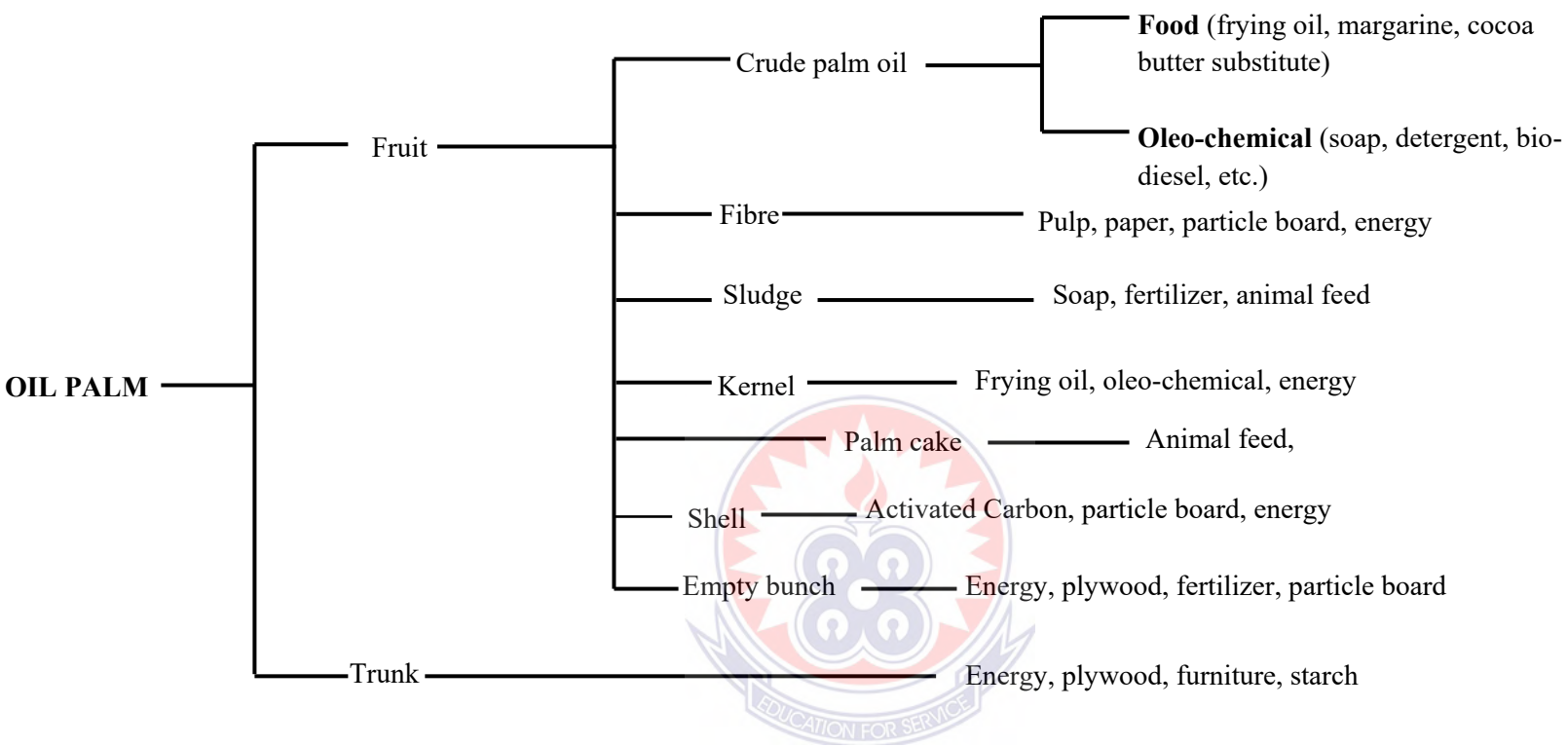


Figure 1: The oil palm value chain

2.4 Palm Oil Processing Activities

Adjei-Nsiah *et al*. (2012) reported that the major operating activities that goes on at the palm oil processing mills include removal of spikelet from the bunch, storage of the fruits containing spikelets, fruit removal from spikelets (threshing) and storage, boiling, digestion of fruits, pressing and clarification of the oil. The purposes of these activities are explained as:

- Cutting of fruit containing spikelets from the fresh fruit bunch is to aid loosening of fruits
- Storage of fruit containing spikelets is also done to facilitate loosening of the fruits
- Loosening and storage of fruits reduce effluent during processing
- Boiling or sterilization of fruits is to inactivate fruit enzymes
- Digestion of fruits breaks cooked fruits for easy oil separation
- Pressing of oil from digested fruits is to separate the oil from the mash
- Clarification of oil separates oil from water and other materials.

The two major processing methods of palm oil that is practiced by small – scale processors are the traditional and the mechanized processing methods. Traditional small-scale method of processing palm oil is of two types: 'the soft oil processes and the 'hard oil processes.

With the soft oil process, the palm fruits are boiled in water and then pounded to disintegrate the pulp. The mass is then mashed in water; the fibre is separated from the liquid by hand squeezing and sieving. The liquid content is boiled till it is cooked. As the

oil settles on top of the liquid, it is skimmed off and heated to dry. With this process, only small amounts of free fatty acids are produced.

The hard process on the other hand, is done by softening the palm fruits by fermentation on wooden troughs. Fermentation is achieved by moistening and pounding the palm fruits for several days. Oil mixed with water and vegetable tissues drain out and is collected and boiled with water and the oil skimmed off. This method produces considerable amount of free fatty acids which gives the oil a special taste and flavor to the liking of many consumers (Bot *et al.,* 2011).

According to Weimer and Altes (1989), traditional method of processing palm oil is characterized by women searching for fruits that have dropped out of bunches from the palm trees or buy loose fruits at the market. In this case women do not climb palms and can only obtain bunches of fruit from what have been cut by men. Bunches are then stripped to obtain the fruit. The fruit is stored for fermentation in a heap for a period of 3-4 days before processing into palm oil.

Poku (2002) has found that, in the mechanized method of processing palm oil, the various stages of the processing are supported by equipment which renders the processing less of a drudgery and less strenuous. Depending on the affordability of the processor, a complete range of machines covering bunch stripping, fruit sterilization, digestion, pressing, clarification, oil drying and storage have been developed for the small – scale processing of palm oil.

2.5 Technologies Used for Small – Scale Palm Oil Processing

In his categorization of the processing of palm oil, Poku (2002) described four methods that processors employ in their processing activities. The methods are termed as the traditional methods, small-scale mechanical units, medium-scale mills and large industrial mills.

The processing units that handle up to 2 tonnes of fresh fruit bunches (FFB) per hour are considered to be small-scale. Installations that are able to process between 3- 8 tonnes FFB per hour are termed medium-scale, while large-scale refers to mills that process more than 10 tonnes per hour. All these methods are associated with some kind of technologies. For the sake of this thesis, technologies practiced in the traditional and the small scale mechanical units were considered.

2.5.1 Traditional technologies

Processing of palm oil by traditional methods has been in existence since the discovery of oil palm. In their study, Wiemer and Altes (1989) identified the traditional palm oil processing with the use of simple available household utensils such as motar and pestle, crushing stones, calabashes and cooking pots. In their explanation, Wiemer and Altes (1989) continued that, palm fruits containing spikelets are cut from the fresh fruit bunch by the use of axe or machette. The fruits are then stored for a period ranging from 3-5 days to facilitate easy loosening or removal of fruits from the spikelets by hand.

The fruits are cooked in a pot and pounded using wooden pestle and mortar or sometimes trampled by feet in a pit. After crushing by pounding or trampling, the mass of the fruit or

pulp are allowed to settle to the bottom. The fibres are then thoroughly washed with water and finally squeezed out by hand to remove oil and oil containing cell material. In some areas, processors collect just the floating cream whereas others make use of the remains after removal of the nuts. The palm oil that settles at the top of the cooked mass is skimmed off and finally purified and dried by heating in a separate pot.

According to WACAPOL (2011), traditional local artisanal methods of processing palm oil that employ indigenous technologies are highly inefficient, labour intensive and produce negligible quantities, low quality and unstable palm oil with a limited shelf life. Cudjoe (2001) also supports the demerits associated with the traditional palm oil processing technologies but argued that some processors found it to be more affordable to acquire and maintain.

2.5.2 Improved technologies

Vissoh *et al* and MASDAR (as cited by Zu *et al*., 2012, p.1) reported that crude palm oil produced in Ghana by the small-scale processors is of poor quality in terms of high FFA, high moisture content and impurities which is as a result of the use of low processing technologies. Orewa *et al.* (2009) has also reported that the national annual estimate of palm oil losses due to inefficient processing techniques in Nigeria was rated at 42% of total production. However, a research work conducted by the West African Institute for Oil Palm Research (WAIFOR) in the early 1960's led to improved efficiency of the small-scale palm fruit processing methods resulting in up-grading the efficiency from 45-60% to about 80 - 85%. This achievement according to Orewa *et al*. (2009) was as a result of the replacement of the traditional curb press with the modified Dutch hydraulic

hand press, the replacement of the manual method of knocking out fruit from bunches using mallet with the hexagonal thresher with wooden slates and the fabrication of clarification drums to replace the plain open drums used in the traditional processing.

The pursuit to minimize the drawbacks in the traditional technologies of palm oil processing has led to the design and manufacture of equipment of various levels of sophistication and capacities by both local and foreign fabrication companies. An attempt has been made to mechanize all the processing stages of the small - scale palm oil industry. The Small Scale Processing Equipment (SSPE) bridges the gap between the local artisanal and industrial scale technology. Some of the recognized local designers and manufacturers of palm oil processing equipment are Technology Consultancy Centre (TCC) and the Department of Agricultural Engineering both of the Kwame Nkrumah University of Science and Technology, GRATIS Foundation, Institute of Industrial Research (IIR) of Council for Scientific and Industrial Research (CSIR), SIS Engineering Limited, Agricultural Engineering Limited and the Rural Technology Facilities.

Stages of the small-scale palm oil processing of which various forms of improved equipment have been produced include:

- Removal of spikelets from bunches
- Sterilization of palm fruits
- Digestion
- Pressing and
- Clarification of the oil.

2.5.3 Threshing (removing of spikelets from bunches)

The use of axe and machete for this operation usually results in fruit bruises which lead to higher FFA of the oil. To minimize this situation, a mechanical thresher or stripper is recommended (Kyei-Baffour & Manu, 2011, p.14). The mechanical thresher or stripper as described by (Poku, 2002) has a mechanized system with rotating drum or fixed drum equipped with rotary beater bars that detach the fruits from the bunch leaving the spikelets on the stem. Poku (2002) further explained that since most processors lack the capacity to generate steam for the sterilization of a whole bunch, the threshed fruits are cooked in water. Whole bunches which include spikelets absorb a lot of water in the cooking process therefore high pressure steam is more effective for the heating of bunches. Most small- scale processors therefore thresh bunches before cooking the fruits, while, others steam the bunch before threshing. Small-scale processors are found to use the empty bunches as cooking fuel and the larger mills incinerate the bunch and use the ashes fertilizer for their plantations.

