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The Need for The Installations of Fully Mechanized/Automated Palm Oil Processing Flow Lines for Large Scale Oil Production in Nigeria

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ABSTRACT

In the 1960s, Nigeria palm oil production accounted for 43% of the world production oil output. TodayNigeria only produces only about (1,300,000) metric tonnes accounting to about 7% of the world total production of 78 million metric tonnes. Nigeria now imports (350,000) metric tonnes of palm oil annually expending an average equivalent of Usd500million in foreign exchange.The factors responsible for Nigerians low production capacity are namely:Political environment, Funding, Lack of infrastructure, Non-mechanization of process of production.

World demand for vegetable oil is rising sharply from (150,000,000) tonnes in 2020 as world population continues to grow.The world oil production today is dominated by Indonesia and Malaysia which produce 85% of the world total production of 78million metric tonnes in the world market 2021/2022. There is then a big supply-demand gap in the global oil market which need to be filled. One of the serious factors responsible for Nigerians low production capacity namely: non-mechanization of process production.There is then every need for Nigeria to address this non-mechanization of the processes production capacity so as to beef up its productions level and assumes its leading position in global oil market.In this work, the non-mechanization of the palm oil production processes is addressed. A fully mechanized/automated processing flow line for large scale oil production is conceptualized. The machines/equipment for Installation of fully Mechanized/Automated processing of 20 tonnes per hour of fresh fruit bunch (FFB) were totalenumerated and cost established. The expected oil production Per hour was computed to give 4,400kg/hr which is equal to 4,840 liters (23.27) drums of red oil.

If a good number of this fully mechanized/automated processing flow lines are in operation in Nigeria and producing to the expected level, Nigeria will in few years bounce back to its leading role in the global oil market. Employment opportunities are enormously associated with the downstream of the processing flow line. The installation of this fully mechanized/automated processing flow linewill stimulate local and foreign financial institutions for collaboration and sponsorship of many other industries in Nigeria.

KEY WORDS: Palm Oil, Machinery/Equipment, Full Mechanization/Automation, Large Scale, Processing.

I. Introduction

It is generally agreed that the oil palm (Elaeis guineansis) originated in the tropical rain forest region of west Africa. The main belt runs through the southern latitudes of Cameroon, Cote d voire, Ghana, Liberia, Nigeria, Sierra Leone, Togo and into the Equatorial region of Angola and Congo. The oil palm flourishes in the humidtropics in groves of varying density mainly in the coastal belt between latitude 10^o north and 10^o south. It is also found up to 20^o south latitude in centraland east Africa and Madagascar in isolated localities with suitable rainfall (RMRDC, 2004).

The main oil palm, growing areas in Nigeria are the south east, south-south and western regions ecologically confirming to the tropicalrain forest and derived savannah portions of the country. Annual rainfall in these regions range from as low as 1500mm in the derived savannah to as high as 3000mm in the tropical rain forest.

Palm oil and palm kernel oil are derived from oil palm tree and as at 2004, the total hectare of palm planted in Nigeria is put at 2,514,090 hectares. Palm oil and kernel oil production data from 1975-2003 shows a progressive increase in oil production from 640,000 tonnes in 1975 to 898,000 tonnes in 1996 to 670,000 tonnes and then increased to 785,000 tonnes by 2003. On the other hand, palm kernel oil(PKO) production rose from 295,000 tonnes in 1975 to 388,000 tonnes in 1995, but declined to as low as 200,000 tonnes in 2021.Several factors affect production of palm oils in Nigeria, they include:

Political environment, Funding, lack of Infrastructure, Shortage of labour, Non-mechanization of the process of production (RMRDC, 2024). In 2023, the production of palm oil in Nigeria reached 1-4 million metric tonnes between 2009 and 2023, the production quantity generally increased registering the highest growth in 2010, when it grew by roughly 14% from 2014 onwards, the output from palm oil production followed a rising trend (https:statista.com>statistics) 9 Nov. 2023. The current challenges of palm production in Nigeria include declining production, out dated equipment, aging plantations, lack of technology access, and shortage of good planting materials (8 Nov 2023. https://typeset.10>questions).

