



TECHNOLOGICAL CAPABILITY OF SELECTED PALM OIL MILLS IN NIGERIA

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ABSTRACT

An assessment of the technological capability of some modern palm oil mills in selected states of Nigeria (viz: Edo, Ogun, Ondo and Osun States) for production of special palm oil was carried out in this study. Information regarding the year of establishment of the mills, ownership of the mills, available facilities, production capacity and status of the mills (among others) were collected from the staffs of the mills. It was observed that government-owned mills (Okitipupa and Nigerian Institute for Oil Palm Research with capacities of 24 and 6 tons/hr, respectively) were in dilapidated condition and not functioning due to lack of proper maintenance. The mills had resulted into the utilization of intermediate technologies that can barely produce special palm oil and hence the huge investment in the mills has been wasted. In contrast, privately-owned mills (Okomu, JB and Royal Farm with capacities of 45, 8 and 3 tons/hr, respectively) which were also visited were functional. Two of them (Okomu and JB) were observed to have state of the art technologies for production of special palm oil and adopted well-arranged routine maintenance of the mills' facilities. The study recommended that the existing public mills should be revived through public-private partnership system while privately-owned small-scale mills can be organized into groups such that they can acquire modern facilities for production of special palm oil. It is also recommended that there should be appropriate linkage between the mills and research institutes for sustainability.

1.0 Introduction

Nigeria lost her position as a leading country in the global palm oil market since the last three decades, because the quantity and quality of her exportable palm oil is declining unabatedly. Indonesia, Malaysia and Thailand are presently ranked by the World Trade Organization as the world's top producers of palm oil (FAO, 2021). In the last two decades, palm oil and Special Palm Oil (SPO) were missing in Nigeria's export list; whereas, Indonesia, Malaysia and Thailand exported substantial quantities within that same period (Adjei-Nsiah *et al*, 2012). Owolarafe *et al*. (2019) established that Nigeria now imports palm oil and SPO (which is a major raw

material for some local industries) to meet domestic demand. These importations deplete foreign reserves, negate terms of trade, and increase manufacturing costs and unemployment rate.

The decline in the country's palm oil production is largely attributed to old age of plantations, small land area dedicated to new plantations, limited extension service system for oil palm farmers and lack of appropriate oil palm fruit processing technology among smallholder processors (FAO, 2002; Elekwachi *et al.*, 2012). Nigeria's human resource, climatic and edaphic conditions favour oil palm production; there are about fourteen states with suitable conditions for cultivation of oil palm (Owolarafe *et al.*, 2019). Lack of appropriate oil palm fruit processing technology among small and medium scale processors, who occupy a major position in the palm oil industry, is perhaps the most critical problem (Owolarafe and Oni 2011; Owolarafe, 2015; Morakinyo and Bamgboye, 2016).

While the problems associated with the age of oil palm plantations and agricultural policies and extension services are being addressed by the government, non-governmental organizations and other actors in the industry (FAO, 2002; Elekwachi *et al.*, 2012), the challenge of appropriate oil palm fruit processing technology for small and medium processors in Nigeria has rarely been given needful attention, inspiring little or no hope in many cases (Owolarafe and Oni, 2011; Badmus *et al.*, 2019). Owing to low processing capacity of the plants and extraction efficiency barely up to 70%, substantial quantities of freshly harvested oil palm fruits accumulate beyond 24 hours, deteriorate and eventually get wasted along the processing line. In many cases, the palm oil quality gets grossly impaired. In addition, the extant technologies among small and medium scale processors can hardly produce SPO which is in high demand by the large-scale food and allied processing industries because it contains <3% of free fatty acid and <1% moisture. The continued importation of SPO by local industries has turned it into a very expensive product. Consequently, many local industries with limited funding for SPO importation go bankrupt and lay off workers within a very short time or use Technical Palm Oil (TPO) as a substitute to produce substandard products which can hardly compete in the global market. This also magnifies the cutthroat competition between domestic and industrial users of palm oil. The corollaries of these factors are that local industries that are dependent on SPO have high workers' downtime and employees' turnover, operation is epileptic and many of them evade taxes to reduce production cost, thereby depleting earnings. There are few mills having the capacity for production of special palm oil in Nigeria and as result, the output is grossly inadequate to meet the demand for the product in the country. In a study, an analysis of SPO requirement of four sampled food industries in the country indicates demand gap of about 94,860 mt (Elekwachi *et al.*, 2012). According to the United States Department of Agriculture (2021), the supply gap for palm oil would increase in subsequent years if appropriate technologies are not put in place to increase the cultivation and processing of palm oil.