2.5.4 Sterilization of the bunches

According to Kyei-Baffour and Manu (2011) sterilization is a very vital part and the first of the palm oil production process since inadequate sterilization can affect subsequent processing activities. Sterilization as described by Poku (2002) is the use of high-temperature wet-steam to cook palm fruit. Sterilization serves several purposes which have been outlined as:

1. Sterilization destroys oil splitting enzymes and deactivates hydrolysis and autoxidation

2. Where bunches are cooked whole the wet steam weakens the fruit stem for easy removal of fruits from bunches
3. Conditioning of nuts and
4. Coagulation of proteins.

Adjei-Nsiah *et al*. (2012) identified the use of metal drums over an open fire as a means of boiling palm fruits among most small-scale processors. This method happens to waste most of the heat generated and the processors are exposed to intense heat.

Kyei-Baffour and Manu (2011) recommend the use of an improved oven with chimney which conserves a lot of heat which is also user friendly. An improved sterilizer with tight cover is again recommended for efficient sterilization. The sterilizer as described is a tank with one- third of the volume separated with a metal mesh from the bottom. Clean water filled to the one third part and the rest covered by the palm fruits.

According to Adjei-Nsiah *et al.* (2012) this steam boiler or sterilizer which uses less firewood and water has been designed recently by the GRATIS foundation but it is not widely patronized by processors due to its high cost.

2.5.5 Digestion of fruits

Digestion of boiled or sterilized palm fruits involves the process of crushing and detachment of the heat weakened mesocarp from the fruit nuts. This operation in an improved set up which uses a digester which consists of a cylindrical vessel fitted with a central rotating shaft with beater arms which pounds the fruits (Poku, 2002). Digesters

are said to work more effectively when it is optimally filled to ensure a well beaten pulp for maximum palm oil extraction. It is also recommended to digest palm fruits hot (above 70℃) to optimize oil extraction (Kyei-Baffour & Manu, 2011, p.19).

2.5.6 Pressing of pulp (extraction of the palm oil)

Pressing is the process of squeezing oil out of the digested pulp. This process as categorized by Poku (2002) is of two distinct methods. The 'dry' method makes use of mechanical presses whiles the 'wet' method uses hot water to leach out the oil.

The mechanical presses come with several designs but works with the same principle of operation. Adjei-Nsiah et al. (2012) found the use of hand operated screw press, hand-operated hydraulic press and a digester screw press to be the widely used mechanical presses by small-scale palm oil processors. Poku (2002) maintains that in screw and hydraulic systems the plunger can be moved by motor which is quite faster but more expensive.

The single spindle screw press consists of a heavy metal perforated cage and a screw threaded plunger. The screw threads are made from hard steel and held by softer steel nuts so that the nuts wear out faster than the screw since it is easier and cheaper to replace the nut. The perforated cage is loaded with the macerated palm fruits. It is then placed on a metal platform under the screw plunger and then pressure applied to the pulp by lowering the plunger by means of the screw. The size of screw ranges from 5 - 30kg with an average size of 15kg. The pressure is applied gradually to allow time for the oil to escape (Poku, 2002, p.22). Kyei-Baffour and Manu (2011) has recommended the extension of the effort arms of the screw press with galvanized iron pipes to the length of

the existing effort arm to 0.5-1.0 m each side to facilitate pressing with less human effort where manually operated. According to Cudjoe (2001) palm oil presses can be manufactured by local artisans except the screw thread which needs special devices and skills to produce.

The hydraulic press is of the same design as the screw press except that the hydraulic press employs hydraulic system to move the plunger. Hydraulic presses are faster and deliver higher pressures than the screw types but if care is not taken, poisonous hydraulic fluid will drain into the oil. With time, moisture is absorbed into the hydraulic oil and the wear of seals tends to render hydraulic presses ineffective (Poku, 2002, p.22).

Owolarafe *et al*. (as cited in Zu *et al*., 2012, p.23) found the digester screw press to be the most economical of all the presses in terms of labour, material and floor space requirements and also revenue generation. Notwithstanding the aforementioned advantages of the digester screw press, Adjei-Nsiah *et al*. (2012) stated the disadvantages of the equipment as high purchase cost and so much effluent discharge which are very difficult for small-scale processors to manage.

The digester screw press as described by Poku (2002) consists of a perforated tube inside which an auger (screw transport) rotates. The auger macerates the palm fruit as it is fed at the hopper and transports it as well. As the macerated fruit is transported, it encounters a regulated cone which gives it a back pressure. The oil is forced out through the perforated sides of the cage while the remaining fibre and nuts are released at the end of the cage through the gap between the end cone and cage body (Poku, 2002 p.4).

Wet method of palm oil extraction is a mechanical improvement of the traditional wet method process. This makes use of a vertical digester with perforated bottom plate (to discharge the liquid content) and a side chute for discharging the fibre and nuts. After digestion, hot water is used to flush the liquid content for further processing (Poku, 2002, p.22).

2.5.7 Clarification of the oil

Johnson & Pehlergard and Orji (as cited in Zu *et al.*, 2012, p.24) reported that moisture and impurities levels of crude palm oil is directly dependent on the final oil extraction and clarification method. In their study Ngando *et al.* (as cited in Zu *et al*., 2012 p.117) found that palm oil clarifying has not been mechanized by small-scale palm oil processors but rather uses the old traditional means. Palm oil that is aimed at soap makers is not clarified at all. Such oil contains high moisture levels which will increase FFA content of the oil during storage.

A clarifier is a mechanical unit used for the purification of the oil off dirt and moisture. It usually consists of two linked tanks, whereby heating with water causes the first tank to overflow at the top into the second tank. The oil is therefore dried by the waste heat from the fire under the first tank.

2.6 Constraints in the Acquisition and Use of Technologies Used for Palm Oil Processing

Poku (2002) argued that raising the level of mechanization from the traditional technologies of using manual labour and simple cooking utensils in palm oil processing demands certain considerations. The availability of raw materials in the locality, the level of technology to be used (the higher the technology, the more skillful the operators should be) and the money available for investment in machines. These considerations determine the type of machinery to select.

In terms of the use of traditional processing technologies, Cudjoe (2001) stated that the high fuel (firewood) consumption, high labour input and low oil extraction are some challenges faced by processors. With the improved technologies, Cudjoe (2001) identified unavailability or insufficient credit to purchase equipment, frequent breakdowns and higher maintenance cost (compared to the traditional technologies) as some of the setbacks associated with it. Halos-Kim and Jeon (as cited in Cudjoe 2001) stated that in the designing and manufacturing of improved equipment, simplicity, ease of operation and maintenance are factors to be considered to ensure that the technology is manageable and also be able to reduce frequent breakdowns.

CHAPTER THREE

METHODOLOGY

This chapter gives a description of the methods and procedures that were used to collect and analyze data. A description of the population and sampling methods as well as the instrument used in collecting data on the topic are also presented.

3.1 The Research Design

A descriptive study design was used for this research. Questionnaire interview, focus group discussions and non-participant observations were used to collect data on the processing equipment and practices being used by the small-scale palm oil processors. This design was appropriate since it enabled the generation of information to describe existing processes and to establish the relative advantage of one technology over another.

3.2 Population

The study was conducted in the communities within the Tano North and South Districts of Brong Ahafo Region of Ghana. The target population included palm oil processors in the two districts. Figures 2 and 3 show the maps of Tano North and South Districts where the research was conducted.

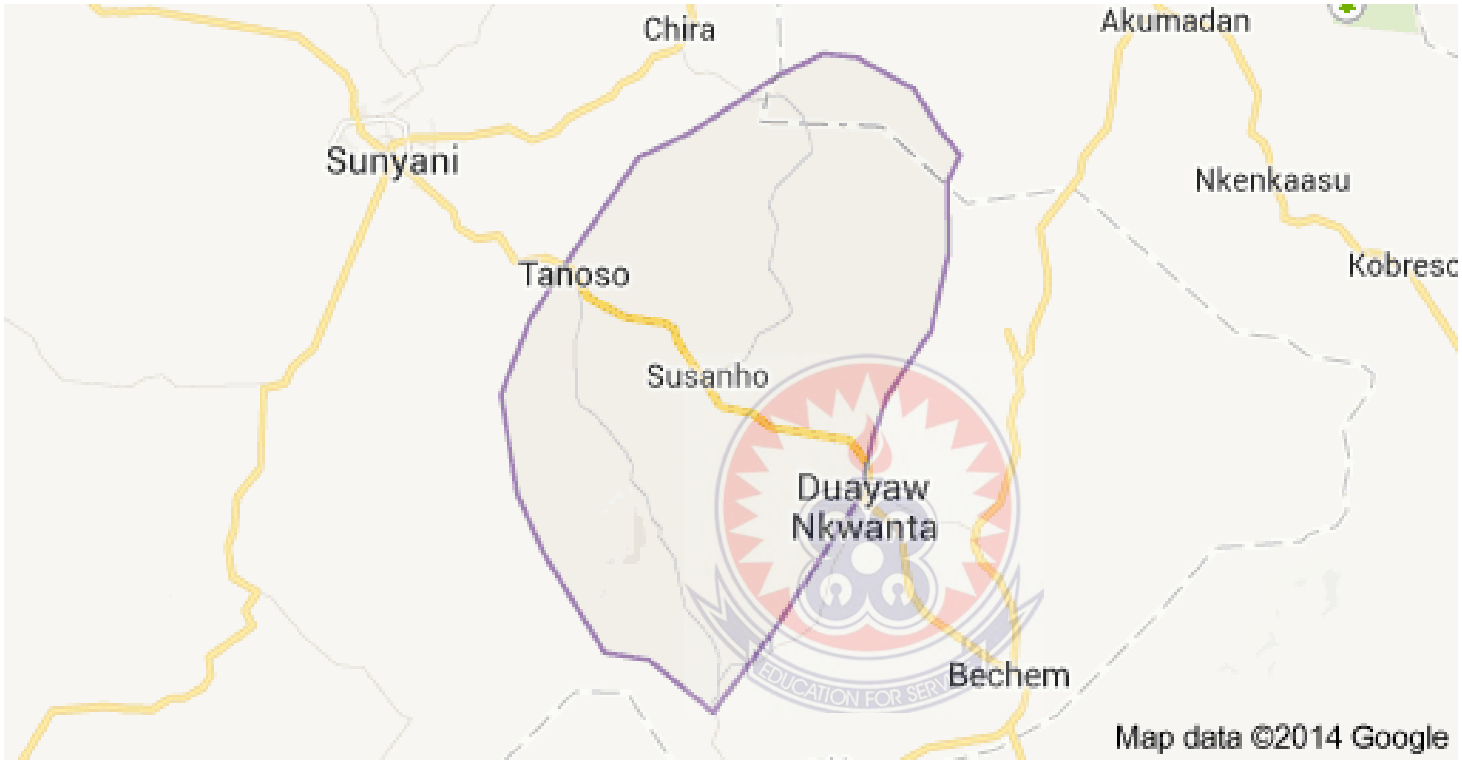


Figure 2: showing the map of the Tano North District

Figure 3: showing the map of the Tano South District

The Tano North District has a total population of 78,415 and lies between longitude 7°00'25', latitude 1°45'W and 20 W with a total land area of 875 km² constituting about 1.8% of the total land area of the Brong Ahafo Region. Its administrative capital is Duayaw Nkwanta. Agriculture is the main occupation in the district. It employs about 64.4% of the total work force in the district. The major food crops grown are maize, cassava, plantain, cocoyam and yam. Some of the cash crops cultivated include cocoa, coffee, oil palm and citrus (Ghana Districts, 2006).

