



Artisanal Milling of Palm Oil in Cameroon

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Cover photo by Patrice Levang/IRD and CIFOR
Tournée-tournée manual palm oil press in Mbongo, Littoral Region

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Abbreviations

CIFOR	Centre for International Forestry Research
CIG	Common initiative group
CPO	Crude palm oil
CR	Centre region
DO	Divisional officer
DTP	Dura, tenera and pisifera
EFB	Empty fruit bunch
FAO	Food and Agriculture Organization of the United Nations
FCFA	Franc de la Communauté Financière Africaine
FFA	Free fatty acid
FFB	Fresh fruit bunch
HP	Hydraulic press
Ha	Hectare
LR	Littoral Region
MINADER	Ministry of Agriculture and Rural Development
MINEPIA	Ministry of Fisheries, Animal Industries and Veterinary Medicine
MINFOF	Ministry of Forestry and Wildlife
NGO	Non Governmental Organization
OPP	Oil palm plantation
PAMOL	Pamol Plantations limited
POM	Palm oil mill
POP	Palm oil processing
PV	Plantations villageoises (small- and medium-sized holdings)
SDO	Senior Divisional Officer
SGSOC	Sithe Global Sustainable Oils Cameroon
SH	Smallholder

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Introduction

The oil palm (*Elaeis guineensis* Jacq.) is a perennial tree crop of the Arecaceae family (Rieger 2012). It is native to the countries bordering the Gulf of Guinea (Hoyle and Levang 2012), with the main belts running through the southern latitudes of Cameroon, Ivory Coast, Ghana, Liberia, Nigeria, Sierra Leone and into the equatorial region of Angola and Congo (Bakoume and Mahboub 2006; Carrere 2006). In the wild, the oil palm fruit occurs in two forms, termed *dura* (with a large kernel) and *pisifera* (having no shell and yet sterile). *Tenera* is a hybrid from *dura* and *pisifera*, and the most cultivated variety because it produces fruits with higher oil content (Rieger 2012). It is the preferred commercial variety cultivated by agro-industries in Cameroon and smallholders close to the agro-industrial areas (Hoyle and Levang 2012).

Processing oil-palm fruits for edible oil has been practised in Africa for thousands of years, and the highly colored and flavored oil produced is an essential ingredient in much of traditional West African cuisine. This crop is versatile and its products [such as palm oil, sauces, soap, wine, fertilizer (ashes), roofing (leaves), building material (trunk), medicines (roots)] are of great economic value in West and Central Africa (Carrere 2010; Ibitoye et al. 2011). For centuries, oil palm has provided local communities with a large number of benefits. Its primary purpose until now has been the extraction of palm oil (from the flesh of the oil palm fruit) and palm kernel oil (from its kernel or seed) for the production of edible and industrial oils (Carrere 2006). Palm kernel waste (after the oil has been extracted) is also used as animal feed and in co-firing in electricity generation. The palm oil industry is worth at least USD 20 billion annually (Hoyle and Levang 2012).

The production of palm oil can be grouped into traditional (artisanal) and industrial milling (Carrere 2010). Modern processing of oil-palm fruit bunches into edible oil (CPO) may be categorized into traditional methods, small-scale mechanical units, medium-scale mills and large industrial mills depending on the degree of complexity. In Cameroon, the production is stratified in three

sectors: an agro-industrial sector, smallholders (SH) in contract with agro-industries and a traditional independent artisanal sector (Bakoume et al. 2002). The traditional process is simple, but tedious and rather inefficient.

Red or Crude palm oil (CPO) is an important source of vitamin A (Atinmo and Bakre 2003) obtained from the transformation of loose palm nuts. The process entails activities that provide many job opportunities to rural people at different levels (skilled and unskilled, formal and informal). This helps in income generation and poverty reduction in the rural setting. The women are involved in different stages of production and commercialization of CPO to assist in the upkeep of their families (Ibeckwe 2008).

Cameroon is ranked the world's 13th largest producer of palm oil. In 2010, it was estimated that Cameroon produced 230,000 tons annually (MINADER, pers. com). Oil palm production in Cameroon increased following the drop in the prices of cocoa and coffee in the early 1990s, which at that time were the major commercial farming crops in the country. This caused many smallholders in the ecologically suitable areas to switch to planting oil palm (Ngando et al. 2011). This is further illustrated by the fact that the purchase of germinated oil palm seeds (chitted nuts) by small- and medium-sized farmers at the Centre for Oil Palm Research at La Dibamba (Cameroon) rose from 20% of the total production in 1996 to an average of 60% during the past 10 years. It is thus estimated that about 5,000 ha of oil palm were planted by small- and medium-sized farmers each year during the last decade, making a total of about 90,000 ha for the non-industrial palm grove in Cameroon (Bakoume and Mahboub 2006). This increase in the number of oil palm smallholders and oil palm plantations has equally resulted in an increase in the number of artisanal oil palm presses in the palm oil production basins in Cameroon. The upsurge has been more in communities around the oil palm agro-industrial corporations of SOCAPALM, CDC and PAMOL Plc, probably initiated by the operations of the corporations.

The present survey has two main objectives:

- To investigate the artisanal processing of fresh fruit bunches (FFB) into red oil and the processing of the kernel into kernel oil.

More specifically to

- determine those involved in artisanal palm oil processing
- identify the different types of artisanal palm oil presses in the production basins
- describe each processing type (value chain) and the relative advantage of one type over the other (with respect to time, quantity of oil/ton FFB or extraction efficiency and quality control methods put in place)
- assess the return to labor, milling charge and contribution to income for each type of oil palm mill

- determine those involved in the processing of kernel into kernel oil and the production of local soap and by-products, and describe the methods and profit margins in this type of business.

- To investigate the commercialization of CPO in domestic markets.

More specifically to

- identify those involved in the sale of CPO in domestic markets
- describe the market chains — artisanal or informal (wholesalers and retailers alike) — and industry
- describe the fluctuation in the prices of a liter of CPO in the local market over the years in village, town and city
- assess the contribution of income generated from sales of CPO to household livelihood.

1. Materials and methods

This study was carried out in three major palm oil basins in Cameroon located around the oil palm agro-industrial zones of Eseka, Lobe and Dibombari, respectively in Centre, South-West and Littoral regions of the Republic of Cameroon.

These regions meet the required biophysical conditions for the growth and development of oil palm. These conditions as put forth by Better Crops International (1999) include:

- High temperatures all year round, between 25–28° C.
- Sufficient sunshine: At least five hours of sun per day.
- High precipitation: Evenly distributed rainfall 1,800 – 2,400 mm/year without dry spells for more than 90 days; higher rainfall can be tolerated as long as soils are well drained.

- Soils: Oil palm prefers rich, free-draining soils, but can also adapt to poor soils with adequate use of fertilizer.
- Low altitude: Ideally below 500m asl.

Agriculture, including palm oil milling, is the predominant economic activity in these regions and serves as the main source of livelihood for over 90% of the population. This study was carried out for two months that is, one month of field work and data collection, and another for data analysis and reporting. Secondary data (literature review), interviews, field observations and survey methods were applied in order to obtain the required information.

