DEVELOPMENT OF SUSTAINABLE PRODUCTS FROM OIL PALM TOWARDS ENHANCING NATIONAL FOOD SECURITY: A REVIEW

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Abstract: Increasing threat insecurity of food production in Nigeria is perceived in almost all parts and areas of the national food production. Food insecurity seems to be a global challenge that has a lot to do with surge in energy demand, population growth, climate change and competition for land, food and water. The rural settlements are more prone to irregular food supply, malnutrition, and low quality foods, high cost of food items and even widespread lack of food. This has created a serious concern towards national food security. However, the availability of agricultural and food products could mitigate this menace. So, in an attempt to arrest this situation, this paper presents a review of the development of some sustainable products from oil palm towards enhancing national food security. In a nutshell, it highlights the overview of oil palm tree, its classification, current and future mechanization, processing of oil palm fruit from the bunch to crude palm kernel oil extraction and other by-products, application of the products; and production capacity of palm oil from 2010 to 2020 in Nigeria.

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Besides, nutritional composition of palm oil and palm kernel oil, rationale for the use of oil palm and its derivatives in the development of sustainable food and allied products are also discussed. Furthermore, concept of sustainable palm oil, some food products made from palm oil and its functional attributes; and the development of some selected food products with palm oil as one of the major ingredients are also highlighted.

**Key words:** Oil palm, sustainable products, national, food, security

**INTRODUCTION**

The alarm of threat to national food security in Nigeria had been sounded for some years now [1]. Food security is referred to as possessing sufficient food, with adequate nutrient, satisfactory and safe all-round the year in a manner that permits everybody to ensure a healthy and energetic life. It also means the ability to source for nutritive and adequate food, by means of simple trading, incomes or productions [2]. Food security is a multi-facet issue with socio-economic and environmental aspects. Regrettably, out of 206, 139, 589 people in Nigeria, 25,600,000 (about 12.4 %) are undernourished [3, 4]. Food is one of the basic necessities of life. Though, several efforts have been sunk into enhancing the quality and quantity of world food production and supplies, food insecurity still remains dominant in Nigeria. Food insecurity has a significant correlation with malnutrition [5]. Many social problems such as riots and civil unrest are a few impacts of failure to guarantee food security in many major cities of the world. Food insecurity is related to other universal issues, such as surge in energy demand, population growth, climate change and competition for land, food and water [6]. However, the poverty rate in Nigeria is alarming, though the largest economic giant of Africa in 2014. About 70% of the Nigerian population is living on less than a dollar per day [7]. Before the discovery and exploration of crude oil in 1970s, Nigeria had been one of the largest producers of agricultural products such as cocoa, groundnuts, palm oil, palm kernel oil and its derivatives, etc., [8]. The agricultural sector hitherto had been the main stay of the Nigerian economy. In fact, the main economic stay of some countries of the world such as Liberia, Somalia, Malaysia, Brazil, United States of America, India, China and Indonesia centers on agriculture [9,10]. Unfortunately, Nigerian crude oil and gas sector had gradually rendered agricultural sector less significant to the government, thus, rendering the nation to be dependent on imported foods [11]. The rural settlements are even more susceptible to irregular food supply, malnutrition, and low quality foods, high cost of food items and even widespread lack of food. This condition is more common in the northern parts of Nigeria [12]. Thus, this in turn has created a serious concern towards national food security. However, the availability of agricultural and food products could go a long way in curbing this situation. In an attempt to arrest this unpleasant trend, this paper reviews of the development of sustainable products from oil palm towards enhancing national food security. The specific objectives were to: (i) identify some products derived from oil palm; and (ii) highlight processing technologies in the development of some sustainable food products from oil palm.
This paper would provide information for small and medium-scale industrialists who may desire to venture into palm oil mill business and perhaps develop some food products for oil palm.

OVERVIEW OF OIL PALM TREE

The oil palm tree (Elaeis guineensis) is a great economic and perennial plant. It is indigenous to tropical areas. Its origin could be traced from Africa, predominantly in the southern parts of Ghana and Nigeria, but grown commercially in Southeast Asia and Southern America. It grows within the altitudes of 500 m above sea level in warm climatic zone and produces its fruits in bunches that weigh between 10 to 40 kg. A mature oil palm tree is a single-stemmed plant which could grow up to 20 m tall.