Tano South District also has Bechem as its administrative capital. It has an estimated population of 78,129. The district lies between latitudes 7° 45W and 2° 15W. it has a total land area of 635 km² which is 1.54% of the total land area of Brong Ahafo Region. Agriculture happens to be the main economic activity of the people. About 64% of the labour force is engaged in agriculture. The major food crops grown are maize, cassava, plantain and cocoyam. Major vegetables grown are tomatoes, garden eggs, okro and pepper. The cultivated cash crops are cocoa, oil palm, coffee and cashew (Ghana Districts, 2006). Both Tano North and South Districts lie in the moist semi deciduous forest zone, which is suitable for the cultivation of oil palm.

3.2 Sampling Techniques and Sampling

Since several small–scale palm oil processing centres are dotted in the various communities of the Tano North and South Districts, it was appropriate to uses the snowball technique to identify the processing centres in the study area. At each mill, random sampling was used to select the respondents. A total of 30 respondents were

selected from the Tano North District. They included five traditional processors using mortar and pestle and 25 processors using improved technologies with equipment such as a diesel powered palm fruit digester with either hydraulic press or manual screw press.

Thirty other respondents were selected from the Tano South District. They were also made of five traditional processors who apply mortar and pestle in their processing activities. The remaining 25 were made of processors who use improved equipment such as the motorized palm fruit/ oil flusher unit and the digester with manual screw press. A total of sixty respondents were randomly picked to make up the sample for the research. In all ten mill owners and fifty fruit processors were interviewed.

3.3 Instruments for Data Collection

Questionnaire interview, focus group discussions, and non-participant observations were used for the collection of data on technologies used for palm oil processing. The variables of the study were captured on the characteristics of the processors, issues on processing practices and the type of equipment they use. Information on the cost of operation, revenue from operation and the constraints associated with the acquisition and use of improved technologies were also collected.

Characteristics of processers included gender, age, marital status, number of children, educational level, financial background, processing methods used, the type of technology and processing activities.

The ease with which equipment are used was determined by items like labour required and the availability of power or fuel for running of machines. Maintainability of equipment was described with question bordering on availability and cost of spare parts and also the capacity of local artisans to make repairs.

Durability of machines was also determined by questions such as frequency at which processors experience breakages and rust or wear of component parts of machines. On the measure of effectiveness of machines, questions like ability to produce large quantities in a shorter period and labour input – output comparison were considered.

On the measurement of how appropriate a technology used is, question items were hinged on the suitability of the processing method to the kind of oil produced, consumer acceptance to taste and the physical appearance of the oil. Question on how technology conforms to traditional processing methods was also asked.

On the issue of profitability of the use of a kind of technology, questions such as capital injection in equipment acquisition, fixed and variable cost production of a tonne of FFB and the revenue generated were asked.

Questions on equipment acquisition constraints were on whether machines are manufactured in the locality, too expensive, cannot locate sources where machines can be acquired and lack of credit facilities to acquire machines.

Generally questions were close ended but some open- ended, for example questions on machines used, processing activities and income and expenditure for processing. A 5-point likert scale was also used to score some of the questions with 1 meaning “strongly

disagree"2 "disagree", 3"Neither agree", 4 "Agree" and 5"strongly Agree". A copy of the questionnaire has been attached in the appendix.

3.4 Methods of Data Analysis

The researcher administered the final questionnaire personally. This was to make the filling of the questionnaire easier to the respondents since most of them have low level of education. It was also to ensure majority retrieval of filled questionnaires.

Cross- tabulation with chi-square was used to analyze the data on characteristics of palm oil processors, processing activities, technologies applied in the processing of the palm oil and the constraints encountered in the acquisition and use of improved technologies. The filled questionnaires were screened, coded, and the data entered into Statistical Package for Social Sciences (SPSS) which was used for the analysis to suit stated objectives of the research.

Cross-tabulation and Chi-square was used to draw the comparative differences of the processing technologies with a confidence level of 0.05. The following variables were included in the cross-tabulation: ease of use, ease of maintenance, effectiveness, durability, and the appropriateness of the technologies.

The net income associated with the various processing equipment was used in making a comparative economic analysis of the technologies used by the palm oil processors.

CHAPTER FOUR

RESULTS AND DISCUSSION

This chapter presents interpretation and analysis of all the findings made from the research.

4.1 Characteristics of Respondents

Table 1: Characteristics of the Respondents

Variables	District (Tano)		Total (%)	Chi-square (p-value)
	South (%)	North (%)		
Gender of respondents				
Male	47.6	52.4	37.5	234 (0.418)
Female	65.5	45.6	62.5	
Age				
< 21 years	57.1	42.9	12.5	2.275 (0.685)
21 – 30	42.9	57.1	12.5	
31 – 40	66.7	33.3	26.8	
41 - 50	43.5	56.6	41.1	
≥ 51	50.0	50.0	7.1	
Marital status				
Married	50.0	50.0	64.3	1.597 (0.809)
Single	58.3	41.7	21.4	
Divorced	33.3	66.7	5.4	
Widowed	50.0	50.0	7.1	
Separated	100.0	0.0	8.1	
Level of education				
No formal education	54.5	45.5	58.6	1.603 (0.808)
Basic Education	53.3	46.7	25.8	
Secondary	50.0	50.0	7.1	
Technical	0.0	100.0	1.8	
Tertiary	33.3	66.7	5.4	
Years of experience				
< 5 years	53.3	46.7	26.8	3.934 (0.415)
6 – 10 years	50.0	50.0	35.7	
11 – 15 years	40.0	60.0	26.8	
16 – 20 years	66.7	33.3	5.6	
≥ 21	100.0	0.0	5.4	
Processors' Status				
Mill operator	41.7	58.3	21.4	0.707 (0.702)
Fruit processor	55.6	44.4	64.3	
Sole Owner	50.0	50.0	14.3	

Table 1 shows the demographic characteristics of the respondents surveyed. From the table it could be noted that more than half of the respondents, approximately 63% were females with the remaining about 38% being males. This is an indication that majority of the palm oil processors in the Tano North and South Districts of Ghana are females. Further observation also revealed that the men involved in the processing industry are either mill operators or are found in management positions. This affirms the findings by Taiwo *et al.* (2002) that females dominate in the palm oil processing while their male counterparts only offer assistance by operating machines and take up strenuous tasks. Again, Adjei-Nsiah *et al.* (2012) also found men to be predominant owners and operators of most improved small scale palm fruit processing mills. The results have been presented in relation to the districts from which the respondents were drawn and further analysis showed no statistically significant association between the gender of the respondents based on their districts (Pearson's Chi-square=234, p=0.418).

In addition, about 41% were aged 41 – 50 years, whereas approximately 27% of the respondents were also aged between 31 – 40 years. The results have been presented in relation to the location of the respondents by which further analysis showed no statistically significant association between the ages of the respondents and the districts they were drawn from (Pearson's Chi-square=2.275, p=0.685).

Analysis of the marital statuses of the respondents showed that more than half of the respondents approximately 64% were married while about 21% were single. A chi-square analysis of the responses (χ^2=1.597, p=0.809) showed no statistically significant association between the marital statuses of the respondents based on the districts they were drawn from.

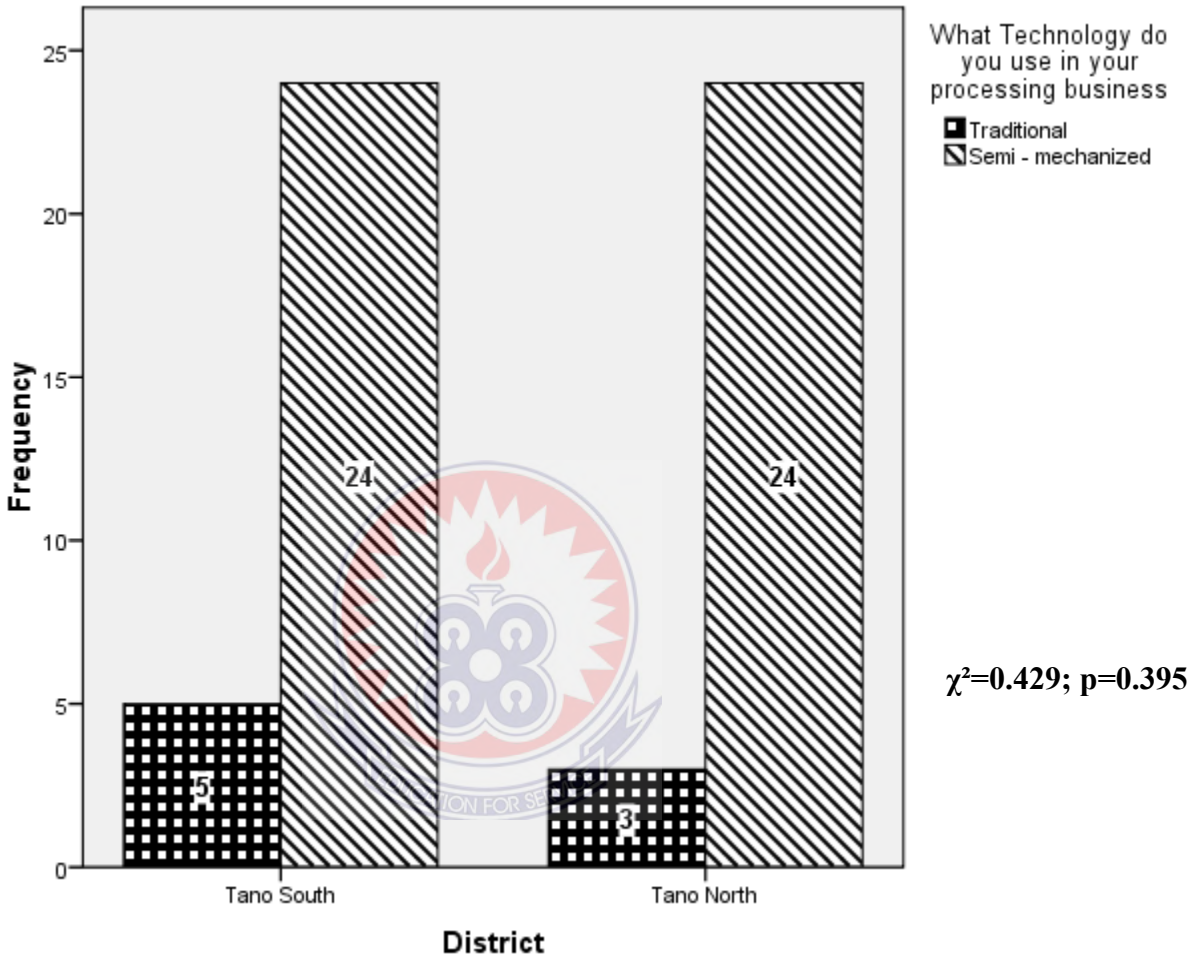
Furthermore, taking into accounts the level of education of the respondents it was found that more than half, approximately 59%, of the respondents had no formal education. Meanwhile about 26% had basic education. Again, chi-square analysis of the responses (χ^2=1.603, p=0.808) showed that there was no statistically significant association between the level of education of the respondents and the districts from which they were drawn from.