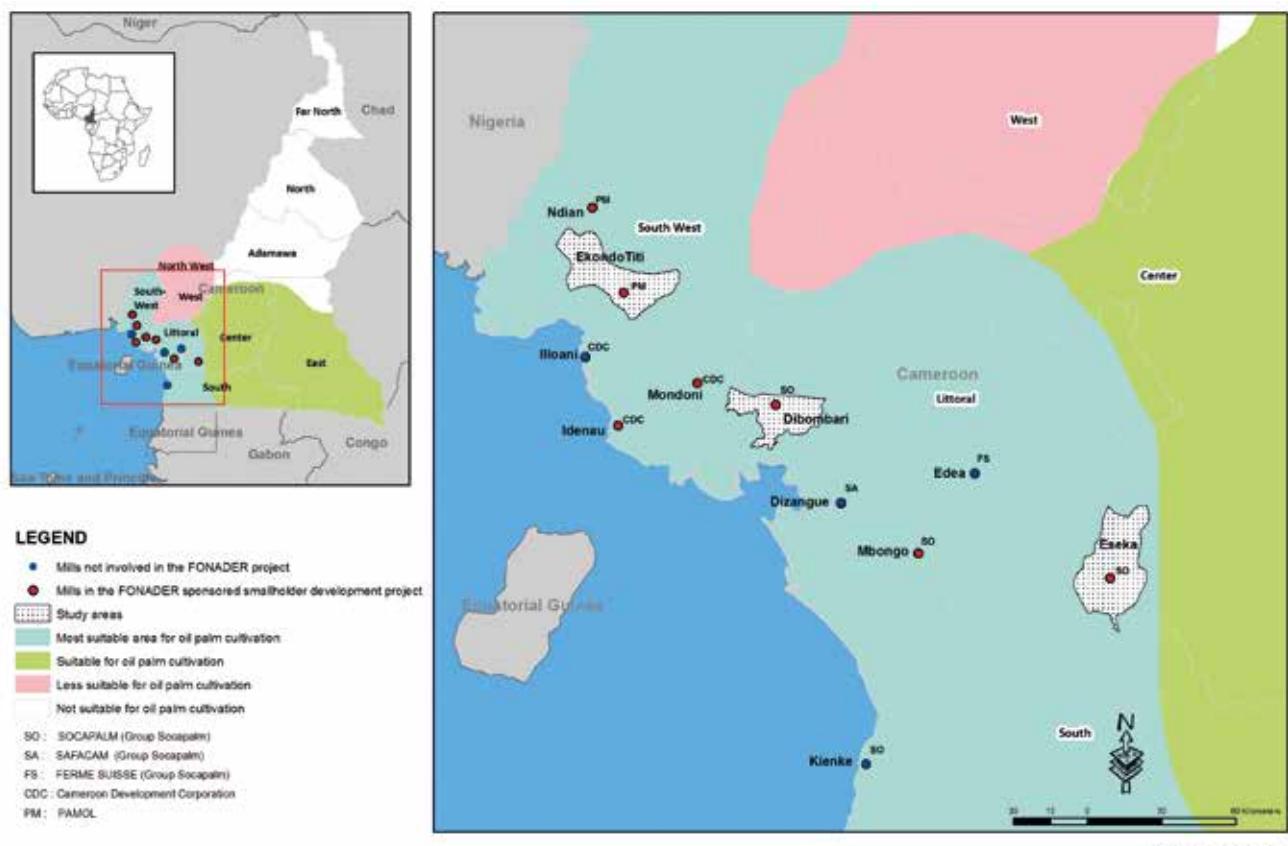


Figure 1. Map of Cameroon showing study locations

During the field survey, the representative agro-industrial corporation of the area was visited and the objectives of the study discussed with a contact person in charge of smallholders in the environment. The villages to be surveyed were systematically selected based on the availability of palm oil mills, smallholders and intermediaries. Structured and semi-structured interviews were conducted to randomly selected respondents in the villages within the areas.

Questionnaires were administered to at least 50 respondents in each zone, ranging from owners and/or managers of artisanal oil palm mills to smallholders and intermediaries (men, women and youths) who take part in the transformation and commercialization of red palm oil (RPO) in the respective areas. Informal interviews were also conducted with women/men who buy and sell palm oil in local markets. Information was also obtained through observation, dialogue and listening. Photographs of the different types of presses, and milling activities with labor, were taken in the different zones.

Data collection sheets were prepared in accordance with the main and specific objectives of the study. Information obtained from the questionnaires was transmitted into a database for eventual analysis using Microsoft Excel 2010. Descriptive statistics was applied with use of tables, frequencies and bar charts.

The net returns (NR) were calculated as:

$$NR = TR - TC$$

Where, $TR = P_i Q_i$, and $TC = \sum_{i=0}^n P_{xi} X_i$

NR is the net return, TR, total revenue from sales per ton of palm oil produced, P_i , price per ton of oil, Q_i , quantity of sales made, TC, total cost of operation per ton of oil produced, P_{xi} = the price of the i^{th} input, and X_i is the i^{th} input. (Ross et al. 2001).

2. Results and discussion

2.1 Small-scale artisanal milling

Before the advent of artisanal mills/presses, smallholders had local/wild varieties that they processed using traditional methods, either by pounding cooked fruits in large wooden or concrete mortars with wooden pestles or by foot-trampling the cooked but cold fruits in specially constructed wooden troughs. The oil was extracted by pressing the pounded nuts with the aid of a bag and a stick.

The agro-industrial corporations later introduced the improved variety wherein the smallholders had an agreement to supply their produce to them at a cost that varied with the area and corporation. As time went on, production increased and often the corporation could not meet up with the processing of all FFBs from smallholder farms. This occurred because accessibility to some farms also hindered transportation. Moreover, the administrative procedures put forth to accept FFBs and pay for the product delivered were considered inappropriate and too slow by the smallholders. The tonnage was reduced at the weighing bridge of the corporation either because the FFBs were too bruised, not yet mature or rotten. It became a cause for concern to the smallholders and they devised a means to curb the losses and generate more income from processing of FFBs to palm oil. It was based on this precept that they resorted to artisanal transformation of FFBs to crude palm oil.

Two distinct palm-oil production seasons were recorded: peak and low. The peak season ranged from February to May, and low season from June through January. Triangulation from the respondents revealed a transition period from low to peak season, which some smallholders described as mid-peak. Taking the mid-peak season into consideration, the peak season was recorded from February to May, low season from June to September and the transition or mid-peak season from October to January.

2.2 Processing of fresh fruit bunches (FFBs) into red oil

Those involved in artisanal palm oil processing

The personal information and type of service provided by respondents indicated a trend of those involved in artisanal palm oil processing (POP) in the study area.

Gender: More men are involved in artisanal milling than women in all areas. In Eseka, up to 20% of women had an oil palm plantation (OPP) or a palm oil mill (POM). In Lobe and Dibombari, less than 20% of the women were involved in artisanal milling. Women were limited by land tenure and acquisition rights to own a plantation, as well as by capital and skills needed to own and manage activities in palm oil mills.

Age group: A greater percentage of the respondents were within the age range of 31–40 and 41–50 years. This illustrates that it is a business for the active population.

Education: The levels of education were basically primary school leavers and junior high school drop outs. Information from the respondents with high school and university certificates showed that over 90% of them use the business as a means to raise capital for further studies or to travel abroad. Good management of the OPP and POM requires education to aid in transfer of improved practices in palm oil production (Ibitoye et al. 2011).

Marital status: At least 70% of the respondents in the area were married and had their families actively participating in the processing of red palm oil. Unlike singles/bachelors, the married people had their families as immediate source of labor. In Eseka and Dibombari, family members were involved in all stages of the milling activities whereas in Lobe, hired labor was dominant.

Table 1. Distribution of respondents in the study areas.