Previous studies (Owolarafe *et al.*, 2002; Salako *et al.*, 2014; Morakinyo and Bamgboye, 2016; Badmus *et al.*, 2019), have enabled small and medium- scale oil palm fruit processors to improve on their traditional processing methods, culminating in improved efficiency and higher product quality. However, the improved methods could not produce SPO; and there is dearth of information about the existing appropriate technology addressing the challenges for SPO production by these categories of processors.

In an effort to find appropriate technology for the small and medium-scale processors who occupy 80% of the actors in the industry, there is the need to ascertain the current level of

technology adopted by the large-scale mills and the improved small and medium-scale mills such that the upgrading of the latter can be facilitated. This study aims at appraising the level of technologies adopted by some mills in the palm fruits processing value chain in Nigeria with special focus on the production of special palm oil.

2 Materials and Methods

Palm oil processing mills in Edo, Ogun Osun and Ondo States were purposively selected due to the high volume of palm oil production (Owolarafe, 2015). These include NIFOR and Okomu oil company mills in Edo State, JB Farms Nigeria Limited in Ogun State, Royal Farms in Osun State, Okitipupa Oil Company in Ondo State. Information regarding the operations of the selected mills was obtained through structured interviews of mill managers, operators, and administrative staff. The visits were executed at intervals within three months to gather relevant information which includes year of establishment of the mills, ownership of the mills, available facilities, production capacity and status of the mills among others. This is based on the findings from literature that over 70% of palm oil production in Nigeria comes from the selected study areas (Udosen and Ugboya, 2013).

3 Results and Discussion

3.1 An Overview of the Mills.

Table I shows some features regarding functionality of the mills. The parameters considered include year of establishment of the mills, ownership of the mills, installed capacity, sources of parts and services, current status of the mills and ability to produce special palm oil. The results show that the palm oil industry in Nigeria falls under private and public ownership and it is characterized by different categories of processors who produce locally or internationally marketable products. NIFOR is a public firm in Edo State, established in 1939 with a mandate to frontier research on oil palm and produce special palm oil. The institute has also developed some cost-effective processing machines to produce palm oil for small and medium-scale processors.

Table I Features of the palm oil production facilities studied

| Features | Mill Names | | | | | |
|------------------------------|------------|-------------------|--------------------------|------------|-----------------------|--|
| | NIFOR Mill | Okomu Oil Company | JB Farms Nigeria Limited | Royal Farm | Okitipupa Oil Company | |
| Location (State) | Edo | Edo | Ogun | Osun | Ondo | |
| Ownership | Public | Private | Private | Private | Public | |
| Capacity of plant (tons/hr) | 6 | 45 | 8 | 1 | 24 | |
| Year of establishment | 1939 | 1976 | 1985 | 2017 | 1976 | |
| Source of parts and services | Imported | Imported | Imported | Local | Imported | |
| Current status of mill | Defunct | Functional | Functional | Functional | Defunct | |
| Ability to produce SPO | No | Yes | Yes | No | No | |

However, NIFOR has extended its mandate to research focusing on coconut palm, shea tree, Raphia palm, and date palm.

The Okitipupa Oil Company situated in Okitipupa, Ondo State has over 30,000 acres of oil palm trees in 10 locations in the state. As a public firm, the company was established in 1976 to produce special palm oil to meet local and international demand. On the 17th of May, 1976, Okitipupa Oil Palm PLC was formed as a limited liability company to take over the Okitipupa Oil Palm Project from the Nigeria Joint Agency Limited. The corporation was taken over by the government in 1980 and did not see the light of the 21st century. The company is now operated as a fragment of the installation made in 1976. There were, however, ongoing efforts to resuscitate the project in another location where it was gathered that new sets of equipment were being installed.