The leaves are pinnate and may be 3 to 5 m long. A young palm tree may produce about 30 leaves a year. However, its flowers are densely formed in clusters. Each distinct flower is very small, with three petals and sepals. Its fruit takes about 5 to 6 months to mature from the period of pollination. Its fruit is reddish, about the dimension of a big plum. Its fruits are harbored in large bunches. Each fruit is composed of pericarp (an oily-fleshy external layer), with single, double or triple seed(s) palm kernel(s), depending on the size and variety. The individual fruit weighs from 60 to 70 grams. It is very rich in vegetable oil [13, 14]. The new cultivars developed by modern breeding technology, under perfect atmospheric or climatic factors and decent management practices are high yielding breeds that could produce more than 19 tonnes of bunches with healthy fruits per hectare per year [15]. The fresh oil palm bunch, as shown in Figure 1, composed of fruits rooted in spikelets which are grown on a major stem [16]. Ideally, the oil palm bunch (Fig.1), is composed of 60.0 – 65.0% fruits, with 21.0 – 23.0% palm oil, 5.0 – 7.0% kernel, and 44.0 – 46.0% mesocarp. Furthermore, the climatic conditions or factors could make expected high yield impracticable to achieve, because, sometimes the climatic factors are generally less than ideal. However, the rainfall may be unpredictable, especially in the Western and Central parts of Africa; hence the trees may be struggling to strive due to inadequate water supply [15]. Oil palm tree is classified based on the morphology of their fruit. The oil palm fruit has endocarp (shell thickness) and mesocarp content [17]. It has three (3) major varieties: namely, the Dura, Tenera and Pisifera as depicted in Figure 2. Dura have large kernel and a very thin pericarp, which contains about 40 -70% oil by weight and with shell thickness of about 2 - 5 mm; Tenera has medium kernel with a thick pericarp of about 60% fruit weight containing a higher % of oil and 1 mm to 2.5 mm shell thickness. Their structural characteristics are shown in Figure 3.
CURRENT / FUTURE MECHANIZATION IN OIL PALM PLANTATION

Technology and invention are very important aspects in the cultivation of oil palm, harvesting and processing of its produce. They are keys to promoting healthy competition among nations’ oil palm industries in the global market. Hence, the implementation of mechanization and automation will go a long way in abating the current challenge of labor shortage, eradicating drudgery associated with whole production processes and boosting productivity. Several agencies/companies such as Malaysian Oil Palm Board (MOPB), Sime Darby, University Putra Malaysia (UPM), Fedepalma / Cenepalma, Deere & Company, Allis-Chalmers Manufacturing, Lovol and others have developed many equipment/machines for use in oil palm plantation operations [18]. Nevertheless, a shift from conventional mechanization to robotic (modern) supported mechanization system cannot be overemphasized because of its unique advantages over conventional mechanization in agriculture.
Pre-harvesting Operations in Oil Palm Plantation

Several machines and technologies have been developed in this regard include: artificial intelligence (AI), robotic systems, unmanned aerial vehicles and manned machines etc.

(a) **Drone System, Manned Machines and Unmanned Aerial Vehicles**

Drone, in high-tech terms, is an unmanned aircraft system or aerial vehicle which may be flown by a robot that is remotely controlled or independently through software application. This application is monitored by flight plans. A drone may compose of three or more propellers which it uses to fly in any direction. Drone system could be used to auto count oil palm trees and possibly forecast their yield which may be cumbersome to count using the convention technique [19]. Its images generated could locate precise empty spots in the field which could be eliminated after a careful confirmation by team and subsequent action taken. Areas prone to floods can be identified through its imagery, and this could lead to redesigning of the drainage system.

Aerial normalized difference vegetation index (NDVI) which is incorporated in it, is employed to track and manage diseases where affected plants, exact location can be identified and specific treatment given instead of mass treatment.

Locations where fertilizer application is required can be spotted out using the web portal imaging. The use of drone system offers faster rate of fertilizer application/spraying.

For instance, it takes about 20 minutes to cover one hectare of oil palm plantation. Besides, oil palm planter can be auto guided using Multi-Global Navigation Satellite System (GNSS) by: (i) designing the planting pattern and determining the planting area boundary coordinate; (ii) making geo-reference using ArcGIS; (iii) using Tracy software application to stake out process; and (v) indicating location with wooden spikes [20].

