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Techniques and Technological Aspects of Palm Oil (*Elaeis guineensis*) Processing in Cameroon

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Abstract

Crude palm Oil (CPO) processing is very popular in African Countries. In Cameroon, various actors are involved ranging from agro-industrial complexes to traditional processing by smallholders who use very inefficient equipment and thus have low oil extraction rates. Small-scale processing by smallholders dates back to the early 1980s and has witnessed a lot of changes as a result of new actors in the sector, changing technologies and to an extent, government policies. This paper attempts a review of the origins and evolution of small-scale palm oil processing using intermediate technology, highlighting its importance to both the farmer and the national economy. An attempt is made to look into the future of this activity, with proposals for its consolidation.

Keywords

CPO, Small-Scale Processing, Oil Extraction Rates, Intermediate Technologies

1. Introduction

The palm tree has its origins in the parts of West Africa that have tropical rainforest, specifically along the coasts of such countries as Liberia and Angola. Due to its importance in the diet of most Africans and also to its new-found economic importance with the advent of colonization, the tree crop was quickly domesticated and its cultivation spread to other parts of Africa and the world, especially Asia [1]. Today Indonesia and Malaysia are the top producers of palm oil in the world. Though Nigeria produces the highest quantity of palm oil in Africa, it is only able to contribute a meager 2% of the global palm oil production [2].

The palm tree grows well in areas with daily temperatures ranging between 25˚C and 28˚C, having more than five hours of sunshine daily, and a high annual rainfall. The agroecology of Cameroon favours the cultivation of palms in up to five of its ten administrative regions namely the South West, the Littoral, South, Center and East regions [3]. Unfortunately, the country is ranked globally only at the 12th position behind other African countries like Ivory Coast (11th) and Nigeria (5th); with a total production of 465,000 MT of CPO in 2020 [4] [5] from a surface area of over 190,000 ha. Apart from the well-established agro-industrial plantations, two other distinct groups of actors can be distinguished in the sector according to their relationship with the agro-industrial complexes namely, the affiliated smallholder farmers who are supervised by an agro-complex in the locality which provides technical assistance to the farmers and the farmers in turn have the obligation of supplying their fresh fruit bunches (FFB) to the agro-complex; and the independent smallholders who have no protocol with the agro-complexes and are at liberty to supply them with FFB or processes it to CPO in artisanal mills. The independent smallholders own more than 50% of the cultivated surface area and contribute less than 35% of annual CPO production in the country, leaving the industrial complexes and their affiliated smallholders with 31% and 18% surface areas and corresponding 52% and 13% CPO production per year [1] [6]. The establishment of palm plantations in Cameroon started as far back as 1907 when Ferme Suisse established 7000ha and in 1928 Pamol plantations came in with 10,000 ha. Between 1947 and 1948, a third agro giant (Cameroon Development Corperation—CDC) established 15,000 ha. The last agro-complex is SOCAPALM that established 25,000 ha in 1968 after SAFACAM had developed 4000 ha about ten years earlier [1] [7] [8]. Recently, another agro-industrial complex is beginning to emerge in the sub-sector: SIC GLOBAL with plantations in Ndian Division and Nguti Sub-division of the South West Region. They have planted a few hundred hectares already and are in the process of installing a pilot processing mill. All these plantations are located in the coastal areas of Cameroon.

Slightly less than 70% of the total surface area occupied by palms in Cameroon is in the hands of individuals (*i.e.* affiliated and independent small holders), and only 25% of them have plantations greater than 5 ha each [9]. Despite the large surface area occupied, these smallholders provide only 48% of the total production corresponding to a very low oil yield of barely 0.8 MT of CPO per hectare. The oil yield per hectare for the agro-industrial complexes is no better (less than 2MT CPO/ha/yr). Comparing this with the Indonesian situation where smallholders are known to achieve up to 3.5 MT of CPO/ha/yr [10], we can see why despite a very vast surface area planted with palms, Cameroon continues to import palm oil with the importation reaching a record high of 60,000 MT in 2020 given that only 465,000 MT of the 525,000 MT needed was produced that year [4] [11]. The 2020 palm oil production for the country marked a 10.7% growth rate in the sector and 15,000 tons more palm oil than projected for that year by the Rural Sector Development Plan was produced [11].