The table further shows that approximately 36% of the respondents have 6 – 10 years of working experience whereas about 27% have less than 5 years of occupation experience. Another 27% approximately had also gained 11 – 15 years of working experience. The results have been presented in relation to the districts of the respondents for which chi-square analysis of the results (χ^2=3.934, p=0.415) didn't provide enough evidence to suggest a statistically significant association between the districts of the respondents and their occupational experience.

The respondents were requested to state the status of their operation and analysis of the responses showed that more than half of the respondents, about 64%, operated as fruit processors whereas 21.4% were mill operators. Again, there was no statistically significant association between the responses and their statuses of operation and the districts from which they were drawn from (Pearson's chi-square=0.707, p=0.702).

4.2 Current Technologies and Practices Used by Palm Oil Processors

The kind of technologies used by palm oil processors



χ^2=0.429; p=0.395

Figure 4: The Kind of Technology Used in Processing Palm Oil

Figure 4 gives evidence of the kind of technology used by the respondents in their processing business. Results in the figure suggest that 48 respondents reported of using semi-mechanized processes whereas 8 respondents on the other hand used traditional processing method. Those who apply the semi- mechanized process were found to have mechanized the maceration and pressing stages. They consider these stages as the most strenuous and time consuming. It was also revealed that, processors would have wished

to mechanize all the palm oil processing stages but lacked the financial capability to do so. Those who are still employing the traditional methods to process palm oil have observed it to be more strenuous and drudgery but probably do not have the means to switch on to the improved processing methods. This confirms the finding by Cudjoe (2001) that the traditional palm oil processors have taken note of all the demerits associated with the method but still stick to it because it is more affordable to acquire and maintain. It is worthy of note that none of the respondents use the fully-mechanized processing. The results has been disaggregated according to the district of the respondents and for which chi-square analysis conducted revealed no statistically significant association between the responses regarding their processes and their districts (Pearson's chi-square=0.429, p=0.395).

The type of equipment used and the activities involved in palm oil processing

Four palm oil processing equipment were identified in the Tano North and South districts of Brong Ahafo. The equipment are the traditional which is mainly composed of mortar and pestle (MP), the digester with separate screw press (DSP), the Flushing Extractor (FE) and the digester with separate hand operated hydraulic press (DHP). Apart from the traditional equipment, the mechanized equipments are powered by either an electric motor or a diesel engine. In all the four equipment, palm fruits are boiled with fire wood and the waste from the palm bunch. Big pots, fabricated metal tanks and metal drums are used for the boiling of the palm fruits. Figures 5 and 6 show photographs of boiling tanks and big pots used to boil palm fruits.

Figure 5: Photograph Showing Fabricated Tanks Used for Boiling Palm Fruits

Figure 6: Photograph Showing Cast Aluminum Pot Used for Boiling Palm Fruits

Palm oil processing activities and practices in the Tano North and South Districts include harvesting of fresh fruit bunches, storage for 3-7 days to soften the fruits which will allow for easy removal of the fruits from the bunch, removal of fruits from bunches and drying to eliminate moisture in the fruits, boiling of fruits and digestion, pressing of pulp to release oil, and drying of oil to dry off moisture in the oil. The aforementioned activities are common with palm oil processing but differ in procedure at certain stages depending on the type of equipment used. It was also noted that, in both districts, digestion of fruits and pressing are the stages that some processors use improved equipment. This is so because processors perceive these stages as time consuming and strenuous.

With the traditional equipment, boiled palm fruits are pounded using a mortar and pestle, after which the pulp is washed off using warm water. This agrees with the findings of Wiemer and Altes (1989) that the traditional palm oil processing is identified with the use of simple available household utensils such as mortar and pestle, crushing stones, calabashes and cooking pots. The crude palm is separated from the fibre and nuts by hand squeezing and sieving. The crude palm is boiled till well cooked. It is then left on less fire for some few minutes. Oil that settles on top of the crude palm is skimmed off for drying. Figures 7 and 8, show photographs of pounding and washing off processes.

Figure 7: Photograph Showing the Use of Mortar and Pestle to Pound Palm Fruits

Figure 8: Photograph Showing the Washing off Method by Traditional Processors

With the use of the digester with separate hand operated screw press, boiled palm fruits are digested using either an electric motor or diesel engine powered digester. The pulp is then loaded into a perforated cage and the oil squeezed out using a hand operated screw press. The oil is finally collected for drying. This is shown in Figures 9 and 10.

Figure 9: Photograph Illustrating the Digestion of Palm Fruits Using Diesel Engine Operated Digester

Figure 10: Photograph Showing the Use of Hand Operated Screw Press to Squeeze Palm Oil Out of the Pulp

The Flushing Extractor which is powered by an electric motor digests the boiled palm fruit after which it is flushed with warm water. The crude palm is automatically separated from the crude palm. The crude palm is then processed as in the traditional method. This is an improvement of the traditional palm oil processing. Figures 11 and 12 show photographs of the activities of the flushing extractor. This method of processing has also been reported by Poku (2002) as the wet method of improved palm oil processing.

Figure 11: Photograph Showing the Use of a Flushing Extractor to Process Palm Oil

Figure 12: Photograph Showing Women Boiling Palm Crude in Drums after Flushing from the Flushing Extractor

Digester with separate hand operated hydraulic press powered by either an electric motor or a diesel engine. The fruit is digested and the pulp loaded into a perforated cage and then a hand operated hydraulic press is used to squeeze the oil out of the pulp. This activity is illustrated by Figures 13 and 14.

Figure 13: Photograph Showing the Use of a Digester and a Hydraulically Hand Operated Press to Process Palm Oil

Figure 14: Photograph Showing Palm Oil Extracted from a Digester and Hand Operated Hydraulic Press

4.3 Differences in the Processing Equipment in Terms of Ease of Use and Maintenance, Durability, Effectiveness, Appropriateness and Profitability

Use of equipment

Table 2: Concerns Over the Use of Processing Equipment

	Equipment use				Total	
Variables	**MP**	**DSP**	**FE**	**DHP**	**(%)**	**Chi-square (p-value)**
1. Easy operation of equipment						
Disagree	0.0	0.0	0.0	80.0	13.3	95.300 (0.000)
Neither	0.0	3.3	0.0	10.0	3.3	
Agree	10.0	93.3	100.0	10.0	66.7	
Strongly agree	90.0	3.3	0.0	0.0	16.3	
2. I need a lot of skills or learning						
Strongly disagree	70.0	3.3	0.0	0.0	13.3	75.366(0.000)
Disagree	20.0	90.0	100.0	20.0	68.3	
Neither	0.0	3.3	0.0	10.0	3.3	
Agree	0.0	3.3	0.0	70.0	13.3	
Strongly Agree	10.0	0.0	0.0	0.0	1.7	
3. Many hands are needed to work						
Strongly disagree	0.0	0.0	0.0	10.0	1.7	63.289 (0.000)
Disagree	20.0	83.3	0.0	90.0	60.0	
Neither	0.0	10.0	20.0	0.0	8.3	
Agree	10.0	3.3	60.0	0.0	13.3	
Strongly agree	70.0	3.3	20.0	0.0	16.7	
4. Fuel or power for processing is not readily available						
Strongly disagree	0.0	10.0	0.0	0.0	5.0	15.412 (0.220)
Disagree	90.0	80.0	80.0	100.0	85.0	
Neither	0.0	0.0	10.0	0.0	1.7	
Agree	0.0	10.0	10.0	0.0	6.7	
Strongly agree	10.0	0.0	0.0	0.0	1.7	

MP=Mortar & Pestle, DSP=Digester with screw press, FE=Flushing Extractor, DHP=Digester with hydraulic press

In Table 2, respondents were asked to show their level of agreement or disagreement with a series of issues concerning the use of the processing equipment. Variable 1 regarding

easy of operation of the equipment showed that more than half, approximately 68% of the respondents, agreed that it is easy to operate the equipment. Again, a further breakdown of the responses in relation to the type of processing equipment used by the respondents provided a statistically significant association between their district and their responses on the use of the equipment (Pearson's chi-square=95.300, $p<0.05$).

Variable 2 concerns the requirements for the operation of the equipment. Analysis of the results as given by the respondents, showed that, approximately 68%, disagreed there was the need for a lot of skills or learning in order to be able to operate the equipment. Again, a statistically significant association was found between the responses regarding the need for a lot of skills or learning and the type of processing equipment used by the respondents (Pearson's chi-square=75.366, $p<0.05$).

On variable 3, the respondents were requested to give their responses on how many hands were needed to work. The responses show that again more than half, that is about 60% of the respondents, disagreed that the operation of the equipment required many hands to enable it work. Chi-square analysis of the results ($\chi 2=63.289$, $p<0.05$) showed a statistically significant association between the responses given by the respondents and the equipment used for oil processing.

Variable 4 dealt with the availability of fuel or power for processing. The results suggest that more than two-thirds, that is 85% of the respondents disagreed that there is unavailability of fuel or power for processing. The results have been presented according to the type of equipment used by the respondents for which chi-square analysis of the results shows that there was no statistically significant association between the variables (Pearson's chi-square=15.415, $p=22$).

A close look on the analysis of the use of the equipment showed that, mortar and pestle appear to be the easiest to operate; probably this is so because it has been in use since the discovery of oil palm of which processors have become used to. This might also be the reason why people still use it.