According to national palm oil association of Nigeria, the annual output of palm oil is one (1) million tonnes, the consumption demand is 2.7 million tonnes giving a supply demand gap of about 2 million tons which means that large quantity of palm oil is imported into Nigeria to make up for the gap.The global production of palm oil was around 78 million metric tons in the marketing year 2022/2023 increasing from approximately 73 million metric tonnes in 2021/2022 (https://www.statistica.com>statistics) in the period Indonesia and Malaysia were the leading exporters of palm oil worldwide.

The world palm oil sector grew to a market value exceeding USD 50 billion in 2021 and is projected to expand at a compound annual growth rate (CAGR) of at least 4%, reaching USD 65 billion by 2027 (research market 2022). More than 7 million small holders globally cultivate oil palm as their means of livelihood. (RSPO, 2022b). palm oil production has grown to 74.7 million tonnes (mt) in 2020 from about 42.6 million tonnes (mt) in 2008 from cultivating 29 million hectaresof oilpalm planted in Nigeria is put to 2,514,090 according to food and agricultural organization of the united nations (FAO) (FAOSTAT), 2022.

Originally found in west Africa, this tropical equatorial plant is cultivated in large plantation and small holder plots, with global land coverage equivalent to the size of brazil/roundtable on sustainable palm oil (RSPO) 2013. Oil palm yields are 2 times higher than those of soya bean, 10times higher than sun flower, and seven times canola per hectare (Thomas et al, 2015). Although 85% of global palm oil comes from Indonesia and Malaysia, palm oil is also grown in parts of Africa, south America, south east, Asia oil palm is highly productive perennial with a 25-year life cycle (murphy et al 2021).In south east Asia millions of small holderfarmers have transitioned over the past decades from cultivating rubber to oil palm to supply the more lucrative and diversified palm oil market (Shaw et al, 2018), tan, 2014; van Noordwijk et al, 2017. In the two largest palmoil producers in the world, Indonesia andMalaysia, the palm oilsector directly employs almost 5 million small holders and workers and indirectly employs additional 6 million people. (Russell, 2018, 2020).

The sector is also responsible for an estimated 2.9 million downstream jobs in importing countries.Global palm oil supply and demand have remained steady over the last five (5) years. Nevertheless, demand has surged with Russia's invasion of Ukraine, the largest sunflower oil producer in the world, restricting its exports. The conflict has triggered a shift in demand for other vegetable oils, such as palm oil which has motivated farmers to expand palm oil production (International food policy research institute (IFPRI), 2022, Yulang, 2022).Palm is a widely attractive ingredient due to its texture, taste, odour, consistency and shelf life. It is relatively inexpensive, versatile and the most widely produced edible oil, meeting 40% of global demand for vegetable oil in less than 6% of all land dedicated to producing vegetable oils (Ritchie x Roser, 2020, World Wide life fund [WWF], 2022). Consequently, its production has increased ten folds since 1960s in response to the soaring demand for vegetable oils, for food, feed and fuel [European palm oil alliance, 2022].

Modern processing of palm fruit bunch into edible oil is practiced using various methods, which may be grouped into four categories according to their throughput and degree of complexity. These are the traditional methods, small-scale units, medium scale mills and large industrial mills. Generally, processing units handling up to 2 tonnes of Fresh Fruit Bunches (FFB) per hour are considered to be small scale. Installations that process between 3 and 8 tonnes FFB per hour are termed medium scale, while large scale refer to that process more than (10 tonnes/hr (FAO, 2011).

II. MATERIALS AND METHODS

METHODS OF PALM OIL PROCESSING

1) **Traditional Method (Non-Mechanical Method):**

Before the advent oil extraction machinery, oil was extracted in Nigeria by crude method that gave generally poor-quality product. These methods stillpersist in palm oil producing part of Nigeria and some African countries especially in rural communities. The method varies considerably in their details but their essentials fall within the two variants discussed below.

a. **Soft Palm Oil Production:**

So,called because the greater part of thee palm was liquid at tropical temperatures. Basically, the harvested bunches are cut up into sections and kept in heaps for 2-3 days. The heaps are sprinkled with water and covered with leaves. Next the fruit is picked from the bunches sections and boiled in large pots or 200 liters drums for about four (4) hours.