Despite the strategic position that small-scale palm oil producers occupy in the palm oil production sector and in the national economy, the sector is still facing a lot of problems. For example the processing technology is still rudimentary, tedious and inefficient leading to low oil extraction yields with doubtful quality. Therefore it is thought that if the processing technology is improved, the positive impact on non-industrial palm oil processing will be enormous. Apart from a very low technological level in artisanal palm oil processing, Nchanji *et al.* [12] enumerate various other setbacks including the sorry state of farm-to-market roads in the country, a labour scarcity especially during the peak season, minor accidents as result of a very scanty knowledge of industrial safety, unstable prices for the CPO produced, inadequate capital for repairs or the acquisition of new technologies to improve on the extraction efficiency, the absence of professional trade unions to carter for their interests among others. Even more pre-occupying however, is the poor quality of the palm oil produced by non-industrial processors. Orewa *et al.* [13] and Hassan *et al.* [14] have pointed out low rate of oil extraction and high FFA content as the two major problems of the sector. These technical problems can be attributed to the type of equipment used. There is a need to step up the technology in the sector and to come up with affordable machinery which is easy to operate and maintain.

While interesting research has been published on some aspects of oil palm in Cameroon, there is a dearth of information in the literature on the state of the art in the palm oil sector in Cameroon. This review paper has as objective to assess the non-industrial palm oil production sector in Cameroon with the view of spelling out its relevance to all stakeholders, and to the country's economy in general. An attempt has also been made to suggest steps to improve artisanal palm oil production both quantitatively and qualitatively.

The next section traces the origins of non-industrial palm oil mills and looks at the factors that contributed to their emergence. Ever since these mills became popular, there have been a lot of technological changes and this is reflected in the degree of sophistication of the mill. As people gain more insights on palm oil processing, new machines are proposed. This evolution has been outlined in section three of the paper. In section four we look at the economic impact of artisanal palm oil production both to the millers and the national economy. Before concluding the paper, an attempt is made to predict the future of artisanal mills and various stakeholders that could contribute to improving the activity have been cited.

2. The Emergence of Non-Industrial (Artisanal) Palm Oil Mills

When the Europeans colonized Africa, one of their major trades was in artisanal red palm oil which they exported to Europe for industrial use [15]. Thus red palm oil production is an age-old practice in Africa. This trade link played a very determinant role in the relationship that eventually existed between Africans and the colonial masters [16]. And so long before the advent of plantation agricul-

ture, farmers in Cameroon just like in the rest of the tropical zone of Africa were harvesting wild oil palm groves to produce palm oil, palm kernel oil and palm wine. In the early days, palm oil extraction was done by the trampling method. Then the use of wooden mortars and pestles to pound boiled palm nuts. The pounded mesh is later squeezed in bags and palm oil is collected and boiled (**Figure 1**). Using this method, farmers in Cameroon were able to obtain about 20kg of CPO from 150 kg of a mixture of dura and tenera fruits [12] [16]. Due to difficulties in threshing the fruits, the FFB upon harvest is left in the open to ferment in order to facilitate threshing. Unfortunately, this practice causes an increase in percentage FFA content of the resulting CPO. Such oil has a sharp taste and is known as "hard" oil. These are fundamentally traditional practices which are rare to find today.