(b) **Artificial Intelligence (AI)**

Artificial intelligence (AI) in agriculture is the science of building intelligent equipment / machines/ gadgets that are used in agriculture in order to increase crop yield but at a minimal production cost. Artificial intelligence is aimed at imitating and surpassing human intelligence in solving problem [21]. With AI, computers virtually “see” as humans see. By installing mobile technologies with AI and built-in computer vision, AI sensors can spot weeds and then decide which herbicides to use within the safe limit to get rid of them, instead of spraying the entire oil palm plantation [22]. Mobile phones could also be connected with cloud data storage systems where managers can get real-time data from workers concerning the plantation and field activities for quick, precise decision making and judicious action. Furthermore, precision farming (PF) uses AI technology to help in identifying, pests, poor plant nutrition on farms, etc. It uses data loggers, yield monitors, Geographical Position System (GPS), Geographical Information System (GIS) and Internet of Thing (IoT) facilities, sensors etc. These tools are fitted on the aerial machines for data collection.
However, the application of PF is dependent on the success of field mechanization processes, assertiveness and management willingness to embrace the technology [20]. Farmers can use AI to generate periodic forecasting models to enhance accuracy and increase productivity.

Through the use of AI and cognitive technologies such as Chatbots, farms could run more proficiently, with less number of workers still producing the reasonable quantity of produce. Consequently, application of AI improves produce quality, productivity, reduces wastage, minimizes environmental pollution and conserves energy.

**Harvesting Operations in Oil Palm Plantation**

(a) **Manned Machines and Unmanned Aerial Vehicles**

The harvesting operations in oil palm plantation involve: (i) cutting of fronds and ripe bunches; (ii) bunch stalk trimming; (iii) reorganizing and stacking of fronds; (iv) gathering of harvested bunches and loose fruitlets; and (v) transportation of fresh fruit bunches (FFB) to tractor hopper or mill. Manned machines available for use at this stage are as follows: (i) Motorized cutter: The C-shaped crescent is used in harvesting about 700 to 1000 ripe oil palm bunches per day and records a reduction of 2 to 3 labors; (ii) Motorized chisel: This uses its chisel to cut down 80 FFB per hour per labor and could prune the oil palm leaves at about less than 2 m high; (iii) Mechanical harvester: It can cut about 4.0 to 6.0 ton FFB per day and 80 to 100 hectares per machine at 6.0 to 10.0 m high, and carry them to accessible road; (iv) Compact transporter. It can transport from 3 to 5 ton FFB per day along narrow terrain areas; (v) Grabber: It is like an arm mounted on a tractor which uses a three-blade clamp to hold about 20-30 ton FFB/day; (vi) Loose fruitlets collector (MPOB TT No.57): This is a mechanism installed on a three-wheeler with the capacity to suck 1400 kg to 1700 kg of loose fruitlets per day.

Another brand of loose fruitlets collector (MPOB TT No.419) has the ability to collect 30 to 60 kg of palm fruitlets per working hour. The fruitlets get into elastic crannies of the rod depending on the surface of the soil where the process is carried out; (vii) Loose fruitlets separator: This separator can be stationary and movable unit, and can separate 97% of 1 clean ton of fruitlets per hour with the fan speed of 1600 rpm; (vii) Motorized injector: It is mechanism for introducing liquid chemicals into the palm stem, e.g. in controlling Ganoderma. About 40 to 50 trees could be injected with it per day [20]. Unmanned aerial vehicle images embedded with YOLO model could identify oil palm loose fruits. The model has adopted numerous enhancements where closely and heavily connected neural network is featured for reprocessing. The multi-layer detection of minute targets, prior box optimization, and swish activation function to get exact bounding box record are also embedded. Based on the report of a study, an excellent mean accuracy of 99.76% as well as 34.06 ms detection time was obtained [23].

(b) **Artificial Intelligence (AI)**

The data relating to the application of AI on harvesting and collection of FFB can be uploaded to the computer system at the estate’s office for immediate actions [20].
With AI agriculture bots or robotic systems, FFB could be harvested at a higher volume, faster pace than human labour with more accuracy based on quick auto identification of the ripe bunches [21].

**Future Realities in Oil Palm Mechanization**

A shift from conventional mechanization to robotic (modern) supported mechanization systems such as drone systems, artificial intelligence (AI), robotic system, unmanned aerial vehicle, etc. cannot be overemphasized. Mechanization packages could be developed based on machine structures and field operations. Weather proofing could also be developed to maintain field infrastructures and promote efficient mechanization. Mechanization systems can be replaced by embracing and adopting automation and robotic technologies [20, 24].