The Okomu oil company located in Edo State is a large-scale, private-owned oil mill fed by about 19,000 ha of oil palm plantation. The Okomu Oil Palm Company was established in 1976 as a Federal Government pilot project to rehabilitate palm oil production in Nigeria. At inception, the pilot project covered 15,580 hectares, out of which 12,500 hectares could be planted with oil palm trees. It was incorporated in 1979 as a limited liability company. The Okomu Oil Company is now majorly owned by a Belgian company with a 62.69% controlling stake in the company's 953.9 million ordinary shares. No other shareholder owns more than 5% of the company. Okomu oil company is famous for producing a high volume of special palm oil for international and local markets. The plant processes up to 45 tonnes per hour of FFB in a fully mechanized and automated process. Also, the plant derives FFB from her oil palm plantation, which seats over 5,000 hectares of land. The company has repeatedly shown the relevance of palm oil and has its stock listed on the Nigeria Stock Exchange. Apart from the success story it has in the palm oil industry, the company has produced about 7,341 tonnes of dry rubber and employed 4,528 of direct and indirect labour, contributing significantly to Nigeria's economy (Okomu, 2020).

The JB farm Nigeria Limited is a privately-owned oil mill, located in Ogun State. The company was established in 1985 and deals in the establishment of commercial oil palm plantations and palm oil production. The firm collaborated with Desmet Ballestra, which yielded the installation of the refineries in the years 2014 and 2021. The company is rapidly developing and expanding its scope.

Also, in the small-scale and private ownership category, Royal farms, established in 2017 at Osun State, is one of the processing centres in the state, whose mandate is to produce special palm oil for industrial application. It has a 1 ton/hr capacity processing mill supplying some towns around Osu and Ile-Ife neighbourhood. Although the mill is expanding yearly, presently, the company cannot meet the local demand for technical palm oil and expect to expand its production capacity. Currently, the company is supplied from 200 acres of young oil palm plantation.

3.2 Technologies, Capacity, Maintenance, and Source of Parts and Services at the Mills

NIFOR has a mechanized palm oil mill which is referred to as a large-scale plant and a medium-scale plants. It also produces palm oil using the traditional method. The large-scale plants, which produced and stored 7000 metric tonnes of SPO stopped production in the first quarter of

2020 due to poor maintenance of the facility and unavailable imported spare parts. However, the small-scale production facility is functional, and it is supported by the traditional production method. The process obtainable in NIFOR produces Technical Palm Oil (TPO), which has a high level of free fatty acid. The Institute was known for the production of SPO in large quantities before the facility was grounded (Figure 1). The unit operations installed includes spikelet cleaner, biomass-fired sterilizer, digester screw press, and clarifier.

The level of technology application in NIFOR was found to promote the emission of greenhouse gases as air emission from the biomass-fired sterilizer forms cloud of smoke. Similarly, the effluent from the clarifier was exposed in an open pit. According to Ohimain et al. (2013), emissions from biomass in a small-holders mill are significantly higher than emissions from fossil fuels.



Figure 1. Abandoned Facilities (a) Sterilizer (b) Stripper (c) Digester Screw Press

NIFOR, in collaboration with the Food and Agriculture Organization of the United Nations (FAO) and United Nations Development Programme (UNDP), developed a semi-mechanized integrated small-scale processing equipment (SSPE), which later improved considerably since its initial introduction. The new model had increasingly high extraction efficiency and required less labour input. These include the NIFOR large, with a throughput capacity of 0.5 - 1.0 tonnes (Fresh Fruit Bunch/ Hour (FFB/HR)), the NIFOR medium, with a throughput capacity of 0.25 - 0.5 tonnes FFB/HR, and the NIFOR mini, with a throughput capacity of 0.1 - 0.25 tonnes FFB/HR.