4.3.1 Maintenance of equipment

Table 3: Ready Availability of Spare Parts
*** Equipment Used for Processing X^2=47.412, P=0.001**

Variables	Equipment used for processing				
	MP	DSP	FE	DHP	Total
1. Ready Availability of spare parts					
Disagree	0.0	3.3	0 .0	0.0	1.7
Agree	10.0	93.3	100.0	100.0	81.6
Strongly Agree	90.0	3.3	0.0	0.0	16.7
Total	**16.7%**	**50%**	**16.7%**	**16.6%**	**100%**

MP=Mortar & Pestle, DSP=Digester with screw press, FE=Flushing Extractor, DHP=Digester with hydraulic press

Table 4: Spare Parts Manufactured by Local Artisans
*** Equipment Used for Processingχ^2=71.282, P=0.001**

Variables	Equipment used for processing				
	MP	DSP	FE	DHP	Total
Strongly disagree	10.0%	0.0%	0.0%	0.0%	1.7%
disagree	10.0%	53.3%	0.0%	60.0%	38.3%
Neither	0.0%	0.0%	0.0%	20.0%	3.3%
Agree	0.0%	43.3%	100.0%	20.0%	41.7%
Strongly agree	80.0%	3.3%	0.0%	0.0%	15.0%
Total	**16.7%**	**50.0%**	**16.7%**	**16.6%**	**100.0%**

MP=Mortar & Pestle, DSP=Digester with screw press, FE=Flushing Extractor, DHP=Digester with hydraulic press

Tables 3, 4, 5 and Figure 15 deal with issues concerning maintenance of the equipment used for the palm oil processing activities. Table 3 requested respondents to give the extent of their agreement or disagreement with the availability of spare parts. The responses indicate that more than two-thirds, about 82% of the respondents, agreed that there are spare parts for the equipment and are readily available. The results presented in relation to the processing equipment used by the respondents and chi-square analysis ($\chi 2$=47.412, p=0.001) showed a statistically significant association between their responses on the availability of equipment spare parts and the type of equipment they use for their operations.

For Table 4, respondents were required to state whether they agree or disagree with the fact that spare parts are manufactured by local artisans. The responses shows that there was a wide spread of responses among the respondents. Majority of the respondents about 42% agreed whereas about 38% disagreed on the other hand. It was observed that most of the localities within which the mills are sited do not have professionals who are able to manufacture the required parts. Again, chi-square analysis of the results ($\chi 2$=71.282, p=0.001) showed a statistically significant association between their responses on the manufacturing of spare parts by local artisans based on the processing equipment used by the respondents.

Table 5: Cost of Repairs is High
*** Equipment Used for Processing X^2=55.710; P=0.001**

Response Items	Equipment used for processing				
	MP	DSP	FE	DHP	Total
Strongly Disagree	40.0%	3.3%	0.0%	0.0%	8.3%
Disagree	50.0%	6.7%	0.0%	0.0%	11.7%
Neutral	0.0%	10.0%	60.0%	0.0%	15.0%
Agree	10.0%	80.0%	40.0%	100.0%	65.0%
Total	**16.7%**	**50.0%**	**16.7%**	**16.6%**	**100.0%**

MP=Mortar & Pestle, DSP=Digester with screw press, FE=Flushing Extractor, DHP=Digester with hydraulic press

In Table 5, respondents were asked to indicate whether there is a high cost of repairs. The responses show that more than half, about 65% of the respondents agreed whereas approximately 15% remained neutral regarding the cost of repairs being high. The results have further been presented based on the processing equipment used by the respondents. Chi-square analysis of the results shows that there was a statistically significant association between the responses given by the respondents based on the type of equipment used (Pearson's chi-square=55.710, $p<0.05$).

A close cursory look of the analysis showed that, processors agreed cost of repairs of equipment were high for the digester with hand operated hydraulic press while it was low for the mortar and pestle. This might be attributed to the frequent leakages on the hydraulic unit of the DHP which calls for professionals to rectify. The mortar and pestle repairs are normally done by the processors themselves at no cost.

List the specific machines you use in the process and repairs are readily available

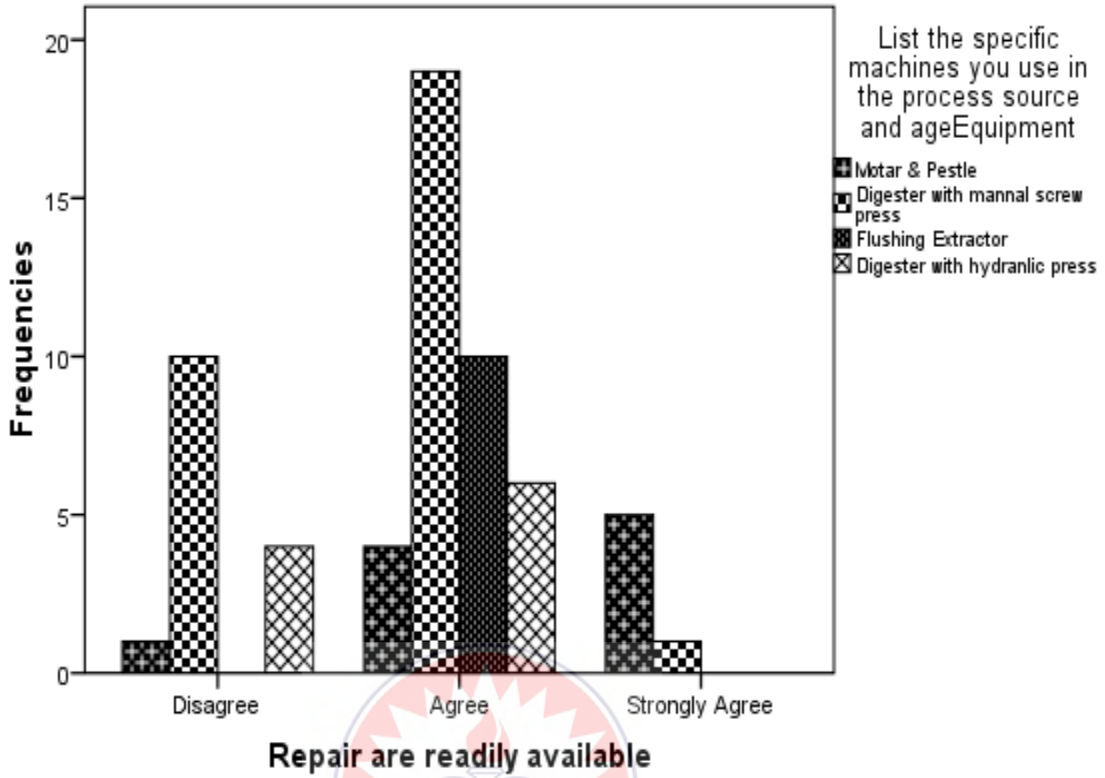


Figure 15: Repairs are Readily Available by Type of Equipment Used for Processing Palm Oil X^2=8.929; P=0.348

Figure 15 also shows respondents view on the ready availability of repairs on their equipment whenever it becomes faulty. From the figure, it could be observed that majority of the respondents agreed to the idea that repairs are readily available. It could further be seen that there were quite substantial number of respondents who disagreed that there is the ready availability of repairs for their faulty equipment. This might be so because most of the equipment are found in areas where mechanics are not resident. Faults can only be rectified either by the owners carrying the part to service workshops far away from the mill or asking the mechanic to travel to the processing centre.

Generally on the maintenance of the equipment, the analysis indicated that processors using the mortar and pestle agreed that their equipment were not difficult to maintain in

that they required just washing with water after use without having to dismantle and reassemble parts. Processors using the digester and hydraulic press perceived it to be the most difficult to maintain, this might be due to the complex component parts of the equipment.

4.3.2 Durability of equipment

Concerning the durability of processing equipment, Tables 6, 7 and 8 have been used to address it. For Table 6, majority of the respondents approximately 82% responded 'Yes' to having abandoned some part of their equipment. The remaining 18% responded 'No' to abandoning any part of their equipment. A breakdown of the responses in terms of the type of equipment used by the respondents for which chi-square analysis showed that there was no significant association between the responses given by the respondents based on the type of equipment used for processing by the respondents (Pearson's chi-square=3.191, p=0.363)

Processors who use the mortar and pestle agreed to have abandoned mostly worn out or cracked mortar and pestle whereas those who apply the digester with separate hand operated screw press reported to have abandoned perforated metal cages, pulley and transmission belts. With the flushing extractor, processors indicated they had abandoned worn out transmission belts and beaters of digester. The processors using the digester with separate hand operated hydraulic press also mentioned abandoning worn out seals, hydraulic pumps and bearings.

Table 6: Equipment Part had been Abandoned
*** Equipment Used for Processing Palm Oil X^2=3.191, P=0.363**

	Equipment used for processing				
Response Items	**MP**	**DSP**	**FE**	**DHP**	**Total**
YES	100.0%	75.0%	80.0%	85.7%	81.8%
NO	0.0%	25.0%	20.0%	14.3%	18.2%
Total	**16.7%**	**50.0%**	**16.7%**	**16.6%**	**100.0%**

MP=Mortar & Pestle, DSP=Digester with screw press, FE=Flushing Extractor, DHP=Digester with hydraulic press

Table 7: Which of these Things Affect your Equipment?
*** Equipment Used for Processing Oil $\chi 2$=2.824, P=0.945**

	Equipment used for processing				
Response Items	**MP**	**DSP**	**FE**	**DHP**	**Total**
Breaking	70.0%	60.0%	66.7%	100.0%	69.0%
Rusting	10.0%	6.7%	0.0%	0.0%	6.9%
Wear and tear	20.0%	33.3%	33.3%	0.0%	24.1%
Total	**16.7%**	**50.0%**	**16.7%**	**16.6%**	**100.0%**

MP=Mortar& Pestle, DSP=Digester with screw press, FE=Flushing Extractor, DHP=Digester with hydraulic press

In Table 7 respondents were required to state what they thought affected their equipment the most. From the table it could be observed that more than half 69% of the respondents reported of 'Breaking' which goes to suggest that the equipment experience breakages. In addition, about 24% of the respondents reported that 'Wear and tear' affected their equipment. The data has been disaggregated in relation to the processing equipment used by the respondents for which chi-square analysis ($\chi 2$=2.824, p=0.945) found no statistically significant association between the responses on what affect the oil processing equipment and the type of equipment used.

Table 8: How would you Describe the Frequency of Breakdown of Equipment within a Year * Equipment Used for Processing Oilχ2=36.807, P=.001

Response Items	Equipment used for processing				
	MP	DSP	FE	DHP	Total
Seldom	70.0%	10.0%	60.0%	.0%	27.1%
Not often	30.0%	83.3%	30.0%	44.4%	59.3%
Often	.0%	6.7%	10.0%	55.6%	13.6%
Total	**16.7%**	**50.0%**	**16.7%**	**16.6%**	**100.0%**

MP=Mortar & Pestle, DSP=Digester with screw press, FE=Flushing Extractor, DHP=Digester with hydraulic press

From Table 8, the respondents were asked to describe the frequency their equipment experience breakdowns. The results depict that more than half approximately 59% of the respondents reported that their equipment does 'not often' experience breakdowns. Furthermore, about 27% of the respondents declared they seldom experience breakdowns with the equipment. Further breakdown of the results in terms of the type of equipment respondents use for processing oil did not show a statistically significant association between how the equipment experienced breakdown and the type of equipment they use in business (Pearson's chi-square=36.807, p=0.001).