In the late 1970s, in an attempt to alleviate poverty among the predominantly rural population of the forest zone, the government of Cameroon created the National Fund for Agriculture and Rural Development (FONADER) [17]. With funds from the World Bank, FONADER was charged with providing cash to CDC, SOCAPALM and Pamol in order to permit them provide technical and material assistance to interested farmers of their respective localities who owned between 2 and 5 hectares of land and fulfilled other selection criteria for the project. In order to be able to pay for the cost of establishing their plantations, these farmers were expected to supply their FFB harvest to the agro-industries for processing [8] [10] [18]. By 1990, some 35,000 ha of oil palm plantations was developed by this project [5] [18]. When these smallholder plantations started producing FFB, they were all processed by the agro-industrial mills but at a point the mills could not handle the entire crop due to poor transport network to the smallholder farms. Moreover, the farmers were not satisfied with the procedure for the reception of, and payment for their FFB because bruised, immature or rotten FFBs were rejected at the weighbridge thereby reducing quantities supplied [5]. In addition, the farmers found the interest they had to pay on the initial amount used by the agro-industrial complex for the development of their farms too high [18]. It is the attempt by these smallholders to circumvent the above hurdles that gave birth to the first generation of mini mills, mostly around the agro-industries of CDC, SOCAPALM and Pamol. These first generation mills were mostly stand-alone plants which could be manually operated or motorized. The different activities in FFB processing received varied attention according to their degree of difficulty. This explains why fruit pressing was the first operation to be mechanized. Various actors (individuals and cooperate) have proposed different presses to the millers (**Figure 2**).

Equally in the 1990s, the two major commercial farming crops in the country namely, cocoa and coffee witnessed a very drastic drop in prices in the world markets. This caused most farmers within the palm oil belt to switch to growing palm plantations [8] [19]. This group makes up what is today known as the second generation of smallholders. They self-sponsored the development of their plantations and developed larger plantations compared to the first generation.

(a) (b)

Figure 1. Mortar and pistle used by villagers to pound boiled palm nuts, (a) [15] before squeezing the pounded mesh in bags to extract palm oil, (b) [4].

(a) (b)

Figure 2. Various early designs of palm oil press in use in Cameroon; manual (a) and motorized (b).

Equally, some elite who benefitted from the FONADER project, developed plantations up to 500 hectares in surface area [8]. It can be argued that this second generation smallholders and the first generation smallholders who single-handedly owned up to 500 hectares of oil palm plantations must have had the establishment of private non-industrial mills at the back of their minds haven seen the difficulties the first generation smallholders were having in their dependence on agro-industrial complexes for FFB processing.

Perhaps a third group of oil palm producers to consider is the group of farmers not found in the coastal part of Cameroon. These are the oil palm plantation owners in Momo and Donga Mantung Divisions of the North West Region of the Country, both areas lying between latitude 6˚N and longitude 10.25˚E [20] [21] where the oil palm culture is developing very rapidly. Apart from the natural groves, the elite are planting huge plantations with high yielding tenera seeds from research centers. In fact the emergence of an NGO—Frontier Agricultural and Industrial Program (FAINAP), is revolutionalising oil palm cultivation in Donga Mantung Division, with the promise of a 1.5 billion FCFA worth oil palm project which has the setting up of small transformation units in high produc-

tion areas in the division as one of its activities [22]. However, no agro-industrial processing facility for palm oil exists in this part of the country yet. The farmers are therefore left with no other option than to establish mini mills. It is expected that the small-scale mills that will sprout in this part of the country will be more modern using modern recent technologies.

So it can be gathered from the foregoing analyses that a number of factors have encouraged the establishment of small scale non-industrial palm oil processing units in the country. Among these factors are issues such as: the dramatic increase in FFB production resulting from an increase in the surface area planted due to funding from FONADER; the fact that the second generation smallholders established their farms not necessarily around or nearby the agro-industrial mills; the deterioration of the road network in rural areas of Cameroon which led to delays in the evacuation of smallholder FFB; such delays resulted in penalties being charged on deteriorating FFB upon reception at the mill weighbridge—an unaccepted practice according to smallholders; the collapse of the FONADER program leading to a deterioration of the hitherto cordial relationship which existed between the agro-industries and the first generation of smallholders; the irregular payment of smallholders by agro-industries; the "abusively" low FFB prices the agro-industries offered irrespective of the fact that they the by-products like kernel, fiber and kernel shells for free; and the complete absence of an industrial plant in some localities to process the FFB from small scale farmers.