The fruit may be left in the vessel for up to 3 days. The boiled fruits are then pounded in a wooden mortar with a wooden pestle until mixture of nuts and crushed pulp of more or less even consistency is obtained. The oil from this mass of pulp is recovered by immersing the latter in water in either a special pit or in some large vessel and whole mass stirred. Crude oil rises to the surface and is skimmed off into another vessel. Next the fiber is shifted out of the water and then followed by the nuts, which is now largely free of fiber. The nuts are dried and cracked. The crudeoil obtained is further boiled in smaller vessels (where any fiber it contains sinks to the bottom), the new oil skimmed off is then fried in a shallow pot to get rid of last traces of water. This method of production largely is employed in the south east and parts of south-south of Nigeria, produces average FFA of about 7-12% with extraction rates of 6-10% (RMRDC 2004).

b. **Hard Palm Oil Production:**

This method is prevalent in Niger-Delta region of Nigeria where the people are not accustomed to pounding. essentially after picking from chopped up bunches, the fruits are placed in a long wooden canoe or pit and covered with leaves. The fruit becomes softened by the heat generated by fermentation caused by microbial and enzyme action. After some days when the fruit is sufficiently softened, it is trodden on in the canoe and the oil allowed to drain

for 3days from the lower endthreading is done. The remaining oil rises to the surface, is skimmed off and purified by boiling as in the soft oil production. The oil prepared from this process solidifies rapidly hence the "hard oil". As would be expected extraction rates is low 4-6% for low mesocarp dura. FFA content is high, 30-50%.

Disadvantages Arising from Soft and Hard Palm Oil Production

i. The methods are crude and ancient

ii. The process is very low quality

iii. The oil produced is of very low quality

iv. The FFA content of the oil produced is very high and renders the oil unhealthy for consumption and even for industrial application.

v. High labour intensive

vi. Processing time is so high and productivity is very low

vii. The product cannot be exported because of very low standard and quality.

2) **Semi-Mechanized (Batch Processing) Method:**

This an improvement on the traditional processing method. In semi- mechanized or batch system unit operation machines are wholly or partially employed but the material transfer process from one-unit operation machine to the other is manual. This system is what is ground in many west African countries including Nigeria and in characterized by low efficiency, increased processing time, low productivity, labour intensive. The free fatty acid (FFA) is high. The processing flow line is shown below. The system cannot produce product for international market.

Fig1 process flow line for semi-mechanized palm oil production

The processing yield of semi-mechanized systems are small as it can only process about 1 to 5 tons of palm fruit per day.