A summary and close analysis of the results on durability of equipment suggests that, the traditional equipment takes time before it becomes faulty. On the other hand, the digester with separate hand operated screw press and the digester with separate hand operated hydraulic press is believed to have less durable component parts which make them experience more breakdowns.

4.3.3 Effectiveness of equipment

Table 9: Production of Large Quantities in a Shorter Time
*** Equipment Used for Processing χ^2=1.102; P=0.001**

	Equipment used for processing				
Response Items	**MP**	**DSP**	**FE**	**DHP**	**Total**
Strongly disagree	90.0%	3.3%	0.0%	0.0%	16.7%
Disagree	0.0%	0.0%	50.0%	0.0%	8.3%
Agree	10.0%	93.3%	50.0%	20.0%	60.0%
Strongly agree	0.0%	3.3%	0.0%	80.0%	15.0%
Total	**16.7%**	**50.0%**	**16.7%**	**16.6%**	**100.0%**

MP=Mortar & Pestle, DSP=Digester with screw press, FE=Flushing Extractor, DHP=Digester with hydraulic press

On issues bordering effectiveness of processing equipment, Tables 9, 10 and 11 have been used to deal with it. Concerning the production of large quantities of oil in a short time, Table 9 gives evidence that more than half, about 60% of the respondents agreed whereas approximately 15% on the other hand strongly disagreed. The result is further given in relation to the type of equipment used in processing oil. Analysis of chi-square showed a statistically significant association between the variables (Pearson's chi-square=1.102, $p<0.05$).

Table 10: Labour Required to Operate Equipment is Reduced
*** Equipment Used for Processing χ^2=1.110; P=0.001**

Response Items	Equipment used for processing				Total
	MP	DSP	FE	DHP	
Strongly disagree	70.0%	3.3%	0.0%	0.0%	13.3%
disagree	20.0%	0.0%	70.0%	10.0%	16.7%
Neither	10.0%	3.3%	20.0%	0.0%	6.7%
Agree	0.0%	90.1%	10.0%	10.0%	48.3%
Strongly agree	0.0%	3.3%	0.0%	80.0%	15.0%
Total	**16.7%**	**50.0%**	**16.7%**	**16.6%**	**100.0%**

MP=Mortar & Pestle, DSP=Digester with screw press, FE=Flushing Extractor, DHP=Digester with hydraulic press

Table 10 shows how labour required to operate equipment is reduced. The responses showed that almost half 48% of the respondents agreed whereas about 17% disagreed. This reveals that when the level of mechanization is increased, a significant amount of labour is saved. Here the equipment with the highest amount of labour saved is with the digester with separate hand operated hydraulic press whereas the mortar and pestle demands a very high labour input. The flushing extractor has a substantial amount of labour input because the process demands a lot of water input and also have to boil the crude palm in the same way as the traditional method. With the digester with separate hand operated screw press, much energy is only exercised with the pressing of the pulp to release oil. Chi-square analysis ($\chi 2$=1.110, $p<0.05$) showed a statistically significant association between the responses on reduced labour required to operate the equipment and the equipment used for oil processing.

Table 11: The Value of Output Compared to Input is High
*** Equipment Used for Processing χ^2=36.228; P=.001**

Response Items	Equipment used for processing				
	MP	DSP	FE	DHP	Total
Strongly Disagree	30.0%	0.0%	0.0%	0.0%	5.0%
Disagree	60.0%	3.3%	0.0%	0.0%	11.7%
Agree	10.0%	93.3%	100.0%	20.0%	68.3%
Strongly Agree	0.0%	3.3%	0.0%	80.0%	15.0%
Total	**16.7%**	**50.0%**	**16.7%**	**16.6%**	**100.0%**

MP=Mortar & Pestle, DSP=Digester with screw press, FE=Flushing Extractor, DHP=Digester with hydraulic press

From Table 11, almost two-thirds about 68% of the respondents agreed that the value of output compared to input is high likewise approximately 15% who strongly agreed to that effect. A further breakdown of the results shows that there was a statistically significant association between the responses given on the variable based on the type of equipment the respondents use in processing oil (Pearson's chi-square=36.228, p=0.001).

On the whole, looking at the analysis on effectiveness, the digester with separate hand operated hydraulic press was agreed to be the most effective among all the identified equipment while the mortar and pestle is the least effective. This supports the findings by WACAPOL (2011) that, the traditional local artisanal methods of processing palm oil are highly inefficient, labour intensive and produce negligible quantities. Poku (2002) also confirms the findings that the hydraulic presses are faster and deliver higher pressures.

4.3.4 Appropriateness of equipment

Table 12: Method is Suitable for the Kind of Palm Oil I am Producing and Equipment Used for Processing Oil X^2=31.425; P=0.000

Response Items	Equipment used for processing oil				
	MP	DSP	FE	DHP	Total
Neither agree	6.7%	3.4%	.0%	.0%	1.7%
Agree	14.3%	93.3%	60.0%	100.0%	76.7%
Strongly Agree	80.0%	3.3%	40.0%	.0%	21.7%
Total	**16.7%**	**50.0%**	**16.7%**	**16.6%**	**100.0%**

MP=Mortar & Pestle, DSP=Digester with screw press, FE=Flushing Extractor, DHP=Digester with hydraulic press

Tables 12, 13 and 14 deal with issues concerning the appropriateness of the equipment used for the palm oil processing. From Table 12 it could be observed that more than two-thirds, about 77% of the respondents agreed that the method they are using is suitable for the kind of palm oil they are processing. Further, about 22% of the respondents strongly agreed with that assertion. Again, the analysis found a statistically significant association between the responses on the methodology used in processing the palm oil and the processing equipment used by the respondents (Pearson's chi-square=31.425, $p<0.05$).

Table 13: The Physical Appearance of the Oil is Acceptable to the Market * Equipment Used for Processing Oil X^2=31.917, P=.001

Response Items	Equipment used for processing oil				
	MP	DSP	FE	DHP	Total
Disagree	0.0%	3.3%	0.0%	0.0%	1.7%
Neither agree nor disagree	0.0%	0.0%	0.0%	10.0%	1.7%
Agree	30.0%	93.4%	80.0%	90.0%	80.0%
Strongly Agree	70.0%	3.3%	20.0%	0.0%	16.7%
Total	**16.7%**	**50.0%**	**16.7%**	**16.6%**	**100.0%**

MP=Mortar & Pestle, DSP=Digester with screw press, FE=Flushing Extractor, DHP=Digester with Hydraulic Press

In Table 13, the respondents were asked to indicate the extent of their agreement or disagreement with the assertion that the physical appearance of the oil they produce is acceptable on the market. The responses suggest that majority, about 80% of the respondents, agreed as well as about 17% who strongly agreed to that effect. The results is further presented by the type of equipment used by the respondents. Chi-square analysis of the results shows that there was no statistically significant association between the two variables (Pearson's chi-square=31.917, p=0.001).

Table 14: Taste of Oil is Acceptable to Consumers
*** Equipment Used for Processing Oil X2=80.412, P=0.001**

Response Items	Equipment used for processing oil				
	MP	DSP	FE	DHP	Total
Disagree	0.0%	6.7%	0.0%	20.0%	16.7%
Neutral	0.0%	0.0%	0.0%	70.0%	4.3%
Agree	100.0%	86.7%	50.0%	0.0%	57.0%
Strongly Agree	0.0%	3.3%	0.0%	0.0%	22.0%
Total	16.7%	50.0%	16.7%	16.6%	100.0%

MP=Mortar & Pestle, DSP=Digester with screw press, FE=Flushing Extractor, DHP=Digester with hydraulic press

Table 14 shows that more than half, approximately 57%, of the respondents agreed that their consumers accept the taste of the oil they produce. Further about 22% of the respondents strongly agreed to that effect. The responses have been presented in accordance with equipment used for processing palm oil. Chi-square analysis of the results suggest there was no statistically significant association between the two variables (Pearson's chi-square=80.412, p=0.001).

The taste of oil from the mortar and pestle appeared to be the most acceptable to consumers. This might be attributed to how the oil is treated with vegetables after its extraction. On the other hand, most of the processors from the improved processing equipment do not care about the taste since they sell it out to soap manufacturers.

Table 15: The Method Conforms to the Traditional Principles Of Processing
*** Types of Equipment Used For Palm Oil Processing X2=15.588, P=0.211**

Response Items	Equipment used for processing				Total
	MP	DSP	FE	DHP	
Strongly Disagree	.0%	.0%	9.1%	10.0%	3.5%
Disagree	12.5%	42.9%	36.3%	30.0%	35.0%
Neither agree nor disagree	12.5%	21.4%	27.3%	20.0%	21.1%
Agree	62.5%	10.7%	9.1%	20.0%	19.3%
Strongly Agree	12.5%	25.0%	18.2%	20.0%	21.1%
Total	**16.7%**	**50.0%**	**16.7%**	**16.6%**	**100.0%**

MP=Mortar & Pestle, DSP=Digester with screw press, FE=Flushing Extractor, DHP=Digester with hydraulic press

Presented in Table 15, gives an indication of the conformity of the methods used for processing the palm oil in relation to the traditional principles of processing oil. Analysis of the responses shows that majority being approximately 35% of the respondents neither agreed nor disagreed with the assertion that the methods adopted conforms to the traditional principles. Again, it could be observed that there was a divided opinion regarding the use of the methods where about 21% for each group strongly disagreed and strongly agreed respectively. The data has been presented in relation to the equipment used for processing the palm oil for which chi-square analysis (15.588, p=.211) showed no statistically significant association between the responses based on the equipment used for processing palm oil.

Detailed analysis of the appropriateness of the equipment suggests that the mortar and pestle is the most appropriate. The reason why processors thought it to be the most appropriate could be that consumers preferred the taste of manually prepared palm oil to that produced with modern equipment.

4.3.4 Profitability of using palm oil processing equipment

The improved palm oil processing system was compared with the traditional method of processing. Since the processing centres in the Tano North and South Districts were identified to have mechanized the maceration and pressing stages of the processing, capital costs were derived from costs of equipment and prime movers that are used for the digestion of the palm fruits and the oil press. Results of the financial analysis are presented in Ghana cedis in Table 17. It indicates that using any of the processing equipment for palm oil processing generates income and is profitable. A further analysis showed that the digester with separate hand operated hydraulic press generated the highest net income of GH₵108.00 which was attributed to its high extraction rate. The acquisition capital for the DHP is quite substantial than the other equipment. The equipment with the least acquisition capital is the mortar and pestle with a net income of GH₵18.00 which also happens to be the least income generating among the others.