The SSPE consists of the unit machines required in palm fruit processing. The units are combined to form a system that would convert an FFB to SPO in a singular operation. A mini-boiler supplies steam to three vertical sterilizers. The two top sterilizers are loaded at once and processed such that the digester receives sterilized FFB and processes continuously. The process of filling the sterilizers continues; to ensure that FFBs are cooked at every instance. The digester further processes the fruit and empty the products into the screw press. The oil is collected in a crude form and processed in a clarifier. In the last production line, the fibers and the nuts are separated as by-products and are manually conveyed to where they would be utilized as biomass for firing the boiler. The fruit sterilizer of the first model was optimized by introducing a tilting system. The sterilizer could accommodate more threshed fruits and would tilt at an angle of 90 degrees to empty the cooked fruits into the digester. Conversely, due to the lack of financial support and poor maintenance of the facilities, NIFOR couldn't finish the development of the system to commercial status.

In the current production system, after harvesting the palm fruit bunches from the farm, the FFBs are shipped to the local oil plant and split into two using an axe; to enhance the separation of the fruits from the calyces. Palm fruits are removed manually from the bunches. The loosed fruits are transported to the cleaning machine manually. The cleaned fruits are weighed to glimpse the volume of the palm oil to be produced. Also, it enhances the evaluation of the efficiency of the machines after converting the cleaned fruits to palm oil. The fruits are subjected to heat by cooking in a sterilizer, and the process takes 1 hour to soften the fruits. After that, sterilized fruits are loaded into the horizontal digester cum mono screw-press for the mechanical oil expression of the oils in the digested fruits. Finally, to enhance the quality of the oil, the extracted oil is further processed in a clarifier, which separates the oil from sludge and dries the oil to the expected moisture content. The flow process of the current system adopted by the small-scale processing equipment unit (SSPE) of the institute is shown in Figure 2 This system cannot produce SPO.

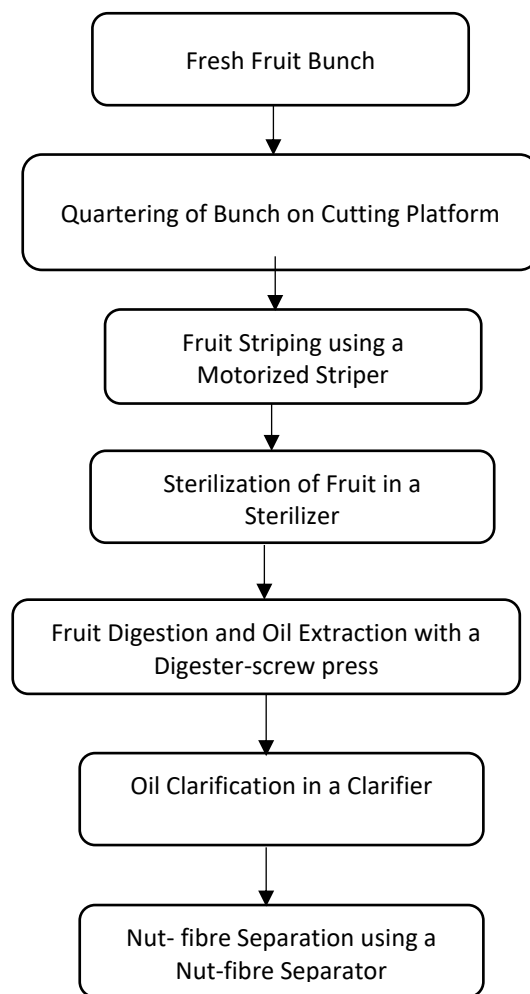


Figure 2: Flow chart of process line adopted by the SSPE unit of NIFOR

The Okitipupa Oil Company operated an imported facility mill capacity of 24 tons of FFB/hr that has been abandoned. All the sets of equipment were already in a complete state of disrepair as at the time of this report. The reasons adduced for these were prolonged lack of maintenance emanating from inconsistency in government policies as it related to the company, and lack of imported spare parts. The popular productive mill has resulted in very small-scale production which cannot support the large expanse of plantations in the company. Oil milling activities in the mill generate a lot of untreated waste which is exposed to the environment.