Variables	Percentage of respondents per area		
	Eseka	Lobe	Dibombari
Gender			
Male	78	86	86
Female	22	14	14
Age group			
≤ 30	22	20	18
31 – 40	28	28	32
41 – 50	24	30	32
51 – 60	8	10	8
> 60	18	12	10
Average ages (years)	43.4	43	41.2
Ethnic group			
Native	94	32	76
Non-native	6	68	24
Level of education			
None	4	0	2
Primary	36	40	3
Junior high school	38	36	42
High school	14	16	14
University	8	8	12
Marital status			
Single	20	14	28
Married	78	78	70
Widow(er)	0	6	2
Divorcee	2	2	0

Source: Field survey, 2012

Ethnic group: The indigenes in the study area are: Bassa in Eseka, Balondo (Oroko) in Lobe and Ahbor (Douala) in Dibombari. In Eseka and Dibombari areas, milling of red palm oil is dominated by natives and in Lobe by non-natives. They get involved in ownership of oil palm plantations, palm oil mills, buying of FFBs from other smallholders, hiring of labor to process FFBs/loosened nuts and sales of CPO.

Also, in Eseka, women have the same access to land for establishment of oil palm plantation and/or palm oil mill as the men though these rights were limited to natives only. The customary rights in this area did not prohibit indigenous women from owning/inheriting land, but did not grant access to land to non-indigenes. In Lobe and Dibombari zones, natives and non-natives alike had access to land for various uses provided they are financially viable and meet up with the conditions put forth by the traditional council.

Type of service providers/processors

Mill owner only: Those who own palm oil mills and either employ or do not employ a manager.

Mill manager only: Those who do not have a mill but have been hired/employed by the owner or common initiative group (CIG) to manage the POM.

Smallholder (SH) only: Owners of oil palm plantations (OPP). They neither own a POM nor buy FFBs. They process only fruits from their farms and pay mill charges.

Intermediary only: Men, women or youths who buy FFBs from SHs and process. Do not own a POM or OPP.

Mill owner and smallholder: Those who own mills and also have OPP.

Mill owner, smallholder and intermediary: Those who own POMs, OPPs and also buy FFBs from other smallholders.

Mill manager and smallholder: Those hired by a POM owner to manage the mill. They also have an OPP.

Mill manager and intermediary: Those hired by a POM owner to manage the mill. They also buy FFBs from SHs to process.

Mill manager, smallholder and intermediary: SHs with OPP, hired by a POM owner to manage his mill. They also buy FFBs from other SHs to process.

Smallholder and intermediary: A smallholder with OPP who buys FFBs from other SHs in addition to his/her harvests to process, but neither owns nor manages a POM.

The distribution of the service providers are represented in Table 2.

Mill managers and smallholders were the dominant service providers in the study area with a frequency of 34 respondents. The degree of complexity in palm oil processing in Eseka is limited with manual press dominating the POMs and few motorized presses. As such, mill owners are virtually the smallholders in

the area. In Lobe and Dibombari, managers are hired to assist in the POM and owners get involved in farming, intermediary businesses and other income-generating activities.

Types of artisanal palm oil presses

There are two distinct methods of extracting oil from the digested material. The “dry method” uses mechanical presses and the “wet” method uses hot water to leach out the oil. The objective of the “dry” method is to squeeze the oil out of a mixture of oil, moisture, fiber and nuts by applying mechanical pressure on the digested mash.

The different types of presses identified in the three areas reflect the degree of complexity of the POMs. Generally, six types of palm oil presses were observed and identified (from literature study) in the study area. They include

- manual press without a digester locally called *tournée tournée* (manual vertical press); this press adopts the wet process where-in the sterilized fruits are poured into the digester and the fruits macerated by manually turning the vertical shaft to extract a mixture of oil and water, which is collected at the base. The resultant mixture of water and oil is poured into larger drums. This

Table 2. Distribution of respondents by type of service provider/processor.

Type of service provider	Frequency of service provider in:			Total frequency in the three areas
	Eseka	Lobe	Dibombari	
Mill owner only	0	1	2	3
Mill manager only	0	1	1	2
Smallholder (SH) only	7	7	2	16
Intermediary only	6	2	4	12
Mill owner and smallholder	15	7	7	29
Mill owner and intermediary	0	2	5	7
Mill owner, smallholder and intermediary	2	2	10	14
Mill manager and smallholder	14	13	7	34
Mill manager and intermediary	0	1	6	7
Mill manager, smallholder and intermediary	2	10	4	16
Smallholder and intermediary	4	4	2	10
Total	50	50	50	150

Source: Field survey 2012

- mixture is then boiled to extract the oil that is going to suspend.
- motorized press (motorized horizontal screw press); this press adopts the wet process technique where-in sterilized fruits are poured into the digester and the fruits are macerated. Hot water is continuously poured into the digester at a regular rate to wash off the released oil. The resultant mixture of water and oil is poured into larger drums. This mixture is then boiled to extract the oil that is going to suspend.
 - manual or hand press with a digester adapted to a car engine [digester with separate metallic cage press (hand operated screw press)]; this press adopts the dry process. A vertical digester adapted to a car engine is used in the maceration process. A mixture of oil, moisture, fiber and nuts is collected at the base and this mixture is hand-pressed in a metallic cage to extract the oil.
 - digester with separate hydraulic press; this press adopts the dry process technique wherein sterilized fruits are poured into the digester and the fruits are macerated. A mixture of oil, moisture, fiber and nuts is collected at the base and this mixture is pressed using a hydraulic press to extract the oil.
 - combined motorized hydraulic digester and press system (digester screw press); this press also adopts the dry process technique. In this press, the digester is linked to the press through an operating table upon which cage presses can slide between stations.

- semi-automated press; this press also adopts the dry press technique. Here little or no human labor is needed as the majority of the different stages (from loading for sterilization through to pressing) involved in oil extraction are mechanized. This press system is the most efficient and the most expensive and that therefore makes it unaffordable to the majority of smallholders.

The manual vertical press was the most frequent type of processing equipment in the area, while semi-automated was the least frequent (2), found only in Ekondo-Titi and Maleke, respectively in Lobe and Dibombari areas. They were owned and managed by PALMAGRO and FACAM common initiative groups (CIGs) respectively. Generally, the following activities were carried out in the POMs as represented on the scheme below.

The processes above apply to presses with digesters such as digester with separate manual metallic cage press, combined motorized hydraulic digester and press system (digester screw press), digester with separate hydraulic press and semi-automated press. The manual vertical press and motorized horizontal screw press do not have digesters. As such, the boiled nuts are loaded directly into the press and nuts are pressed either manually or mechanically.