Table 16: Comparative Analysis of the Cost and Revenue of Improved Palm Oil Processing Packages and the Existing Traditional Processing Method per Tonne of Fresh Fruit Bunches

Cost Items	Equipment used for processing (Amount in Ghana Cedis)			
	MP	**DSP**	**FE**	**DHP**
1. Capital cost	120	5500	5500	7500
2. Fresh fruit bunches	100	100	100	100
3. Operational costs				
• Transport	20	20	20	20
• Firewood/fuel/electricity	10	5	10	5
• Water	8	4	8	4
• Maintenance & spare parts		2	2	5
• Wages of workers	12	10	8	6
4. Production cost (2+3)	**150**	**141**	**148**	**140**
5. Income from sale of oil	160	200	200	240
6. Income from sale of kernel	8	8	8	8
7. Total revenue (5+6)	**168**	**208**	**208**	**248**
Net Income (7-4)	**18**	**67**	**60**	**108**

4.4 Challenges that Exist in the Acquisition and Use of Improved Technologies

Table 17: Difficulties in Acquiring Improved Machines for Use

	How long have you been processing palm oil? (%)					Total	χ2 (p-value)
	Less 5	6 – 10	11 – 15	16 - 20	>21		
1. Machines not manufactured in my locality							
Strongly Disagree	0.0	5.0	6.7	0.0	0.0	3.4	9.970 (0.619)
Disagree	47.1	30.0	60.0	66.7	100.0	48.3	
Neither agree	0.0	5.0	0.0	0.0	0.0	1.7	
Agree	52.9	60.0	33.3	33.3	0.0	46.6	
2. Machines are too expensive							
Neither agree	5.9	0.0	0.0	0.0	0.0	1.7	14.823 (0.063)
Agree	94.1	85.0	93.3	66.7	33.3	86.2	
Strongly agree	0.0	15.0	6.7	33.3	66.7	12.1	
3. Lack of credit to acquire machines							
Neither agree	0.0	0.0	6.7	0.0	0.0	1.7	12.239 (0.141)
Agree	76.5	65.0	80.0	66.7	0.0	69.0	
Strongly agree	23.5	35.0	13.3	33.3	100.0	29.3	

Table 15, gives information concerning how difficult respondents find it to acquire machines for their business operations. Variable 1 dealt with the question of machines not manufactured in their localities. The results showed that, nearly half, approximately 48%, respondents disagreed that the machines are not manufactured in their localities. However, about 47% respondents agreed that the machines are not manufactured in their localities. It appears that processors are aware of the establishment of the Rural Technology Facility at Bechem where agro processing equipment are manufactured. The others who agreed to the statement might not have any knowledge of the technology facility. Chi-square analysis shows that there was no statistically significant association between the variable and the length of time they have been in business (Pearson's chi-square=9.970, p=0.619).

Further from the table it could be observed that approximately 86% of the respondents find the machines too expensive to acquire. Meanwhile about 12% strongly agreed the machines are too expensive. The results were further presented in relation to how long the respondents have been in the palm oil processing industry. Most of the palm oil processing equipment are bulky and also demand materials and parts which are strong enough to withstand the stresses set up by the palm fruits and as a result render the price of equipment quite expensive. Chi-square analysis of the results showed no statistically significant association between the respondent's responses on the cost of the machines and the length of time they have been in the palm oil processing business (Pearson's chi-square=14.823, p=0.063).

It was found again that more than half about 69% of the respondents agreed that there is lack of credit facility for them to acquire machines. Approximately 29% of the respondents strongly agreed that they lacked credit to acquire machines for their operations. Amongst the challenges that constrain the palm oil processors in the acquisition of improved processing equipment, the ability of processors to access credit to finance the purchase of equipment ranked the highest. This might be the reason why most of the processors are still using the traditional technology which has been found to be more of a drudgery and strenuous. It was also observed that the processors were not in groups to enable them seek help from banks. Cudjoe (2001) also acknowledged that unavailability or insufficient credit to purchase equipment is a major setback for the small scale palm oil processing industry. The results have been presented in relation to how long the respondents have been in the business. Chi-square analysis of the results ($\chi 2$=12.239, p=0.141) suggested no statistically significant association between the responses on the availability of credit facility and how long they have been in business.

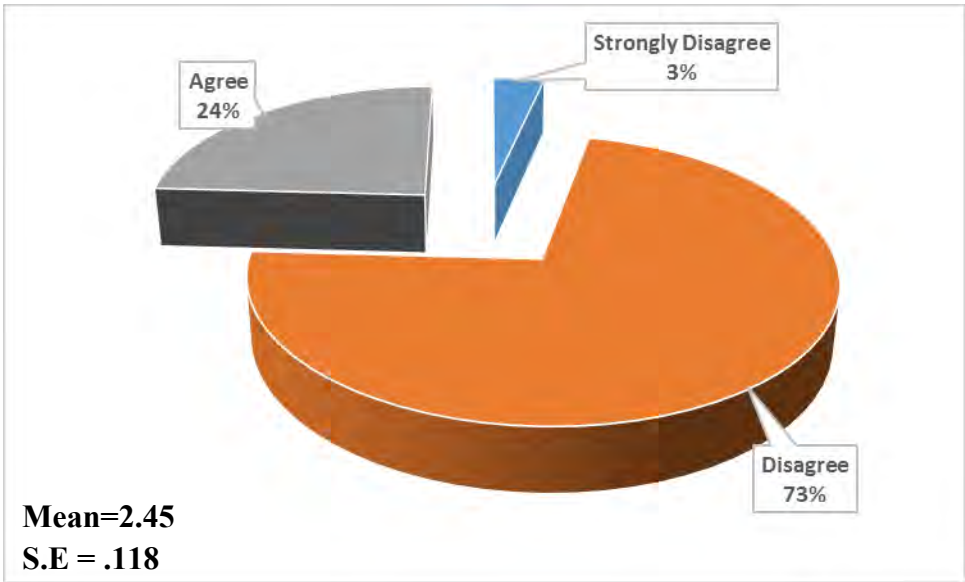


Figure 16: Cannot Locate Sources where Machines are Acquired

Figure 17 presents the responses on whether the respondents cannot locate the sources where they can acquire machines for their operations. The responses suggest that almost two-thirds 73% of the respondents disagreed whereas 3% strongly disagreed that they cannot locate the source of machines for acquisition. However, 24% on the other hand agreed that they could not locate the source of machines for operations. There was a mean score of 2.45 with a standard error of mean of 0.118 indicating the extent of deviation from the mean score obtained. This confirms the fact that processors have knowledge of where to get their equipment but lacked the financial capacity to acquire them.

CHAPTER FIVE

SUMMARY OF FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

This chapter being the final part of the study presents the summary of the data collected. Conclusions will also be drawn and then finally, recommendations or suggestions will be made based on the findings.

5.1 Summary of Findings

Palm oil has been identified as the most important single source of edible oil for most West Africans and the world at large. It has a wide range of uses and benefits such as the manufacture of margarine, compound cooking fats, soaps and fuel blend for internal combustion engines (Adjei-Nsiah *et al*, 2012). According to Cudjoe (2001), one area that serves as an important source of income for a large number of Ghanaians especially women is the oil processing sector and more especially the small scale palm oil processing industry.

The major challenges in the palm oil processing industry as found by Orewa *et al.* (2009) are the low oil extraction rate and the high free fatty acids content in the palm oil due to the traditional processing methods and techniques. In a bid to curtail the challenges associated with palm oil processing, various improved equipment have been developed by research and technology based institutions.

This research was conducted to assess the various palm oil processing technologies in existence to help prospective entrepreneurs in the palm oil industry make informed

decisions on the choice of technology to adopt. Again this work sought to inform engineers in the design and manufacture of palm oil processing equipment.

A summary of the findings of the research have been presented under the following sections:

- The characteristics of the palm oil processors in terms of gender, age, marital status, educational background, work experience and status of processors
- The current technologies and processing practices employed by the small scale palm oil processors
- The differences in the technologies in terms of ease of use and maintenance, durability, effectiveness, appropriateness and profitability and
- The challenges that constrain the acquisition of improved technologies.

5.1.1 Characteristics of palm oil processors

The main findings in relation to this section were that:

i. More than half of the respondents approximately 63% were females with the remaining about 38% being males
ii. 41% of the respondents were aged 41-50 years while approximately 27% of the respondents were aged 31-40 years.
iii. Majority, approximately 64%, were married whereas about 21% were single
iv. More than half of the processors approximately 59% were found to have no formal education while 26% of them had basic education

v. Approximately 36% of the palm oil processors had 6-10 years working experience while 27% of them had less than 5 years experience and another approximately 27% had gained 11-15 years of working experience.

vi. Fruit processors formed the majority of about 64% whereas approximately 21% were mill operators with the rest being mill owners.

5.1.2 Current technologies and processing practices of the small scale palm oil processors

On the issue of current technologies and processing practices used by small scale palm oil processors, the result showed that:

i. Majority of the respondents numbered 48 were using the semi-mechanized technology with only 8 respondents using the traditional method of processing palm oil

ii. Four processing equipment were found in the Tano and South districts namely the mortar and pestle (MP), the digester with separate hand operated screw press (DSP), the flushing extractor (FE) and the digester with separate hand operated hydraulic press (DHP)

iii. The identified improved processing equipment were powered by either an electric motor or a diesel engine

iv. Palm fruits are boiled using big aluminum pots, fabricated tanks and metal drums

v. Generally, the activities that the processors were found involved in were harvesting of fresh fruit bunches, which are then stored for 3-5 days to soften the fruits for easy removal from the bunches, fruit drying to reduce moisture from

fruits, boiling and digestion of the fruits, pressing of the pulp to release the oil and finally the drying of the oil to get rid of moisture.

5.1.3 Differences in the processing equipment in terms of ease of use and maintenance, durability, effectiveness, appropriateness and profitability associated with their use

The findings under this section were:

i. Respondents agreed generally that all the processing equipment are easy to use but the traditional technology which is mainly mortar and pestle was observed to be the easiest to use.

ii. In terms of maintenance of the equipment, the mortar and pestle was agreed to be the easiest to maintain since it demanded only washing with water after use unlike the others that needed dismantling and re-assembling of some component parts. The digester with separate hand operated hydraulic press was perceived to be the most difficult to maintain because of its complex component parts which called for professionals to fix

iii. The least durable equipment was found to be the digester with separate hand operated hydraulic press. The rate of breakdown was quite higher than the others. It was also noticed that the cause of the frequent breakdowns with the DHP might be due to the early wear of seals and other component parts of the hydraulic unit

iv. Considering the effectiveness of the equipment, the findings revealed that the digester with separate hand operated hydraulic press was the most effective. The production of large quantities of palm oil in a shorter time was quite higher with the DHP than the DSP which was also in turn higher than the FE and the MP

v. The mortar and pestle was perceived to be the most appropriate equipment as compared with the improved or mechanized equipment.

vi. With all things being equal, the digester with separate hand operated hydraulic press was agreed to be the highest profit yielding equipment but was capital intensive to acquire.