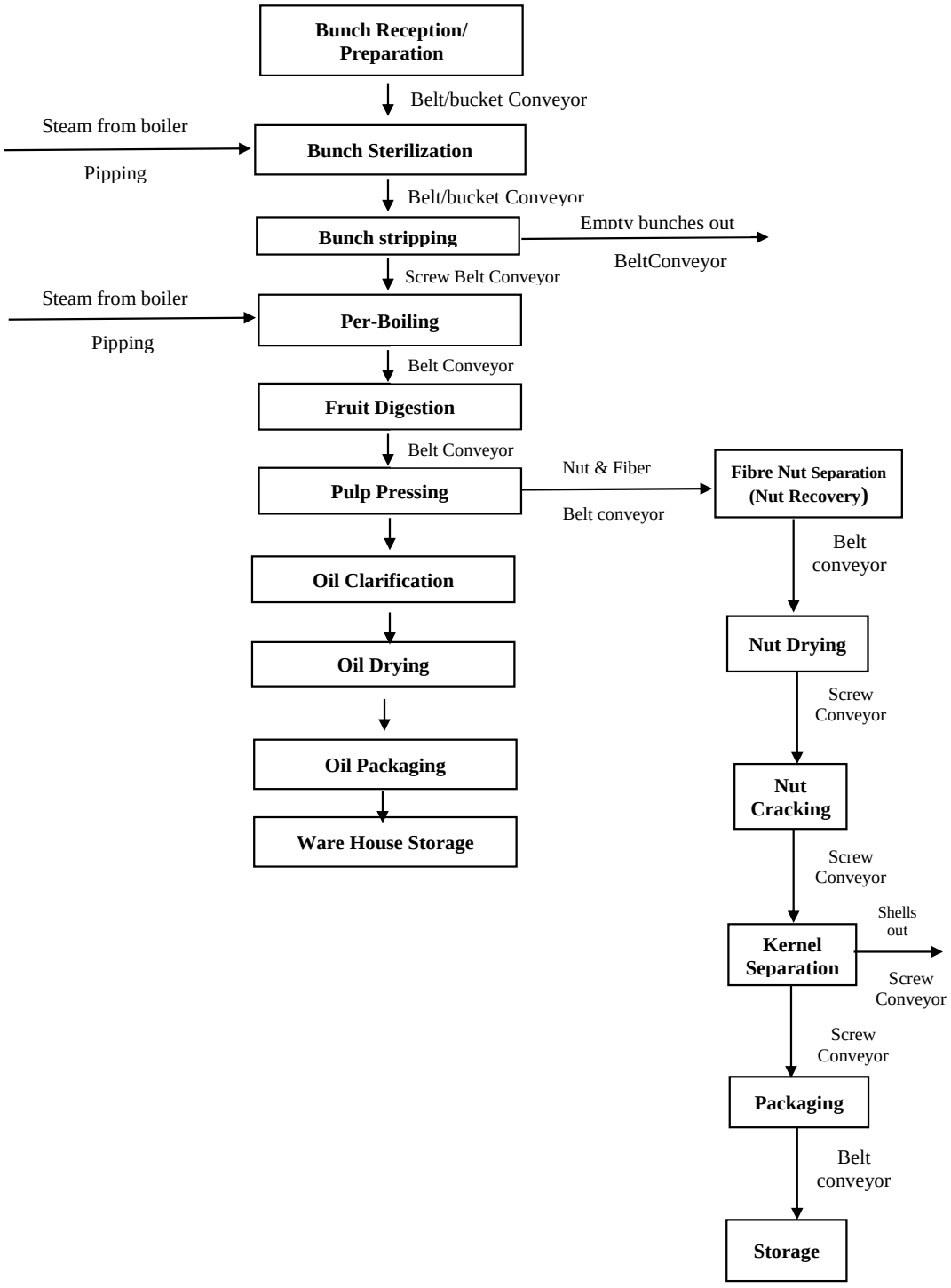
1) **Fully Mechanized Palm Oil Processing:**

Research and development work in many disciplines-Biochemistry, chemistry and mechanical engineering and the establishment of plantations, which provide opportunities for large-scale fully mechanizedprocessing resulted in the evolution of a sequence of processing steps designed to extract, from harvested palm oil bunch, a high yield of product of acceptable quality for the international edible oil trade. The oil winning process, in summary involves the reception of fresh fruit bunches from the plantations, sterilizing, and threshing of the bunches to free the palm fruits, mashing the fruit and pressing out the crude oil.

The crude oil is further treated to purify and dry it for storage. Large scale plants featuring all stages required to producepalm oil to internationalstandard generally handling from 3 to 60tonnes of FFB/hr,**(food and agricultural organization https://www.FAO.org>)**.The large installations have mechanical handling systems (bucketscrew conveyorspumps and pipe lines and operate continuously depending on the avail ability of FFB. Boiler,fueled byfiber and shell produce superheated steam, used to generate electricity through turbine generations.

The lower pressure steam from turbine is used in heating purposes throughout the factory. Most processing operations are automatically controlled and routine sampling and analysis by process control laboratories ensure smooth, efficient operation. Although such installments are capital intensive, extraction rates of 23-24% palm oil per bunch can be achieved from good quality tenora.