Table 3. Type of processing equipment used

Type of processing equipment	Frequency of equipment used by respondents			Distribution of types of presses in the study area
	Eseka	Lobe	Dibombari	
Manual vertical press	44	1	22	67
Motorized horizontal screw press	6	0	25	31
Combined motorized hydraulic digester and press system (digester screw press)	0	5	0	5
Digester with separate manual metallic cage press (hand- operated screw press)	0	35	1	36
Digester with separate hydraulic press	0	8	1	9
Semi-automated press	0	1	1	2

Source: Field survey 2012



Picture 1. Manual vertical press



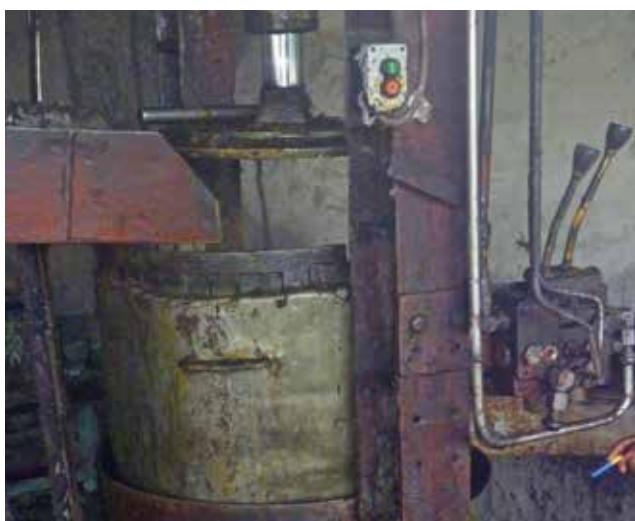
Picture 2. Motorized horizontal press



Picture 3. Combined motorized hydraulic machine and press system



Picture 4. Semi-automated press (side view)



Picture 5. Semi-automated press (side view)



Picture 6. In-built metallic drums for CPO clarification

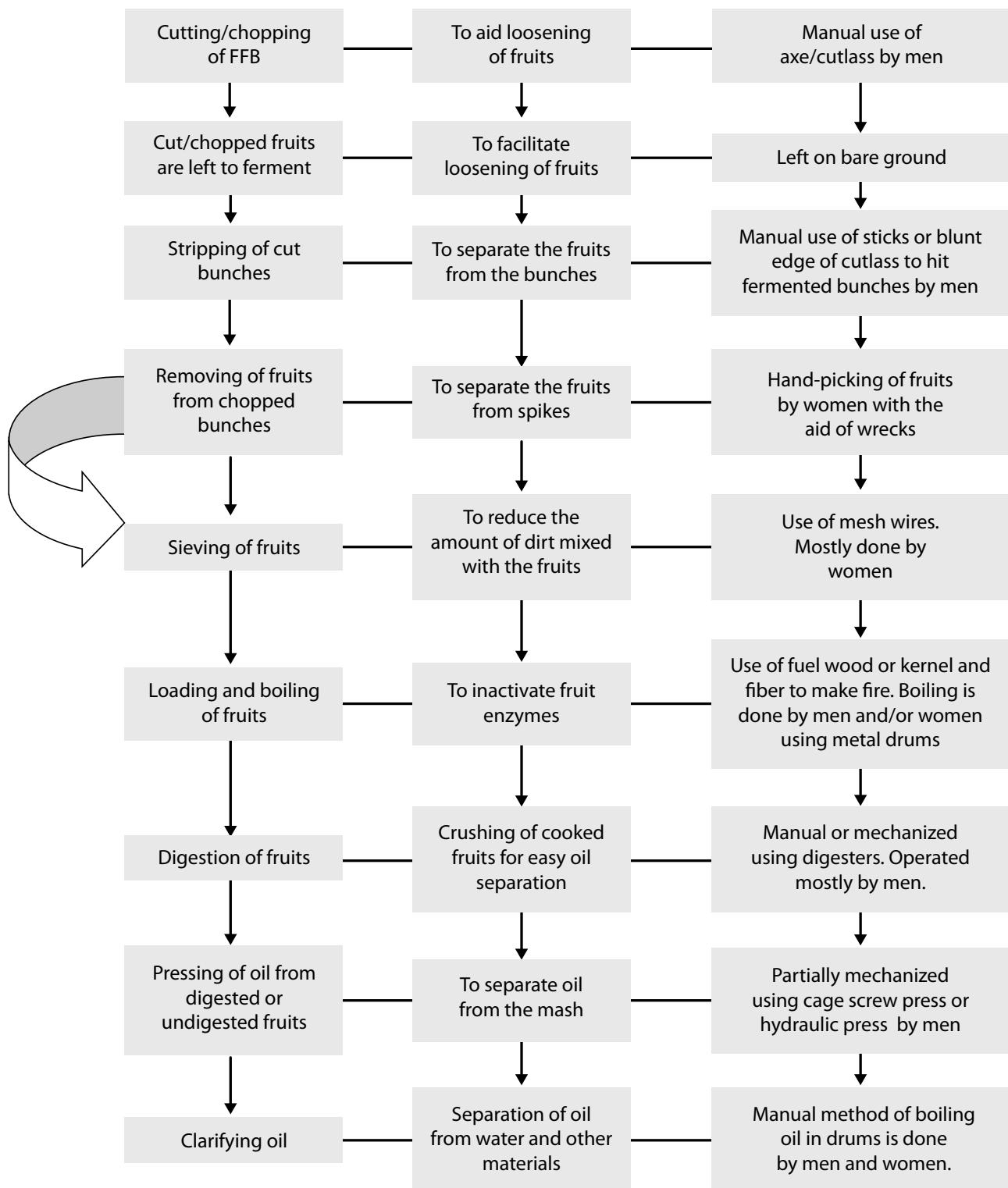


Figure 2. Schematic representation of milling activities

In the Lobe area, a section of the communities (Ekondo-Titi and Bekora) have been allocated a specific area for construction of POMs and processing of palm oil. These sites were described as industrial zone for the production of "Red Gold". This shows the recognition of red palm oil processing as an industrial activity in the area. It provides job opportunities to inhabitants for both skilled (such as mill managing) and unskilled labor (such as harvesting, chopping and cutting of FFBs, stripping, loading, boiling, pressing of loosed nuts and clarification of red palm oil).

Processing (value-chain) and relative advantage of various types

Processing

The value chain of the mill was determined by the type of press used in processing the red palm oil. Six different types of presses were identified in the study area as represented above. The transformation of FFBs to CPO involves a number of activities. After harvesting, the FFBs are transported to the palm oil mill, allowed to ferment for an average of 5–7 days before FFBs are shredded into pieces. The major operating activities at the mills include splitting (cutting) and/ or chopping (shredding) of FFBs, stripping to separate fruits from bunches, selecting and sieving of stripped nuts using wreck and mesh wires respectively, loading and boiling of nuts, crushing of boiled nuts pressing and clarifying the red palm oil. Of these, only digestion and pressing are either fully or partially mechanized.



Picture 7. Chopped or shredded FFBs

Splitting/Chopping of FFBs: This process involves the use of an axe or cutlass and it is usually performed by men due to the strength required. Splitting is usually done on bare ground. Splitting or chopping results in fruit bruises that lead to reaction within the oil cells thereby increasing the free fatty acid (FFA) content of the oil. In order to limit this reaction within the oil cells, FFB should be handled with care (Ngando et al. 2011).

Storage of cut/chopped bunches: After chopping/ cutting of the FFBs, they are stored in heaps for 5–7 days to facilitate easy loosening or removal of fruits from spikelet. This method of storage facilitates the wilting of the tissue connecting the fruit to the bunch/spikelet, thereby causing the fruit to easily detach from the bunch/spikelet during stripping. The fermentation process further increases the FFA content. Poor and lengthy storage of fruits lead to a considerable increase in FFA that affects the quality of palm oil produced from the loose nuts (Corley et al. 2003; Owolarafe et al. 2008; Ngando et al. 2011). Where quality control methods are applied in processing, it is recommended that palm fruits should be processed within 48 hours after harvesting. This is to stop the action of lytic enzymes and prevent the production of FFA (Poku 2002). The field survey revealed that these fruits were stored for some days prior to processing due to the following reasons:



Picture 8. Halves of cut FFBs

- i) Difficulty in the detaching of fruits from the bunch immediately after harvesting to prepare for boiling.
- ii) Fruit storage is believed to increase oil content as the mesocarp of the fruits becomes soft and easier to press after storage and fermentation. This perception is in contrast to the findings of Badmus (1991) and Tan et al. (2009) who consider that the fermentation process results in low quality oil and increases FFA levels.
- iii) Fruit storage is also believed to reduce the moisture content of the fruits, consequently leading to a lower quantity of palm-oil mill effluent.