**PROCESSING OF OIL PALM FRUIT**

The palm fruits are harvested and thereafter subjected to series of processing stages such as bunch reception, threshing (stripping or detachment), sterilization (heating of the fruits), digestion (pounding), palm oil extraction/ clarification, nut-fibre separation, nut drying and cracking, kernel separation, kernel crushing and pressing as presented in Figure 4. However, two methods are used. The principles involved are the same but the difference is in the facilities employed. The cracked nut mixture, shell fragments and kernels are shown in Figure 5. [2,15].

![Diagram: Stages involved in palm fruits processing into palm oil, kernel oil and kernel cake](image-url)
Methods of Processing of Oil Palm Fruit

Traditional Method of Processing

Traditional method of processing palm fruit involves the following:

a) Threshing
This is the process of detaching palm fruits from their bunches. The bunches are cut into bits with either a machete or an axe, then water-sprinkled, covered with plantain or banana leaves and left for two to three days. This promotes the separation of fruits from the spikelets by hand. Small-scale operators employ the waste/empty bunches as manure or cooking fuel.

b) Heating
The fruits are boiled in a drum containing water. The heating process aids in:

I Inactivation of enzymes responsible for splitting the oil, and prevention of hydrolysis and oxidation.
II Coagulating microscopically dispersed protein in the cell that bears oil. It permits the oil-bearing cells to be collected together for easy flow.
III Softening the the pulp structure for easy detachment of fibrous material and its contents.

c) Pounding
Pounding is done with a big mortar and pestle. The mortar is made from a big drum placed in a dug ground. Pounding helps in detaching the mesocarp from the palm nut.
d) Extraction

Extraction could be done by hand picking or using manually operated machine.

I Hand picking: In a small-scale operation, hands are used to select out the kernel and nuts. Then, the oil is pressed out using hand or sack bag from the fiber and collected into petroleum drums or plastic drums. This method is laborious and time-consuming. The selected fiber is covered to internally generate heat by exothermic reactions, for about 2 to 3 days. Then, the fiber is pressed using a spindle press mechanism to get back the rancid-type of palm oil that is used in making soap. The fiber is now collected as dried matter and kept for use as biomass (fuel).

II Use of manually operated machine: The pounded mixture is emptied into a screw press machine with cylindrical perforated sides. When the T-shaped iron bar fixed to the screw is rotated manually, a flat metal plate presses the pounded mixture and forces the oil to flow out [25].

e) Nut Drying
The nuts are usually sun-dried by spreading them on a bare ground or floor for some days depending on the sun intensity. After this stage, the nuts could be stored in silos, bins etc., or subjected to cracking.

f) Nut Cracking
Cracking palm nuts is commonly done by stone-arrangement and mortar/pestle method. The stone arrangement employs impact principle, where a nut is placed on a leveled stone and another stone (as hammer) is used to crack it. It is commonly done by women and children. This technique is primitive, inefficient kernel recovery, uneconomical, labor intensive and injurious to the operator [26].

g) Separation of Cracked Nut Mixture
Children and women are used in picking out kernels from cracked nut mixture. These people make income from this process. The shell fragments left are collected for many applications.

h) Palm Kernel Oil Extraction
Kernels are normally heated (roasted) in a vessel until dark brown crude palm kernel oil is collected and stored. It may be used by locals as medicine and body cream [25].
Modern Method of Processing

a) Bunch Reception

The fresh fruits are received, emptied into wooden boxes and weighed. In a large scale mill, trucks loaded with the fruit are made to pass through the weighing bridge directly and the weight noted. It is worthy to note that the quality of bunches received would affect the quality standard of the end-products. The mill could only abate further deterioration.

b) Threshing (Stripping)

The fresh bunch mainly comprises fresh fruits. In a modern mechanized process, a rotating or fixed drum is fitted with rotary beating bars. These bars help in detaching the fruit from the bunch, leaving the spikelets on the major stem. In larger mills, the bunch waste is incinerated into ash. The ash obtained is very rich in potassium which could be used in making fertilizer for plant use [15].

c) Bunch Sterilization

Sterilization involves the use of wet-heat treatment operated at high temperatures to loosen the fruits. Sterilization in other words means cooking. It normally uses hot water or pressurized steam. The cooking action serves several purposes as already explained in traditional method. The steam breaks down resins and gums. During frying, foams are formed as a result of the presence of gums and resins. Gums and resins are water-soluble while others may be induced to be soluble in water.