In addition to all these worries, non-industrial oil palm farmers have been virtually abandoned to themselves since 1990 with little or no support from both government and the private sector. Therefore, manual workshops have emerged to deal with their FFB and generate income for their livelihood.

3. The Evolution of Non-Industrial Palm Oil Mills (POMs)

What today constitutes non-industrial (or artisanal) POMs in Cameroon can be anything from a single manual press to a combination of a few palm oil processing unit operations that are carried out by a mechanized stand-alone machine, up to a continuous flow FFB processing unit with capacities ranging from a few hundred kilogram of palm fruits to 2 tons FFB per hour [5] [15] [23].

APICA, a private engineering firm researching in agro-equipment; as early as in the late 80s developed a press, based on the principle of that of a French firm (CALTECH), "Pressoirs Colin" which was to work continuously and to combine two unit operations namely fruit digestion and pressing. The first version was manual with an average capacity of 100 kg per hour, and required two persons to operate. This version was however short-lived because it failed to reduce the drudgery of the purely traditional methods. A motorized version that uses 2.3 hp, with a capacity of 200 kg per hour was then proposed. This came along with an imported "COLIN" press, called SPEICHIM M-10. The latter used a 4.5 hp power source and had a nominal capacity of 300 kg per hour. These two had oil extraction rates of 16.9% and 21.1% on FFB respectively for tenera; as compared

to 13.8% obtained for traditional process [12].

The APICA press eventually became unpopular because it was too expensive—US$3240, for CALTECH and US$7398, for a motorized colin press), very difficult to maintain with a reduced extraction efficiency, when compared to those that were coming up.

After this remarkable attempt by APICA, many technologies have been developed in different parts of the country, in accordance with the socio-cultural lifestyle and the economy of the people. Unlike these traditional methods, the improvement of artisanal or non-industrial mills will have little or nothing to do with the people's cultures and will rather depend heavily on the technological experience of the designers. Small-scale palm oil processing systems have tried to combine these two characteristics; i.e. adaptability to a given social context, and technical efficiency and reliability. Existing small-scale systems in an area can therefore be improved if due consideration is paid to the understanding of traditional methods (not cultures) and a thorough knowledge of modern technology.

Nchanji *et al.* [5] working in three of the seven palm oil basins in the country identified six different types of presses namely (**Figure 3**) the manual vertical press (A), hand-operated screw press (B), motorized horizontal screw press (C), digester with separate hydraulic press (D), combined motorized hydraulic digester and press system (digester screw press) (E), and the semi-automated press (F).

A summary of their characteristics is presented in **Table 1**.

It is observed from **Table 1** that mill capacity and extraction efficiency are positively correlated ($R^2 = 0.99$) but the extraction efficiencies have remained very low.

So far quality issues like the free fatty acid (FFA) content and other quality parameters like moisture and dirt content of palm oil produced by small scale millers are far from meeting international standards.

Lots of efforts have been made by researchers, development agencies and private sector engineering companies to mechanize and improve local palm oil production. Unfortunately, as noted by Food and Agricultural Organization (FAO) 2000, these activities have been carried out in a haphazard manner with little or no coordination and have been focused on a very few unit operations like digestion and upon the improvement of oil extraction efficiencies. Little or nothing has been done with regards to steam generation, quality assurance and to make the process (semi-) continuous like in agro-industries. If small-scale millers could be able to generate steam for FFB sterilization and use in palm oil clarification, the quality of their crude palm oil (CPO) will greatly improve. Clarification, followed by the drying of the clarified oil is a critical unit operation in palm oil processing because it eliminates dirt and other unwanted material that is soluble in water thereby enhancing the quality of the CPO. However, this is perhaps the most neglected unit operation in palm oil processing when it comes to technological improvements despite its importance in the quality of the oil obtained. Poor clarification and dehydration have very adverse effects on the

(a) (b)

Figure 3. Combined motorized hydraulic machine and press system (a); Semi-automated press (b) [8].