Fig2 Full Mechanized Palm Oil Processing Flow Diagram



Source: Oriaku et all

In fully mechanized palm oil processing system, the material transfer from one unit to another and removal of unwanted materials achieved using mechanical linkages e.g.: belt conveys. Screw conveyors, bucket elevators, chain conveyors, cams pulley etc. as the case may be.

Advantages of Palm Oil Over Other Oils

To many people, palm oil is preferred to other oils because of the reasons stated below.

I. Palm has relatively long shelf life when compared to other edible oil with good storage facilities in place, palm oil can be stored for up to one year without its quality dwindling down.

II. Palm oil isa very good source of vitamin E, which promotes skin health and improves its immunity to infections it also enhances vision and prevents eye-related diseases.

III. Palm oil has low cholesterol and low-density lipoproteins. These are the culprits behind many cases of hypertension and and other health problems, and the present in some other edible oils.

In addition to the above mentioned, palm oil is used for a number of industrial purposes such as in the production of ice cream, margarine, creams, soaps, vitamin supplements, shampoos, lipsticks, body lotions, packaged foods, animal feed and biofuels etc.

Automated Palm oil Processing Flow Line:

The automated palm oil processing flow line is very similar to the fully mechanized system. The difference is that electrical, electronic, hydraulic, pneumatic and computer programme (automation elements)areintroduced at certain points in the processing flow line for the system to work better.

For this type of automated flow line, material transfer from one-unit operation to another, flow systems are controlled by introduction of automation elements e.g. Timers, limit switches, censors, activators, temperaturecontrols, computer programme, control panels etc. into the system to make it work better.

Advantages of Mechanized/Automated palm oil processing

I. Increased through put or productivity.

II. Improved quality or increased predictability of quality.

III. Improved robustness (consistency), of process product.

IV. Increased consistency of output.

V. Reduced direct human labour and expenses.

VI. Mechanization/automation reduces cycle time.

VII. Maintains high degree of accuracy.

VIII. Replaces human operators in task that involves hard physical or monotonous work.

IX. Replaces humans in tasks done in dangerous environments (i.e. Fire, space volcanoes, nuclear facilities, under water etc.

X. Performs task that are beyond human capabilities of size, weight, speed, endurance etc.

XI. Reduces operation and work handling time significantly.

XII. Free up workers to take on the other roles.

XIII. Provides higher level jobs in the development, deployment, maintenance and running of the automated processes.

Estimated Cost of Equipment/Machinery required for Installation of Full Mechanized/Automated Palm Oil System for Processing 20tones FFB/Hour

In this cost analysis,only cost of machinery/production equipment are considered.

Cost of land, houses, personnel and administration are not considered.

Table 1. cost of machinery/production equipment as at 25/08/2024.

S/n	Equipment/Machines	Capacity	Quantity	Unit CostN	Total CostN
	Reception/Preparation				
1	Silo	18 tons	2	9m	18m
2	Steam boiler (bio mass)	30 tons/hr	1	20m	20m
3	Palm fruit sterilizer	800 bunches/hr ($36.712m^2$/hr	5nos	42m	84m

4	Threshing/de-bunching machine	800 bunches/hr	2nos of 400 bunches/hr	7m	14m
5	Palm fruit per-boiler (cooker)	15.4m^3 16m^3	4 nos of 3m^3 each	4m	16
6	Horizontal continuous digester, fruit digester	12 tons/hr	3 nos of 4 tons/hr each	7m	28m
7	Hydraulic press	12 tons/hr	2 (6 tons each)	10m	20m
8	Oil dryer (with heater)	4 tons	4 tons each	30m	60m
9	Oil clarifier (with pump)	4 tons	4 tons/hr each	3m	6m
10	Vibro-filter	4 tons	2	6.5m	13m
11	Storage tanks	5,280 litres	10-20 for continuous production	80m	120m
12	Oil pumps		2-4	2.5m	10m
13	Bucket conveyors	800 bunches/hr	2	7m	14m
14	Belt conveyors	800 bunches/hr	10	1.5m	15m
15	Screw conveyors	12 tons/hr	6-10	2m	12m
16	Piping's/connectors	1-6 pipes, bends connectors	300-500pcs		10m
17	Plat form structures	Angle iron/u-channels, 1 beans etc	300-500pcs		15m
18	Fibre nut separator	10-12 tons	2	7	14
19	Kernel dryer	10-12 tons	2	25m	50m
20	Kernel cracker/ separator	10-12 tons	2	8m	16m
21	Control system/panels		6	3m	18m
22	Automationelements, (limit switches, actuators, temperature sensors, controls, etc.				10m
23	Laboratory equipments for analysis of the produced products e.g. Palm oil analyzer, necessary chemicals for test.		3		80m
24	Transportation				10m
25	Miscellaneous				
26			Sub-total		683m
27	Installation = 25% of Machine cost =				170.3m
	TOTAL COST				853.3m