The sterilization process causes the nuts to expand due to moisture movement. Nuts contraction helps the kernel to be detached from the shell wall as a result of reduction in pressure. This process later accelerates nut cracking operation to release whole kernels.

d) Fruit Digestion

Digestion simply refers to the breaking down or rupturing of oil-bearing cells of palm fruits to release palm oil. The digester usually employed comprises of a steam-heated cylindrical container fixed with a principal rotating shaft that bears a number of stirrers or beater arms. Action of these rotating beater arms digests (pounds) the fruit. Fruit digesting at high temperature decreases the palm oil viscosity; destroys the exocarp (outer covering) of the fruit, and enhances oil cells disruption which must have begun during the cooking phase. Meanwhile, iron contaminant with palm oil is common and is very high during digestion as a result of peak rate of metal tears and wears. This contamination accelerates palm oil oxidation rate and subsequent results in rancidity of the palm oil [15].

e) Pressing (Palm Oil Extraction)

Two distinct methods could be used in extracting palm oil, namely: the dry and wet methods. The dry method employs mechanical presses.
The mechanical pressure is applied to the digested mash which aids in squeezing out the oil from the mixture of water, oil, nuts and fibre. The wet method makes use of hot water to seep out the oil. After this stage, a mixture of nut and fibre is left.

f) **Clarification and Drying of Palm Oil**

The reason for oil clarification is to segregate the oil from its ingrained, foreign materials. The fluid from the press is composed of fibrous material, cell debris, palm oil, water, and ‘non-oily particles’. Due to high viscosity of the non-oily particles, hot water is added to the fluid in order to reduce its viscosity.

This treatment allows the dense solid particles to get to the bottom of the container whereas the less dense portion (i.e. palm oil) flows over the watery mix to the top when heat is supplied to disrupt the suspension. Addition of water is always in a ratio of 3:1. The diluted mix is screened to eliminate the bristly fibre. The screened mix is heated for 2 – 3 hours. This is later allowed to settle down by gravity in a large vessel so that the clear oil (palm oil), which is less dense than water, is collected into a tank (reception vessel). At this point, the clarified oil is re-boiled so that the moisture content could be reduced to 0.15 to 0.25 %. This prevents increase in free fatty acid content by autocatalytic hydrolysis. The oil can now be skimmed off. The wastewater is disposed into the nearby sludge pits for use as herbicide [15].

g) **Storage of Oil**

In a commercial palm oil mills, the filtered and dried palm oil is pumped to a reservoir (storage tank) before dispatch from the mill. The storage vessel is always maintained at about 50°C, because increase in temperature increases oil oxidation rate; and a low-pressure steam-heating coils or hot water is always used to abate fractionation and solidification.

h) **Palm Nut Recovery and Drying**

The residue from the press comprises of a mixture of palm nuts and fibre. In the large-scale nut recovery process, the nuts could be separated from the fibre using nut-fibre separator [27] or a depericarper. The nuts could be dried using any suitable method e.g. oven, solar dryer, etc. The nut could now be stored in silo between 6 – 8% moisture content wb [15].

i) **Palm Nut Cracking and Kernel Separation**

The dried nuts are cracked by employing centrifugal nut crackers to release whole kernels. The kernels are generally screened from the shells using a combination of hydrocyclones and winnowing, inclined draper, etc. The kernels obtained are conditioned (dried) to about 7.0 percent moisture content before packaging [28, 29, 15, 30, 31].
j) Extraction of Palm Kernel Oil

The palm kernels obtained are further crushed using mechanical crushing and pressing machine to obtain crude palm kernel oil (CPKO) and cake. The CPKO and cake are collected and stored in tanks and bags, respectively [27].

PRODUCTS OBTAINED FROM OIL PALM TREE

Many products are obtained from oil palm trees. These include palm oil, kernel oil, palm wine, kernel cake, fibre, wood plank, fatty alcohol and broom. Palm kernel oil can be used for making polish, glycerin, medicine, margarine, oil paint, candle, pomade, cosmetics, toothpaste, etc. [32, 33, 34, 35, 36]. Shell particles are generally used as domestic fuel for cooking, decorating houses in many rural communities and a source of coarse aggregate in light concrete mix. Other usages are as a key biomass material, replacing fossil fuel for steam power plant [37]. The kernel cake, on the other hand, is used in making livestock feed [33].