Table 1. Efficiency of palm oil presses found in four oil palm basins [6] [8].

S/N	Equipment Description	A	B	C	D	E	F
1	N°. counted in the four localities	70	36	46	12	5	3
2	Percentage of total	40.7	20.9	26.7	7.0	2.9	1.7
3	Capacity (tons FFB/hr)	0.13	0.17	0.20	0.25	0.28	0.50
4	Extraction efficiency (%) in peak season	13.3	14.1	14.7	14.9	15.1	18.0
5	Extraction efficiency (%) in low season	12.8	13.4	13.6	14.4	14.6	18.0

quantity of oil extracted and a damaging effect on the organoleptic and nutritive qualities of the oil [24].

However, recent technological advancements in the palm oil processing sector in Cameroon have popularized continuous flow mini-mills of capacity mostly between 1 and 2 tons FFB/hr. A project by the United Nations Industrial and Development Organization (UNIDO)—the APROCOM-PH project saw the installation of three mini-mills in Sombo (3˚53'N and 10˚42'E) [25] on the Douala-Yaounde highway in the Centre region, Mkpot village near Mamfe located between 5˚30' to 6˚00'N and 8˚15' to 9˚45'E [26], in the South West Region and Tezie-Ngie near Mbengwi (6˚1'N and 10˚0'E) [27] in the North West Region all of capacities 2 ton FFB/hr; and the renovation/upgrade of a 5 ton FFB/hr mill in Green valley plantations in Idenau-Limbe (4˚0'N, 9˚13'E) [27] in the South West Region. These mills have extraction rates of between 18% - 20%, comparable to what is obtained in most agro-industrial complexes in the country.

We therefore observe that various attempts have been made to mechanize palm oil production at small-scale in Cameroon and to improve on livelihood. Table 2 summarizes the evolution of the intermediate technologies that have been employed so far.

Table 2. Evolution of small-scale palm oil milling technologies in Cameroon.

Period	Technology in use	Reference
Before the 1980s	Purely traditional, using rudimentary tools like mortar/pistle, cutlass, axe, sticks, etc.	[4] [15]
In the 1980s	Stand-alone plants (especially the press); operated manually.	[4] [5]
Mid-80s	Caltech-type press both manual and motorized	[4] [5]
In the 90s	Semi-automation of various press designs and mechanization of other unit operations like threshing and digestion.	[10] [14]
Early 2000s	Combined motorized hydraulic machine and press systems and various other combinations of units. Emergence of prominent semi-continuous small-scale processing lines	[5] [14]
By mid 2000s	Complete integrated continuous palm oil mills with capacities mostly between 1 and 2 tons FFB per hour	[14] [28]

4. Economic Importance of Non-Industrial POMs

According to Ngando *et al.,* [29], 30% of CPO consumed in Cameroon is produced in artisanal mills. When compared to agro-industrial complexes, non-industrial milling is seen by the Ministry for Agriculture and Rural Development as a huge waste because of its low extraction efficiency [6]. However, the artisanal extraction of red oil by the farmer with a small-scale mill increases his income by about US $46.8/ha/year, with nearly no added production costs [30]. Such farmers will never see reason in supplying FFB to industrial mills.

Zongabiro [31] worked in the Pouma palm oil basin, (3˚51'N, 10˚31'E) comprising Pouma, Ngok-Mapubi, Matomb and Eséka administrative units and established that 60% of small-scale producers in the basin exploit the palm grove for survival reasons. They prefer processing the FFB they harvest rather than supply such to an agro-complex. During high demand such farmers get up to US$1.26/litre of CPO sold as against between 86.4 and US$90 per ton of FFB sold [32]. Therefore it is observed that though unprofitable to the economy as a whole, the processing of palm oil in artisanal mills remain very profitable to the individual farmers.