Okomu oil mill, on the other hand, processes 45 tons/hr capacity of FFBs with all the sets of equipment, accessories, and spares imported. The facilities available in Okomu oil mill include an FFB splitter, tilting sterilizer (Figure 3a), 45 tonnes capacity steam boiler, conveyor, FFB stripper (Figure 3b), twine shaft digester screw press, clarifier, centrifuge pumps, and 7000 tonnes capacity SPO storage tank (Figure 3c).

Once FFB arrives from the farm, they are weighed and transported to the FFB cage and conveyed with the conveyor chain to the splitter. The splitter has spines to punch holes in the bunches to enhance humidification during sterilization. The products go to the tilting sterilizer, which cooks the fruits at a temperature greater than 100°C and a pressure of 3 bar supplied from a 45 tonnes capacity steam boiler (powered by the shredded fibers; a waste product of the plant). The tilting sterilizer is equipped with a hydraulic system that empties the FFB into a hopper leading to a conveyor. The conveyor transports the cooked FFB to a stripper or thresher, separating the fruits from the bunches. The fruits are conveyed into a vertical digester for maceration, then discharged into the twin-cam screw-press by gravity for extraction of the palm oil.



Figure 3. Functioning Facilities (a) Tilting Sterilizer (b) Stripper (c) SPO storage tank

Another essential process in the purification of crude palm oil is the centrifugation of the oil. The extracted oil flows to the centrifuge machine, and oil is separated from the sludge. In the absence of this process, about 8-10% of oil production will be lost to the sludge and other waste from the oil extraction process. Before the oil clarification process, some fully stripped bunches with trapped oil are further pressed to extract the oil. One by-product (fibers) is transported to the field and used as mulch to retain water in the soil and prevent the rapid growth of weeds in the nurseries. The last production stage is converting the palm nuts into, palm kernel oil (PKO) and palm kernel cake (PKC) used as animal feed because of its high protein content.

The available storage tanks have about 7000 tonnes capacity to store SPO. The company is expanding its storage capacity during the time of the report. The proposed new storage tanks would have the capacity to store up to 15,000 tonnes of SPO. The usual practice is to sell the SPO (pure olein) in trucks to the industrial market. However, about 15% of the total production is sold to the local market in a 1-liter bottle. Despite the high volume of production of palm oil at the Okomu oil mill, there is a vast market gap to meet up the local market demand for the SPO. The facility is operated 24 hours a day to prevent frequent cleaning of the machines. However, routine maintenances are done at designated times to prevent downtime and wear of machine components. All the parts of the machines are imported, and a break or wear of the parts can lead to great loss except there is a spare part already sourced from the international market. The flow process operated in the mill is shown in Figure 4.

The JB farm Nigeria Limited possesses two medium-scale mills (refineries and fractional plants) which process 8 tonnes of FFBs per hour equivalent to 200 tonnes per day (Figure 3). From raw materials (FFBs) to palm oil production processes, the processing machines available are sterilizer, stripper, digester screw press, clarifier (purification and drying of oil), and SPO storage tank. Other material flow processes include nut and fibre separation, nut conditioning and cracking, cracked mixture separation, and kernel drying and storage for the kernel line. The dried kernels are crushed for the extraction of crude palm kernel oil. The boiler is fuelled by biomass (fibre and shell) to produce superheated steam, used to generate electricity through a turbine generator. The lower pressure steam from the turbine is supplied to the sterilizer and clarifier to enhance the palm oil production technique. The installations have mechanical handling systems (bucket and screw conveyors, pumps and pipelines) and operate continuously, depending on the availability of FFBs. Above all, the farm has a cost-effective effluent treatment system that prevents environmental pollution caused by sludge. In some mills, such systems are not provided because of their cost implication. The flowchart of the process adopted by Okomu and JB Farm as modern method is shown in Figure 5.