It is worthy to note the following

i. The ratings of all the machines given in this work is based on engineering design decisions.

ii. All the prices of the machines given in this work are based on importation considerations.

iii. This system can be scaled up or down upon demand.

iv. The system can also be fabricated and installed locally.

Expected production of red oil from processing 20 tons of FFB/hour.

From the information sourced from researchgate.net>ide…

Ideal composition of palm fruit is shown in table 2 below.

Table 2.Ideal Composition of Palm Fruit:

S/N	COMPOSITION	QUANTITY/BUNCH
1	Bunch Weight	23-27kg
2	Fruit/Bunch	60=65%
3	Oil/Bunch	21-23%
4	Kernel/Bunch	5-7%
5	Mesocarp/Fruit	44-46%
6	Mesocarp/Fruit	71-76%
7	Kernel/Fruit	21-22%
8	Shell/Fruit	10-11%

Source: https://ww.fao.org

From this table, the expected quantity of production of oil from 20 tons of FFB is hereby estimated

Average weight of a palm fruit bunch = 25kg.

Average percentage oil per bunch = 22%

Quantity of oil per bunch = $\frac{22 \times 25}{100}$ = 5.5kg

Approximate expected quantity of oil from processing of 20 tons of FFB =

No of bunches in 20 tons of FFB

= $\frac{20 \text{ tons}}{25\text{kg}} = \frac{20{,}000}{25}$ = 800 bunches.

Expected quantity of oil from

800 bunches = 800 x 55 = 4,400kg/hr.

1kg of oil = 1.1 litre of oil (https://gheestore.in>.i-kg-of-oil-is)

4,400 x 1.1 = 4840 litres

A drum has capacity of 208 litres. (https://lubmarine.totalenerguis.com>...)

$\frac{4840 \text{ litres}}{208 \text{ litres}}$ =23.27 drums

From this analysis processing of 20 tons of FFB/hr will yield 23.27 drums/hr

Eight-hour work in a day will result to approximately

23.27 x 8 = 186.16 drums of oil.

Conclusion:

The expected impact of establishing fully mechanized/automated palm oil processing flow lines to Nigerian economy cannot be over-emphasized.

Firstly, when these flow lines are in place in Nigeria producing standard palm oil for local and export, food security (oil) will be ensured.

Nigeria will then contribute a great deal to the world palm oil market and take its proper position in the oil trade which is seriously dominated by Indonesia and Malaysia.

Unemployment in Nigeria will be drastically reduced as most of the unemployed youths will be directly engaged in the oil mills. The presence of these oil mills will stimulate a lot of employment opportunities downstream. Farmers in Nigeria will have the impetus to invest in establishing thousands and million of hectares of palm plantation that will produce palm fruits yearly to sustain the operating fully mechanized/automated mills.

This situation will stimulate the local and international financing institutions like, The Bank of Industries, Central Bank of Nigeria, Federal Ministry of Agriculture, Federal Ministry of Industry, World Food Programme (WFP), Food andAgricultural Organization (FAO), The International Fund for Agricultural Development (IFAD) and other organization towards sponsorship for establishment of more palm oil processing mills in Nigeria.

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