5.1.4 The challenges that constrain the acquisition of improved technologies

The results revealed the following findings as associated with the challenges that constrain the acquisition of improved technologies:

i. Nearly half of the respondents, approximately 48% of the respondents, disagreed that the processing equipment are not manufactured in their locality whereas 47% of the respondents agreed to the fact that equipment are not manufactured in their locality. It was perceived that while some processors have knowledge of the existence of a technology facility that manufactures agro processing equipment others do not.

ii. Generally all the improved equipment were considered to be expensive which processors found difficult to afford and thereby stuck to the traditional processing technique which had quite some drudgery and was strenuous.

iii. The highest amongst the challenges processors face in the acquisition of improved equipment was the lack of access to credit to purchase equipment. The processors were observed not to belong to any group which supported them to get help from the banks.

iv. Almost two thirds, 73%, of the respondents disagreed they cannot locate the source to acquire processing machines while 24% of them agreed that they could

not locate the source that manufacture processing equipment. This is an indication that most of the processors can locate sources where to acquire their processing equipment but probably lacked the financial capacity to acquire them.

5.2 Conclusions of the Study

The following conclusions were arrived from the findings of the study:

1. The processors were found with the following characteristics;
    i. Majority of the processors were found to be females with few of them being males who take charge of the operation of the improved processing equipment.
    ii. Processors in the palm oil business are found in the active working class of 31-50 years.
    iii. Majority of the processors are married who may have dependents.
    iv. Most of the respondents did not have formal education but are quite skillful and experienced in their job
    v. The status of majority of the respondents was fruit processors whereas the minority of them was found to be mill operators and owners.
2. Concerning the current technologies and processing practices adopted by processors, the following conclusions were made;
    i. A large number of the respondents use the semi-mechanized technology to process their palm oil while the rest use the traditional technology
    ii. Processing equipment namely mortar and pestle (MP), digester with separate hand operated screw press (DSP), flushing extractor (FE) and the

digester with separate hand operated hydraulic press were identified in the Tano North and South districts. Also found were diesel engines and electric motors which are used as prime movers. Again big pots, fabricated tanks and drums were used for the boiling of the palm fruits. Alternatively fabricated steamers which conserve a lot of energy could be acquired and used to save cost.

iii. On processing activities, it was realized that the processors are deeply involved in the purchasing of the fresh fruit bunches, storage from 3-7 days to soften the fruits in the spikelets to enable easy threshing, drying of the fruits to expel moisture, boiling and digestion/pounding of the fruits, pressing of the pulp to release oil and finally drying the oil to eliminate moisture in the oil. It was observed that these activities apply to all the equipment except the digestion and pressing stages that differ due the type of processing equipment being used. It is worthy to note that none of the processors were found to clarify the oil to get rid of unwanted particles. This calls for training of the processors to adopt the clarification method.

3. On issues dealing with the differences that exist in the palm oil processing equipment in terms of the ease of use and maintenance, durability, effectiveness, appropriateness and profitability the following conclusions were drawn;

i. The traditional equipment which consisted of the mortar and pestle is the easiest to use, maintain and durable as well as the most appropriate for local consumers but is the least effective thereby generating least income.

ii. The most effective equipment was observed to be the digester with separate hand operated hydraulic press and also generates the highest

income but has been found to be a little difficult to use and maintain and again capital intensive. This is due to its complex nature.

4. Conclusions on the challenges that constrains the acquisition of improved processing equipment is that;

   Most processors do not have much problem in locating sources where agro processing machinery are manufactured but their major challenge lies with accessing credit to purchase equipment which they deem to be very expensive.

5.3 Recommendations

Palm oil processing has been identified to be one area that employs a lot of rural folks especially women and people in active working class therefore the following recommendations could help shape the industry to be a source of income for them.

1. Palm oil processors should be encouraged by agricultural extension officers to adopt modern equipment such as the digester with screw press also known as the palm oil expeller which has been found to be more effective.
2. Processors should be reached out and encouraged by institutions such as the banks and other financial organizations to adopt the culture of belonging to groups and saving to enable them qualify for credit to purchase improved equipment.
3. The processors should be supported by governmental and non- governmental organizations such as the District Assemblies, Rural Enterprises Programme, GRATIS Foundation, GIZ and many others to offload part of the cost of improved equipment as grant or can establish processing mills and monitor till processors are able to complete payment. This will go a long way to support

the processor to own mills which can be a form of industrializing the rural areas and also reduce poverty.

4. The Ministry of Food and Agriculture in collaboration with the Ministry of Trade and Industry should fund training programmes on proper palm oil processing methodologies that yield profit to support the palm oil processors. The training should also include technical orientations such as skills in proper operation and maintenance of machinery as well as simple management skills.
5. Engineers should be supported by their respective ministries, departments and agencies to do continuous redesign of the existing processing equipment to make it more women user friendly, effective and affordable especially the digester with separate hand operated hydraulic press and also come out with machines that are more appropriate and effective to our traditional methods of processing palm oil.
6. For further research, the traditional method of processing palm oil should be closely studied and a set of improved equipment that will be more appropriate to the traditional standards but will eliminate the drudgery and strenuous activities which is as well affordable should be designed and developed by scientists and engineers. Again, effective means of supporting processors to acquire credits as well as being credit worthy should also be researched into.

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APPENDIX

UNIVERSITY OF EDUCATION, WINNEBA

COLLEGE OF TECHNOLOGY EDUCATION

SCHOOL OF RESEARCH AND GRADUATE STUDIES

FACULTY OF TECHNICAL EDUCATION

DEPARTMENT MECHANICAL TECHNOLOGY EDUCATION, KUMASI

QUESTIONNAIRE FOR PALM OIL PROCESSORS

I am a second year MTECH student at the above named university conducting a research on Technologies used in Small Scale Palm Oil Processing Industries in the Tano North and South Districts in the Brong Ahafo Region of Ghana for my degree.

The objective of this questionnaire is to assess the status of the technologies used by small scale palm oil processors. It would help to reveal the strengths and weaknesses in the processing technologies which would go a long way to provide information for entrepreneurs, governmental and non-governmental organizations who wish to venture into palm oil processing.

Please, you should be rest assured that, any information you give out would be treated with maximum confidentiality. Your objectivity would be very much appreciated.

Thank you.

Please indicate your response by ticking (√), circling or supplying answers where appropriate.

1. District.

a. Tano South ( )

b. Tano North ( )

2. Sex?

a. Male ( )

b. Female ( )

3. What is your age?

a. Less than 21 ( )

b. 21-30 ( )

c. 31-40 ( )

d. 41-50 ( )

e. 51 and above ( )

4. Marital status

a. Married ( )

b. Single ( )

c. Divorced ( )

d. Widowed ( )

e. Separated ( )

5. How many children do you have? ……

6. Your Highest Educational level

   a. No formal education ( )

   b. Basic education ( )

   c. Secondary ( )

   d. Technical education ( )

   e. Tertiary education ( )

7. For how long have you been processing palm oil?

   a. ≤ 5 ( )

   b. 6-10 ( )

   c. 11-15 ( )

   d. 16-20 ( )

   e. ≥ 21 ( )

8. What is your status in this process industry?

   a. Mill Operator ( )

   b. Palm Processor ( )

   c. Sole owner ( )

   d. Member of joint owner ( )

9. What is the main source of capital for the business?

   a. Personal ( )

   b. Family ( )

c. Friends ( )

d. Bank ( )

10. The business is registered with

a. Registrar General's Department ( )

b. Local / District Assembly ( )

c. Ghana Standards Authority ( )

d. Food and Drugs Board ( )

11. What Technology do you use in your processing business?

a. Traditional ( )

b. Semi-mechanized ( )

c. Fully-mechanized ( )

12. List the specific machines you use in the process, source and age.

NO.	MACHINERY USED	SOURCE OF MACHINERY	AGE

13. State the processing activities and the practices employed.

……

……

……

……

……

……

14. To what extent do you agree to the following statements in relation to the ease of use of equipment?

No.	**Statement**	**1. Strongly disagree**	**2. Disagree**	**3. Neither agree nor disagree**	**4. Agree**	**5. Strongly Agree**
1	The equipment is easy to operate					
2	I need a lot of skills or learning					
3	Many hands are needed to work					
4	Fuel or power for processing is not readily available					

15. Indicate the extent to which you agree to the following statements in relation to maintenance of your equipment.

No.	Statement	1. Strongly disagree	2. Disagree	3. Neither agree nor disagree	4. Agree	5. Strongly Agree
1.	Spare parts are readily available					
2.	Spare parts can be manufactured by local artisans					
3.	Cost of spare parts is high					
4.	Repairs are readily available					
5.	Cost of repairs is high					

16. Have you abandoned any part of the equipment as a result of failure?

a. Yes ( )

b. No ( )

17. If yes, state those parts

……..

……

……

……

18. Which of these things affect your equipment? (Tick as many)

    a. Breakage ( )

    b. Rusting ( )

    c. Wear and tear ( )

    d. Theft ( )

19. How would you describe the frequency of breakdown of the equipment within a year?

a. Seldom ( )

b. Not often ( )

c. Often ( )

20. To what extent do you agree with the following statements in relation to effectiveness of the equipment?

No.	Statement	1. Strongly disagree	2. Disagree	3. Neither agree nor disagree	4. Agree	5. Strongly Agree
1.	I am able to produce large quantities in a short time					
2.	Labour required for use of the equipment is reduced					
3.	The value of output compared to input is high					
4.	Spillage is reduced					

21. Indicate the extent to which you agree to the following statements in relations to the appropriateness of the equipment.

No.	Statement	1. Strongly disagree	2. Disagree	3. Neither agree nor disagree	4. Agree	5. Strongly Agree
1.	The method is suitable for the kind of palm oil I am processing					
2.	Taste of oil is acceptable to consumers					
3.	The physical appearance of the oil is acceptable to the market					
4.	The method conforms to the traditional principles of processing					

22. How much capital was injected into the acquisition of the technology? (Please state in Ghana cedis (GH₵)…….

Please state the cost of materials and activities from Questions 23-28

23. One tonne of Fresh Fruit Bunches (FFB) …….
24. Fire wood/fibre/diesel (fuel) to process one tonne of FFB……
25. Water for processing one tonne of FFB ……
26. Wages of workers when one tonne of FFB is processed……
27. Amount that goes into maintenance and spare parts when one tonne of FFB is processed…….
28. Miscellaneous expenses done when one tonne of FFB is processed……..
29. What quantity of FFB is processed to realize one tonne of palm oil? ……
30. How much do you get as revenue when one tonne of FFB is processed into palm oil? ……..

31. Indicate the level to which you agree to the following statements in relation to the constraints in acquisition of improved technologies for palm oil processing?

No.	**Statement**	**1. Strongly disagree**	**2. Disagree**	**3. Neither agree nor disagree**	**4. Agree**	**5. Strongly Agree**
1.	Machines are not manufactured in the locality					
2.	Machines are too expensive					
3.	Cannot locate sources where machines can be acquired					
4.	Lack of credit to acquire machines					