Nchanji *et al.* [5] found out that milling is the most lucrative activity in the palm oil basins, in terms of revenue generation. Nkongho *et al.* [8] established that some farmers get up to 74% additional profits when they decide to mill their crop rather than sell to agro-industries. Nkongho *et al.* [3] carried out studies in some palm oil production basins in Cameroon and established that the activity is very profitable. According to this study, the net profit obtained by an intermediary processor (person who buys FFB for milling) in the palm peak season gets up to US $19/tFFB and as much as US $81.2/tFFB in the low crop season. Cor-

responding values for a plantation owner with a mill are 81.2 and US $170.8/tFFB respectively.

Proceeds from CPO greatly impacts livelihoods in the rural areas. Acquisition of new farmlands, children's education, the construction of better family houses, improved management of existing palm plantations and the purchase of more sophisticated milling equipment are some of the uses this proceeds is put to. Compared to other African countries within the palm oil belt, non-industrial processing is still as important as it is to the rural communities in Cameroon. Ordway *et al.* [23] found that 72.7% of the farmers surveyed in the South West Region of Cameroon processed their crop in non-industrial mills, while Izah and Ohimain [25] reported that non-industrial processors account for up to 80% of the Nigeria oil palm sector, compared to 60% for Ivory Coast [33]. Nwaliejiand Ojike [34] studied small scale palm oil production in Anambra State of Nigeria and established that the activity was very profitable with an annual mean revenue generation of US $392.2. In South-East Asia however, the approach to palm oil production is markedly different. Only agro-industrial complexes undertake the processing of FFB as all small holder farmers are affiliated to and must sell their FFB harvest to the industrial processors. Small scale processing is completely absent [35].

5. The Future for Non-Industrial POMs

The National Centre for Studies and Experimentation in Agricultural Mechanization (CENEEMA); established by the government in 1973 [36], with a mission to champion the mechanization of rural agriculture in the country seems to pay more attention to modernizing crop production. This has not helped the lack of appropriate technical skills in handling post-harvest machinery which has been identified as one of the major difficulties non-industrial POM owners battle with [14]. Though other constraints such as limited access to finance and high production cost equally hamper the growth of this activity [36], for the technological factor to be addressed it is important that the rural farmers, the government, the private sector and other stakeholders develop dynamic partnerships that could see the cost of importation of machinery components, and the training of manpower; reduced and made affordable to a considerable percentage of farmers and entrepreneurs.

If this is taken into consideration, it will go a long way to encourage the development of appropriate technologies for small scale CPO processing. Such a venture will require engineering expertise no doubt, leading to the improvement of both existing processes and equipment, as well as manufacture of such equipment (**Figure 4**) and establishing maintenance services. However in addition to these engineering skills, once the equipment has been put to use, a socio-economic evaluation of its performance must be carried out. The socio-economic groundwork has largely been done; except for new technologies which will only be tested as they are developed. In this respect, the works of Khatib and Sisak [1] and Khatib [27] are very remarkable as they have pointed to