Stripping of cut bunches: After softening of the fruits, these bunches are stripped using sticks or the blunt edge of a cutlass to remove any nut that is still attached to the bunch. Stripping is mostly done by men and the average cost per ton of FFB is 2,579 FCFA, 896 FCFA and 1,550 FCFA for Eseka, Lobe and Dibombari respectively.

Sieving: Sieving is done to reduce the amount of dirt mixed with the fruits before boiling. It is done with the use of locally fabricated mesh wires and usually by women. The average cost of sieving oil palm fruits stripped from a ton of FFB ranges from 1,971 FCFA



Picture 9. Sieving of palm fruits

for Eseka, 681 FCFA for Lobe and 1,056 FCFA for Dibombari. After sieving, the nuts are loaded into metallic drums ranging from 200 liters as was observed in Eseka and some mills in Dibombari to 1,000 liters in volume as observed in Lobe and some mills in Dibombari as well. These drums were filled with at least 35 – 140 liters of water depending on the size of the drum before boiling.

Boiling of fruits: After loading of the drums (on fire stand) with fruits and required quantity of water poured into it, fire is lit beneath using wood and palm kernel mixed with fibers from the waste of palm oil extraction. Fuel is constantly added to provide sufficient fire throughout the cooking. Old cloths and at times jute bags are placed over the filled drums to conserve heat and reduce the loss of vapor from the top. The fruits are expected to be ready after boiling on intensive heat for an average of four hours. Some processors allow the boiled fruits overnight on the fire to ensure they are well cooked. In such instances, the fruits are re-boiled (warmed) early in the morning, before starting with the digestion or pressing process. Boiling is considered to be one of the major operations in the processing of palm fruits. The objective of boiling is primarily to soften the fruits and also to inactivate enzymes, conditioning of nuts and coagulation of proteins (Babatunde et al. 2003; Chaw and Ma 2007).

Digestion (Crushing) and pressing: Digestion is the process by which boiled or sterilized fruits are macerated for easy separation of oil from the fiber. This involves crushing and detachment of the heat-weakened mesocarp from fruit nuts. This process is highly mechanized and most of the mills visited in the study area performed this operation with the aid of a machine. Pressing has two major processes: continuous and discontinuous (Jannot 2000). In the **continuous** process, the boiled fruits are pressed using either a manual vertical or motorized horizontal press. In this case, the oil mixed with water and sludge is collected at one end while the waste is emptied at another end. In the **discontinuous** process, the boiled fruits are crushed or digested in a separate machine and pressed to extract oil in another machine, which can either be joint or not to the previous one. After the fruits are crushed, the crushed material is pressed to release oil as shown in pictures 10 and 11.



Picture 10. Crushed material emptied into metallic cage



Picture 11. Crushed material pressed to extract RPO using hydraulic press

With the combined motorized hydraulic digester and press system (digester screw press), the crushing/digestion and pressing is done by a single machine; for the digester with separate manual metallic cage press (hand-operated screw press) or hydraulic press, the crushing of boiled fruits is performed by the mechanical digester and the pressing is done either by a separate hydraulic or metallic cage (hand-operated screw press).

The processing capacity of the metallic cage press (hand-operated screw press) is limited by the extra energy put in by the mill workers to load crushed fruits and to operate the equipment, whereas the hydraulic press does not require extra energy in the operation.

The combined motorized hydraulic digester and press system (digester screw press) is more economical in terms of labor, material and surface area required. It also generates more revenue than the manual vertical press and a motorized horizontal screw press. The introduction of the combined motorized hydraulic digester and press therefore improves on the milling efficiency and the capacity of processing equipment.

Clarifying: Clarification is the last major operation in the production of red palm oil. After oil processing, the sludge is steamed/boiled to separate the oil from the effluent. The clarifying process was either manual or mechanized in the mills visited. In POMs operating the manual vertical press and motorized



Picture 12. RPO directed into well built-in hole



Picture 13. RPO filled into containers

This oil is collected and poured into drums of about 200-litre capacity and allowed to settle.

Quality control methods put in place

Some artisanal palm oil mills endeavor to put in quality control measures:

- During selection/sieving, bad nuts are separated from good nuts to ensure resulting CPO is of high quality.
- CPO collected as well as sludge is steamed and allowed to cool before filling in containers.
- The FACAM CIG that operates a semi-automated palm oil mill at Maleke sterilizes the FFBs before processing proper as a quality control method.

Other than the quality control methods which are already being put in place, more needs to be done, including:

- Reduction in the duration of the fermentation process so as to reduce the amount of FFA content in palm oil.
- Use of hygienic equipment by mill workers from one stage to the next during the milling process.
- Reduction in the moisture content of oil by carrying out efficient clarification. The duration

of steaming should be monitored. The aim of steaming is to convert the crude oil to edible oil by removing impurities to desired levels in the most efficient manner. If done properly, the red-color, carotene-rich oil is produced with the retention of the beneficial carotene, tocopherols and tocotrienols, which are known to possess special nutritional attributes (Affandi 2010). If steaming is done for a longer duration, the CPO loses the red color and other desirable components.

- Storage of palm oil for a limited time to avoid it becoming rancid.
- Construction of well-dug trenches for the discharge of effluent from the mill.
- Recycling of empty fruit bunches (EFB) on farms as manure.
- Building pots in oven-like structures to minimize the release of heat into the surroundings, which is usually dangerous and uncomfortable to workers.
- Construction of chimneys in each mill such that smoke can easily go out in one direction.
- Introduction of modern machines with improved oil extraction rate.

Production efficiency of the different types of presses

The different types of presses and their efficiency in the respective areas was assessed, as well as the average time taken for each type to process 1 ton of FFB and also the average quantity of CPO generated per ton of FFB in peak and low seasons. Results are presented by type of press (Cf. table 4). The extraction efficiency of POMs was obtained by extrapolation

from the quantity (in liters) of CPO produced from 1 ton of FFB and the density of 1 liter of palm oil 0.9 kg (Ngom pers. comm.).

Therefore; **Extraction efficiency (%) = (M*N).**

Where M = Quantity of oil in liters per ton of FFB and N = density (kg) in volume per ton of FFB.
For example, if 1 ton FFB=200L of CPO, it implies $200 \times 0.9 = 180 \text{ kg} = 18\%$

Table 4. Average production efficiency of different types of presses

Efficiency parameter	Type of presses					
	Manual vertical press	Digester with separate manual metallic cage press	Motorized horizontal screw press	Digester with separate hydraulic press	Combined motorized hydraulic digester and press system	Semi-automated press
Average time (hours) to process 1 ton	8	6	5	4	3.5	2
Average quantity (in L) of CPO/ton of FFB in peak season	148.86	156.94	163.55	166.22	167.77	200.00
Average quantity (in kg) per ton of FFB in peak season	133.98	141.25	147.20	149.60	151.00	180.00
Extraction efficiency (%) in peak season	13.3%	14.1%	14.7%	14.9%	15.1%	18.0%
Average quantity (in L) of CPO/ton of FFB in low season	142.77	149.44	152.04	160.83	162.22	200.00
Average quantity (in kg) per ton of FFB low season	128.50	134.50	136.84	144.75	146.00	180.00
Extraction efficiency (%) in low season	12.8%	13.4%	13.6%	14.4%	14.6%	18.0%

Table 5. Relative extraction efficiency (%) per ton of FFB during the peak and low seasons in the area

Quantity of CPO (in kg) per ton of FFB	Extraction efficiency (%)	Eseka (% of respondents)		Lobe (% of respondents)		Dibombari (% of respondents)		Average in study area (%)	
		Peak (P)	Low (L)	P	L	P	L	P	L
≤150	≤15	74	78	42	66	50	66	55	70
151-200	15.1-20	26	22	58	34	50	34	45	30
201-250	20.1-25	0	0	0	0	0	0	0	0

Extraction rates differ with the different equipment types.