At Royal farm, the production line is a setup of the NIFOR SSPE, which consists of units of palm fruit stripper, sterilizer, digester-screw press, and clarifier. As shown in Plate 4, the operation of the mill still simulates the typical traditional method of oil extraction, which is inefficient (Owolarafe and Oni, 2011). However, there is a trace of adoption of modern technology even though they are not functional yet because of the limited supply of FFBs.

3.3 Current Status of the Mill

The technology at the NIFOR mill is already obsolete, and the NIFOR SSPE currently in operation cannot produce SPO since fruits must be fermented before being processed. Fermentation of fruits increases the Free Fatty Acid (FFA) present in palm oil after processing (Adjei-Nsiah *et al.*, 2012). The bunch stripper available was not in use because facilities to sterilize whole bunches were not available. However, the digestion and oil extraction systems are efficient. NIFOR oil mill continued technical palm oil production using traditional methods.

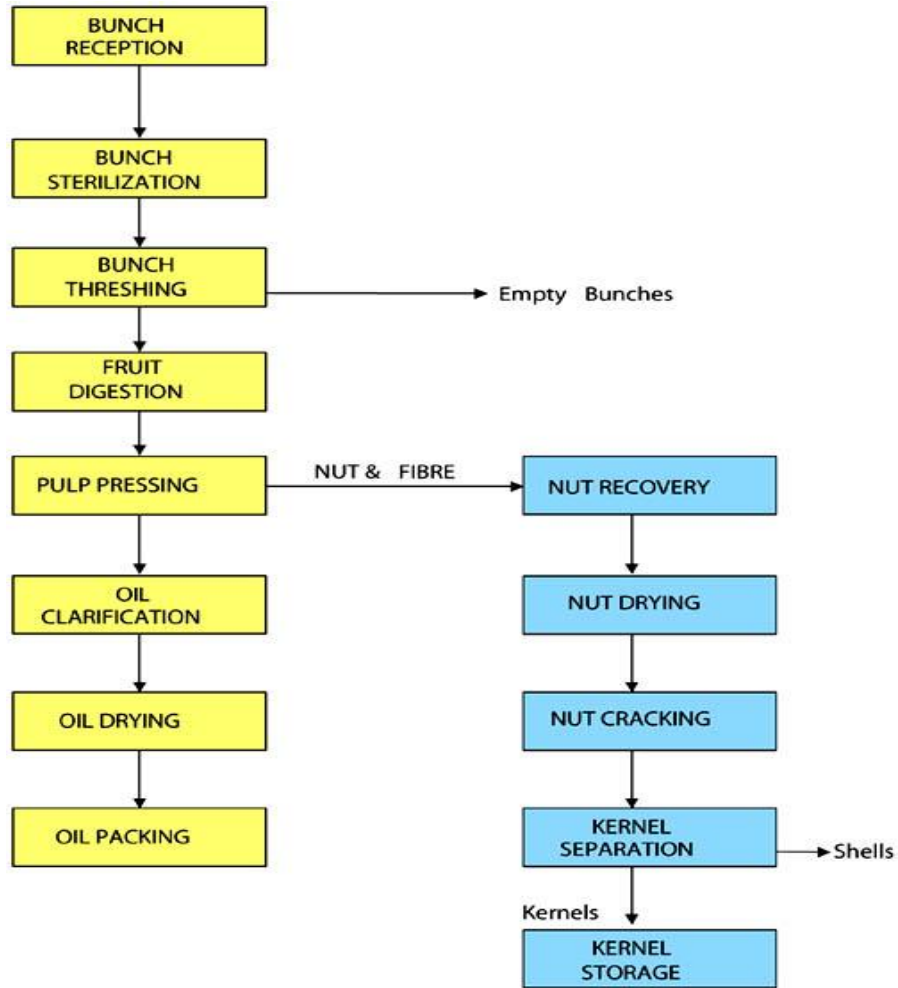


Figure 5: Flow chat of the Complete FFB Refining and Fractionation Plant Operation adopted by Okomu Mill and JB Farm