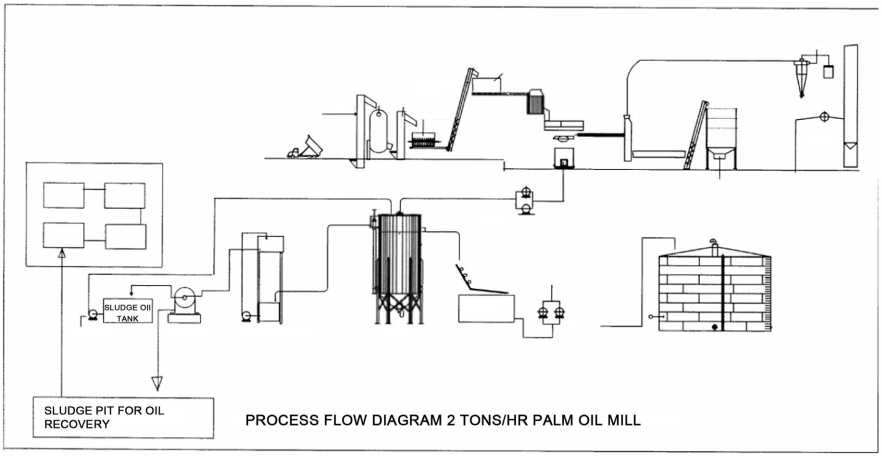

Figure 4. 2 tons/hr CPO mills installed in three localities in Cameroon [27].

an improved productivity and quality as a result of new technology, leading to better marketability of the oil.

It has been observed that most non-industrial processors sterilize palm fruits by cooking in water rather than using steam. Unfortunately when treated this way the bonding substance between the cells is dissolved leading to a suspension of 'still-intact' cells. Obtaining palm oil from such cells is very difficult. This therefore contributes enormously to the low extraction rates recorded by this group of processors. The solution to this problem lies in the design of an appropriate combination of a steam generator and a sterilizer vessel that will enable the sterilization of FFB using steam rather than by use of hot water on fruits, thereby improving the quality of CPO produced as FFA content in the final product will drastically reduce. The provision of steam will not only better the quality but will equally increase productivity since FFB will be processed as soon as it is received in the mill.

It is usually advised that vegetable oils be stored at relatively low temperatures, in airtight, dry and clean containers to prevent the oil from rapid deterioration. A well designed clarification section for a mini mill will enable a long shelf life of the palm oil by ensuring that the moisture and dirt contents are within acceptable limits. This adds value to their product and makes them more competitive.

An investment in processing equipment with improved oil extraction rates or with a reduction in drudgery is no doubt a profitable venture. This can be undertaken by individual plantation owners or entrepreneurs. However, self-help groups, (CIGs), NGOs, organized oil palm farmers' associations in the country (e.g. the Cameroon Oil Palm Operators' Union, UNEXPALM); and other more formal community cooperatives (e.g. the Cameroon Cooperative Credit Union League, CamCCUL or its affiliated branches), can be encouraged to establish such oil processing units.

A government policy to financially support or facilitate the establishment of non-industrial palm oil processing units especially in those areas where relevant agro-industries do not exist will go a long way to cater for the farmers in these

areas and help government achieve its palm oil production targets in the near future. In this regard, the South West Development Authority (SOWEDA), and the North West Development Authority (MIDENO) are in the process of installing two mini palm oil processing mills each in some localities of the two regions [37]. Meanwhile some local equipment manufacturers in the country are beginning to emerge. More than 75% of the equipment used for the APROCOM-PH Project, was manufactured locally.

6. Conclusions

There has been considerable research and development work in the area of design of equipment for the non-industrial palm oil processor in Cameroon. However, some issues seem to still be begging for attention namely: the difficulty in steam production, the poor quality of the CPO produced, the low extraction rates (especially for micro-processors), and the non-continuous nature of the processing units.

To address these issues will require a well-designed processing unit that can sterilize and thresh FFB and uses a good quality expeller-type press, an adequate clarification section, oil dryer and a storage tank; all well organized in a continuous flow layout without disregard to the financial incidence of such a design. This is the technology appropriate for the sector in the present dispensation as discussed in Section 3 of this article.

Overall, the profitability of using any processing equipment is dependent on the capacity and the extraction rate. The extraction rate for palm oil processing is a function of three major factors namely the processing technology in use, the type of FFB being processed, and the degree of ripeness of the FFB at the time of harvest and processing.

From the engineering point of view, the first of these factors is the issue. Research engineers must carefully consider the existing technologies and designs in order to provide small scale oil palm farmers with adequate equipment that will assure profits to both the individual farmer and the national economy.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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