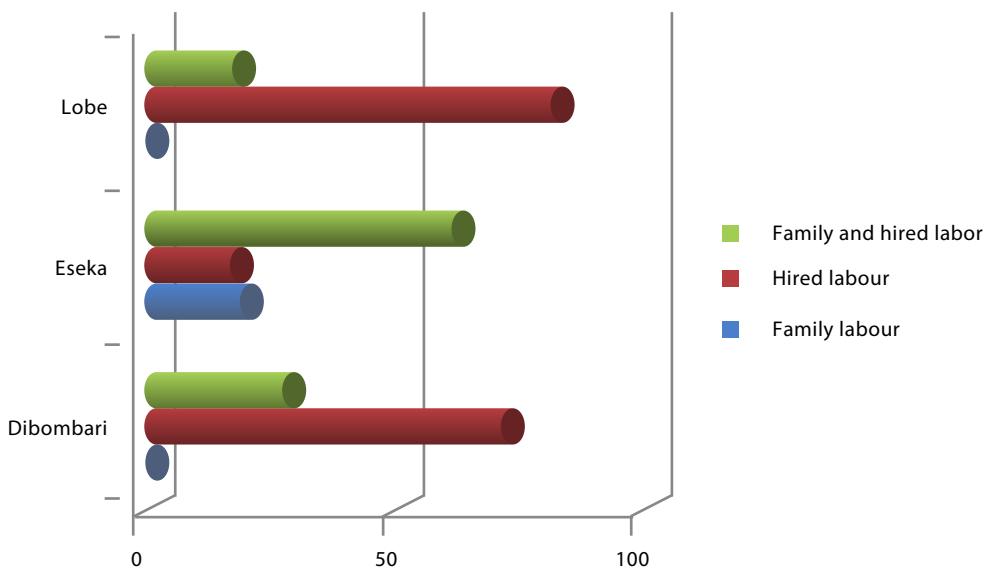
From the table above, during the peak season, an average of 55 % of respondents POMs had an extraction efficiency ≤15 % in the three study areas. This was followed by 45%, for extraction efficiencies ranging from 15.1 – 20%. No POMs had extraction efficiencies of 20–25%.

The return to labor, milling charge and contribution to income

The type of labor incorporated into the milling process was either family, hired or both. Hired labor was paid per activity, while family labor was compensated through different forms of motivations.

In Eseka, where family labor was dominant, some parents gave their children a portion of the oil palm plantation to control and process the FFBs to enable them to take care of their basic necessities. Others believed the milling activity was for the upkeep of the family; therefore, labor rendered by family members is not paid but motivated. This goes to confirm the findings of Adegeye (1993) that family labor is very important and minimizes cost in palm oil production.

Men and women were involved in different stages of production, with women actively involved in sieving, loading and boiling. The women contributed to family and/or hired labor in the process.

**Figure 3. Contribution of family and hired labor**

Hired labor was paid for per activity and the average cost per activity in the areas was verified as represented on the table below. Artisanal oil palm processing clearly provides important indirect employment.

The high net income in Lobe area during peak season is probably due to the low cost of labor per activity relative to other areas and the total labor cost is less than that of Eseka and Dibombari. Furthermore, buyers come in during the dry season. During the

rainy season, few buyers come in, leading to a drop in prices irrespective of the low cost of labor. Dibombari zone has a high net-income especially in low season because of accessibility. Buyers who find it difficult to go to Lobe or Eseka during the rainy season can always afford to go to Dibombari and thus the high prices for palm oil.

The contribution to income for each type of processing unit also varied in the study areas.

Table 6. Average labor cost per activity in the processing of 1 ton of FFB

Activity	Average cost (FCFA) per activity per area per 1 ton of FFB			Average cost (FCFA) per activity per 1 ton of FFB
	Eseka	Lobe	Dibombari	
Chopping/shredding			1750	1750
Splitting	2125	1343	2023	1830
Stripping	2579	896	1550	1675
Sieving	1971	681	1056	1236
Loading	1156	528	936	873
Boiling	1300	979	1848	1376
Off-loading boiled nuts	1107	400	1081	863
Digesting (where necessary)		600		600
Pressing	3759	1878	2542	2726
Thinning/steaming	667	867	1024	853
Total labor cost:	Peak	8845	7869	8812
	Low	8435	7869	8812
Milling cost:	Peak	7139	3727	5414
	Low	9410	3727	6171
Other cost		758	1488	1123
Total expenditure:	Peak	30437	30775	37618
	Low	30973	36238	39984
Gross income:	Peak	57160	66225	69825
	Low	76131	77675	86608
Net income :	Peak	26723	35451	32207
	Low	45158	41234	46556

Source: Field survey, 2012

2.3 The production of kernel oil and soap

Some respondents in the production areas were involved in the extraction of kernel oil from palm kernel and also the production of soap from the last grade of palm oil. Fiber-kernel separators in use were observed only in the Dibombari area as in picture 14. Fiber-kernel separators are used to detach the palm kernel from the fibers and the kernels sold to buyers especially from Douala at an average price of 50 FCFA/kg. Loaded bags of kernels were observed as in picture 15.

Respondents who owned fiber-kernel separators like that in picture 14 said a ton of FFB gives 100 kg of palm kernel (as in picture 15). The extraction rate for kernel oil is 3–4%.

Average price (FCFA) of kernel = 38 FCFA/kg.

Average price (FCFA) of kernel oil = 688 FCFA/liter.



Picture 14. Fiber-kernel separator

Extraction of kernel oil from palm kernel was recorded in Eseka and Dibombari sections of the study. The production was in small scales for home use or sold at an average of 700 FCFA/L. Soap making was recorded only in Eseka and production was also in small scale for home use only. The soap was known locally as “sabula”. Women were the only gender involved in soap making and extraction of kernel oil.

Method of production

Kernel oil: The extraction of kernel oil starts with the shelling of the palm nuts (Carrere 2010; FAO 2011). The endocarp is cracked with use-stones separating the shell from the kernel. The required quantity of kernel is sundried and later fried in a dry pot on heat to extract kernel oil. The sundried kernels are put in a pot and placed on the fire. The content of the pot is stirred over and over for about three hours. While stirring, the kernel produces oil until it burns up and can no longer produce oil. The pot is then removed from the fire and oil filtered, allowed to cool and later filled in containers to be sold in liters or used at home.