Figure 6: JB Farms Functioning Palm Fruit Processing Plant



Figure 6: Royal Farm Mill

At Okomu company complete automation of the processing of fresh fruit bunches into special palm oil is adopted and still working well. Fresh fruit bunches are conveyed to bunch sterilizer, the sterilized bunches are subjected to agitation in a stripper to strip the fruits which are subsequently sent to a digester for thorough digestion. The fruit mash flows under gravity into a screw press which separates the crude palm oil from fibres and nuts, the crude palm oil is transported to a clarifier that purifies and dries the palm oil, a centrifuge pumps that removes impurity such as sludge, and finally to a 7000 tonnes capacity SPO storage tank. The mill sells the SPO (pure olein) in trucks to the industrial market. Conversely, about 15% of the total production is sold to the local market in a 1-liter bottle, the rest is exported (Owolarafe, et al., 2002). Thus, the company cannot support the huge demand for SPO by local industries

Unlike Okomu oil company, JB farm Nigeria Limited is a medium-scale palm oil production with the potentials to increase its capacity. As stated earlier, the oil mill has installed a plant in a bid to increase the number of fresh fruit bunches processed per day and to produce special palm oil to close the demand gap of SPO by the industry. Similarly, Royal farm in its current state operates as a small-scale mill due to its small supply of FFB. However, the company is planning to install a medium-scale locally made facility to boost special palm oil production in Osun State.

3.4 Projections for Future Development for the Production of Adequate High-quality Palm oil for Domestic and Industrial Applications.

The machines required to produce special palm oil include a Conveyance system, Steam boiler, Sterilizer, Stripper, Digester screw press, Clarifier, Centrifuge, and Storage system (Salako et al., 2014; Morakinyo and Bamgboye, 2019). The complete set of the processing unit is usually imported by the existing large-scale mills in Nigeria. Among these large-scale mills, it is evident that only the privately-owned are functioning effectively and efficiently. The public mills having one problem or the other are either moribund or performing far below installed capacity. Some small and medium-scale mills are however coming up with local content, notable in this study is the JB firm with about 8 tons /hr capacity mill. This provides an insight on the development of appropriate mills for production of SPO in the country. Since there is huge market for SPO (Elekwachi et al., 2012; Owolarafe, 2015), there arise the need to have a plan to support small and medium-scale processors in acquisition of modern facilities capable of producing SPO. Local fabricators should also be supported with adequate training to improve

the situation in the fabrication of sets of equipment for production of SPO. Considering the capital requirement for establishment of plant for production of SPO, small scale processors may have to be organized into clusters to have central mills with capacity of about 5 -10 tons/hr which will be in form of public-private partnership as recommended by Owolarafe and Oni (2011). Input for such mills will have to be in kind such that they can thrive and be sustained. It is expected that, more than four million participants/actors in the palm oil industry will be productive in line with the new focus of producing SPO and serve the food and agro-allied industries appropriately

4 Conclusion

An appraisal of selected palm oil mills carried out in this study indicates that privately-owned mills function effectively and efficiently more than the public mills at all the scales of production considered. The public-owned mills which initially had imported facilities for production of SPO had gone moribund due to lack of proper maintenance particularly procurement of spare parts. In contrast, the private mills are able to source their parts due to proper management mechanism geared towards profit-making for the mills. Though functional large and medium scale mills visited are expanding, they are unable to produce enough SPO to meet the demand from food and agro-allied industries. However, for the fact that the medium one is able to source the spare parts and services within the country raises the hope for local capacity building in that respect. In order to achieve enough SPO production, public-private partnership of existing public mills should be encouraged. Furthermore, small processors should also be organized to pool resources together such that they can procure modern facilities for production of SPO with support in form of loan from the government. Linkage between research institutes and the upcoming mills should also be established to foster local content development for sustainability of the mills. These efforts are likely to address shortage of special palm oil for the use of food and agro-allied industries in Nigeria.

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