Picture 15. Loaded bags of palm kernel



Picture 16. Local soap produced from palm oil



Picture 17. Palm oil retailer

Soap making: Ingredients; 1 kg of caustic soda, 6 liters of water, 6 liters of oil (palm oil or sludge), 3 sachets of detergent (Saba, Madar, Bleu, etc.). The oil is warmed and kept to cool. The caustic soda is poured into the water and stirred with a stick until the content is well mixed. The detergents are added into the mixture and stirring continues until an even mixture is attained. The oil is then poured into the mixture and stirred in one direction (clockwise or anticlockwise) until a uniform texture is obtained. It is then poured in a wooden trough or any available container that can give it a good shape for solidification. When it cools and solidifies, it is cut into required sizes for eventual use. The profit margin could not be determined because the products were mainly for home use and the quantity sold was insignificant.

2.4 Commercialization of CPO

Field survey and market evaluation revealed that sales of CPO were in the form of retail, wholesale or both. All the producers were involved in the sale of CPO wherein they sell at wholesale at their palm oil mills or retail when there is a fraction that cannot make up the usual 20L or 120L. They receive orders to supply even before processing. Both men and women were involved in sale of CPO.

Sale of CPO in domestic markets

In domestic markets, CPO is sold in 1L, 1.5L, 5L and 10L containers for retail prices in the study areas. The wholesale quantity in Eseka and Dibombari was a 20L “bidon”, while in Lobe it was in 30L or 120L “1-round jars”.

Both men and women were involved in the commercialization of CPO. While the men buy from the mills and take to cities for wholesale, the women buy from mills and retail in local markets. Some women come from near and/or distant towns to buy. During peak season, there is high production and prices are reduced, while in low season the supply is reduced and prices are increased. There is a constant demand for CPO irrespective of the season or price. In Eseka and Dibombari areas, it was recorded that some persons store oil during peak season to be sold in September or December when prices are high. The income generated at this time of the year enables them to pay school fees for their children in September and/or for the festive period in December.

Commercialization in the study area was categorized into four main groups:

- Processors/producers were mainly men and few women who were either POM owners or managers, SHs or intermediaries.
- Primary buyers were those who buy CPO from producers and sell in local markets. It was observed to be practised by young women.
- Secondary buyers come from towns and buy from the local markets or producers, and later transport to town for sale. It was observed that this category was dominated by women and few men.
- Tertiary buyers purchase CPO in large quantities, usually tankers of at least 8,000L to supply to companies for the production of refined palm oil or soap. They have their agents or contacts in the communities who buy and store the oil, and later contact them when the required quantity is ready. This category buys the different grades of oil at different prices. Those involved were mostly men.

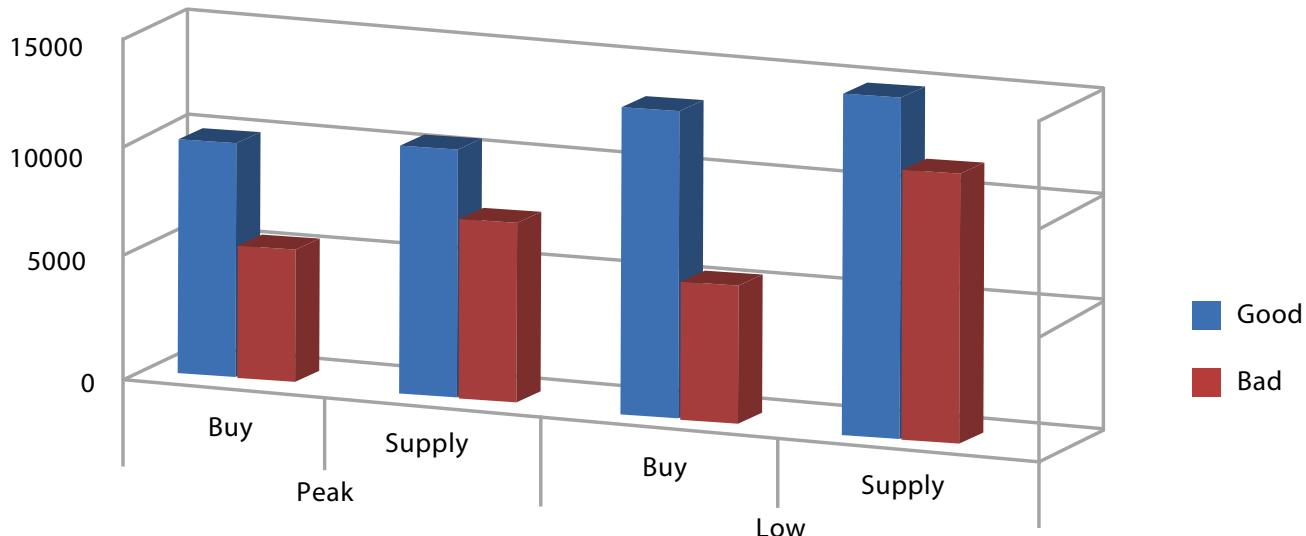


Figure 4. Average cost of first and second grades of oil supplied to tertiary buyers (in 20L)

Description of market chains — artisanal, informal and industrial

Due to high production of palm oil in these areas, buyers come from different parts of the country to purchase CPO in the palm oil mills and local markets. In Eseka, buyers generally come from Douala, Yaounde, Bafoussam, North and a local large-scale buyer from Badjob within the area. In Lobe, buyers generally come from Kumba, Douala, Bamenda, Dschang, Bafoussam and Nigeria when exchange is profitable. Some community members also buy and store oil to transport through the beach at Ekondo-Titi to Nigeria. In Dibombari, buyers come from Douala, Bamenda, Bafoussam, Dschang, Bangante, Mbouda, Foumban and Nkongsamba.

In all, buyers from Douala and Bafoussam go to all the production areas to buy red palm oil. The buyers

from these different areas buy in large quantities (wholesale) and supply to other markets in retail or wholesale.

The tertiary buyers with tankers supply their oil to refineries and soap production companies such as Mayor and Azur among others for further processing into finished products.

Fluctuation in prices of 1 liter of CPO in local markets over the years

There is fluctuation in the prices of CPO over the years in different areas. Generally, the prices of sales of RPO are unstable. They vary with the season, accessibility to the mill, demand at local market and supply at the mills. This price in local markets is probably affected by the fact that palm oil producers do not have cooperatives (Ibitoye et al. 2011)

Table 7. Fluctuation in prices of CPO in local markets

Quantity	Unit (L)	Area	2009		2010		2011		2012	
			P	L	P	L	P	L	P	L
Retail	1L	Village	400	450	400	450	450	600	400	700
		Town	400	500	400	600	500	700	600	800
		City	600	700	600	800	700	800	600	800
Wholesale	20L	Village	9765	11279	10457	11700	10809	12271	9281	12468
		Town	9765	11279	10457	11700	10809	12271	9281	12468
		City	11265	13279	12457	13700	12809	14271	11281	14468
Wholesale	120L	Village	44000	55000	58000	52000	55000	58000	58000	70000
		Town	54000	60000	58000	62000	65000	68000	65000	75000
		City	58000	65000	58000	62000	65000	70000	65000	75000

Table 8. Contribution of income (from sales of CPO) to household livelihood in the study areas

Household livelihood	Contribution of income to household livelihood			Contribution of income in study area	
	Eseka	Lobe	Dibombari	Average score	Rank
	Score	Score	Score		
Feeding	44	46	47	46	1 st
Education	38	42	37	39	2 nd
Health care	39	40	32	33	3 rd
Savings	4	15	15	11	4 th
Farm extension	4	17	10	10	5 th

2.5 Contribution of income to household livelihood

Main source of income: After scoring and ranking the main sources of income of the respondents, milling (and sales of CPO) had the highest score and was ranked first in the study area, followed by farming of food and/or cash crops. The income generated from sales of CPO had significant contributions to household livelihood. The income was used in feeding, health care, education, farm extension, land acquisition, home constructions and management of palm oil farms and mill among others. The contribution to household livelihood was recorded by scoring, ranking and prioritizing the commitments as in the table below.

From Table 8, it can be deduced that feeding, education and health care were the priorities of over 90% of palm oil millers in the study area. Income generated from artisanal palm-oil milling enables the service providers to save. Savings, which take place mostly through “njangis” or tontines, were ranked fourth highest in the area

2.6 The role of women

Palm oil is very important as an income generator for women. Women are involved in buying FFBs from smallholders and processing the oil palm fruits into red palm oil. They take part in selection/sieving and loading, and hire labor for the tedious part of the milling process. They are in charge of selling the product in the local and even national market. They make more profit when they buy FFBs and process before selling the CPO than when they buy only CPO to sell (Ezealaji 2011). During the survey, apart

from those who buy fruits and mill, two women were encountered in Eseka who own oil palm plantations (SHs) and two others in Lobe and Eseka respectively who have POMs.

2.7 Constraints in small scale/artisanal milling of red palm oil

The processing and marketing of red palm oil by artisanal POMs is a good initiative, but is subject to some difficulties.

Poor accessibility: The smallholders encounter a lot of difficulty in the transportation of FFBs from farms to the mills due to the poor road network in the study area. Accessibility to some farms is very poor. During the rainy season, roads are muddy and vehicles cannot ply the poorly developed farm-to-market roads. SHs incur additional expenses to hire labor in transporting FFBs to the mills. At times they devise a means wherein, after harvesting, the FFBs are kept in the farms, cut/chopped, stripped, sieved and loaded in bags. Workers are then hired to convey the loaded bags to the mills and commence with boiling. In Lobe area, buyers find it difficult to travel to the area to buy RPO, and if they manage to go there, they cannot find a vehicle to transport the palm oil. This tends to affect the prices during rainy season and processors are obliged to sell at prices offered by the few buyers.

Scarcity of labor: There is scarcity of labor especially during the peak season where almost every service provider in the area is actively involved in milling activity. POMs that do not have enough permanent workers available increase their bid on labor cost so as to attract more laborers.

Accidents: Minor accidents do occur such as fire burns at the mills, hot oil or sludge spilling on a worker and the inhaling smoke by workers, all of which are detrimental to the health of the workers.

Negligence by workers to control fire for proper cooking of fruits at night can lead to fire outbreak in mills as the fire can easily extend to the dry planks usually used to construct the mills.

Unstable prices: The prices of RPO are unstable generally and in Eseka and Lobe areas, the state of the roads influences the prices of oil. During rainy season, there is a limited influx of buyers due to bad roads and the prices are reduced.

Inadequate know-how: Some of the processors have worked with the agro-industries and have a good knowledge of quality control methods in palm oil milling. More than 80% of the processors have not acquired any training in production of red palm oil. The inadequate know-how of the processors on the technical aspects of the business is a major constraint as reported in Ghana by Akangbe et al. (2011).

Inadequate capital: Some of the processing equipment is locally fabricated and requires regular repairs. Some mill owners may abandon their POMs to process fruits in another mill because of machine breakdown that they cannot afford to repair immediately.

Poor environmental management: The waste generated from milling activities such as empty fruit bunches,

palm kernel and fiber, and effluent, are disposed around and no waste management scheme has been devised so far. The waste accumulates around the POMs and tends to reduce space/surface area for milling activities. The accumulated waste also pollutes the environment and serves as breeding grounds for mosquitoes.

Poor dynamics of smallholders' schemes: The smallholders process and sell the RPO individually without a common price at a particular season of production. They are not informed about improved sustainable processing methods, market strategies or market information systems.

2.8 Oil storage

Artisanal or small-scale mills simply fill/store the clarified oil in used plastic gallons of 20L "bidon" or 120L (round jar) and store the drums at ambient temperature. Oil to be stored is steamed after processing to prevent coagulation and fractionation and the container is tightly covered to avoid possible airspace that can cause oxidation (FAO 2011). In Eseka, stored oil is usually placed on a plank because the cold from the floor can cause it to solidify quickly. Local perception believes that if the storage conditions are not followed, the stored oil may produce a bad odor and change the color from red to reddish-black.

3. Conclusion and recommendations

Men were more involved in the transformation process than women, while women were more involved in the commercialization of palm oil. The role of women in the process was evident in sieving and loading during transformation and buying and selling the CPO in local markets and towns. Both family and hired labor were observed, although family labor was predominant in Eseka.

Commercialization of crude palm oil was observed and recorded to be a lucrative business in the study area. The millers sell the CPO in the village, while buyers come from different parts of the country to purchase in gallons of 20L and 30L, as well as drums of 120L and 200L. The prices vary with the season of production wherein it is low in peak season, increases through low season and is more expensive in “mid-peak”.

Ameliorations in the transformation and sales of CPO depend on the variety of oil palm in the plantation, the type of machinery and operations, the labor force and the quality control methods put in

place. Smallholders should come together and form a dynamic scheme that can enable them to improve on their oil palm plantations, processing equipment and methods, as well as on marketing strategies that provide access to market information systems of CPO in towns, cities and internationally.

Moreover, women should be given the opportunity to acquire land to establish oil palm plantations and palm oil mills. Women are very dynamic and their role in the transformation and commercialization of CPO will go a long way to improve on local livelihoods. Women groups should be trained on modern soap-making techniques using oil extracted from the mesocarp and endocarp of palm fruits.

Traditional milling methods served as a foundation to modern milling of palm oil. The incorporation of artisanal milling in policies of oil palm processing may serve as a rescue mission in the foreseeable future. This will generate more income and enable them to gain capital for diverse activities.

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This study was carried out in three major palm-oil producing areas in Cameroon with the aim of investigating the artisanal milling and commercialization of red palm oil. Structured and semi-structured questionnaires were administered; focus group discussions and participatory observation were applied to obtain required information. Those involved were identified and the service providers ranged from mill owners or managers to smallholders and intermediaries, some of which were involved in two or three of the services. All told, 83% of those involved were men, and the women represented 17% of the service providers. Six different types of processing equipment were identified in the production areas and it was revealed that semi-automated press and combined motorized hydraulic digester and press system (digester screw press) were the most efficient. After harvesting of fresh fruit bunches (FFBs), the major operations were: chopping or cutting, stripping, selecting and sieving, loading to drums for boiling, off-loading to the digester or press for crushing and/or pressing, and clarifying of palm oil. Family labor, hired labor or both, contributed greatly to the success of the milling operations. Family labor was not paid, but motivations were given to family members, while hired labor was paid per activity. The average cost of labor per ton of FFB in the study area was 8,812 FCFA for both peak and low seasons. The average net return in the processing and marketing of 1 ton of FFB was 32,207 FCFA in peak season and 46,556 FCFA in low season. This income-generating activity was ranked as the first main source of income in the study area and has valuable contributions in household livelihood. The production of palm kernel oil and local soap was also recorded in the area, but this was mainly for home use and not for sale. Poor accessibility and unstable prices were the main constraints in the production process. While the men were dominant in processing, women were dominant in the commercialization of RPO. Artisanal palm-oil milling is a lucrative business in the area and will go a long way to alleviate poverty if the smallholders could come together and form a dynamic scheme.



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