PRODUCTION OF PALM OIL IN NIGERIA BETWEEN 2010 – 2020

Nigeria is one of the five major producers of palm oil globally. The production capacity from 2010 to 2020 is presented graphically in Figure 6.

Fig. 6. Palm oil production capacity in Nigeria from 2010 to 2020.
From Figure 6, there was a drastic decrease in palm oil production from 971 – 880 thousand metric tons from 2010 to 2013 [38]. From 2013 – 2017, 16.4% increase was observed. Thereafter, decreased by 0.97% and remained unchanged in the last three years (1,015 thousand metric tons) as estimated till 2020 [38].

**NUTRITIONAL COMPOSITION OF PALM OIL AND PALM KERNEL OIL**

Palm oil has 99.9% crude fat, 0.1 mg Fe /kg and 9380 kcal gross energy / kg. It also has 11% vitamin E. Its fat generates all the calories. Its fatty acid is made of saturated-fatty acids (50%), mono-unsaturated fatty acids (40%) and poly-unsaturated fatty acids (10%). Its main unsaturated fat is palmitic acid. It also has smaller composition of stearic and linoleic acid but higher composition of oleic acid. The red pigment in the red palm oil contains antioxidants known as carotenoids. Human body is able to transform these carotenoids into vitamin A [36]. Palm kernel oil has higher saturated fats than palm oil. Besides, it is high in lauric acid, which is believed to raise blood cholesterol content, both as low-density lipoprotein (LDL-C) and high-density lipoprotein (HDL-C) (David, 2012). However, overall cholesterol concentration increase may be as a result of more of HDL-C than LDL-C. About 16.2% myristic acid (C14), 48.2% lauric acid (C12), 8.4% palmitic acid (C16), and 15.3% oleic acid (C18:1) form the main composition of fatty acid found in palm kernel oil. The minor ones are 3.4% capric (C-10), 3.3% caprylic (C-8), and 2.5% stearic (C-18), all of which are the saturated fatty acids except oleic and linoleic [14, 39]. However, palm kernel oil is used commercially for cooking because it is more affordable than other oils and is stable at higher cooking temperatures [40].

**RATIONALE FOR THE USE OF OIL PALM AND ITS DERIVATIVES IN THE DEVELOPMENT OF SUSTAINABLE FOOD AND ALLIED PRODUCTS**

Need for the use of palm oil in many food applications cannot be overemphasized. About 72% of it is used in the food manufacturing industry. It is the most commonly demanded vegetable oil because it is economical to cultivate and its oil is characterized by neutral flavor. The demand is expected to be doubled by 2030 and tripled by 2050 [41]. Palm oil is semi solid at room temperature while other vegetable oils require hydrogenation (i.e. making them to be semi-solid). This process creates trans-fatty acids or trans-fats which raises cholesterol. Moreover, it is odorless, and resistant to deterioration. It has an elongated shelf life. Palm oil is an inexpensive alternative for hydrogenated vegetable oils as found in many foods. It may be cumbersome to spot food products that contain palm oil or its derivatives. There are a lot of compounds that are made from palm oil fatty acids. Words such as glyc, palm, laur and stear could be used to identify these food products.
Sustainable Palm Oil

In recent years, the move towards sourcing for sustainable palm oil that is certified as organics by food industries has been encouraged by Roundtable on Sustainable Palm Oil (RSPO). Unfortunately, RSPO had been criticized for failing to sanction defaulting food industries in terms of non-compliance. Other approaches such as High Carbon Stock (HCS) and establishment like The Palm Oil Innovation Group (POIG) are known for standard higher than those projected by the RSPO [42].

Some Food Products Made From Palm Oil and its Functional Attributes

Some food products made from palm oil (as vegetable oil) as well as its functional attributes in food products formulation are presented in Table 1 [43].

Table 1. Food products from palm oil and its functional attributes

<table>
<thead>
<tr>
<th>S/No</th>
<th>Food products</th>
<th>Functional attributes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Biscuits/Cookies</td>
<td>Palm oil shortens dough to give a melt-in-the-mouth and flaky texture.</td>
</tr>
<tr>
<td>2</td>
<td>Bread</td>
<td>It enhances loaf volume and softness.</td>
</tr>
<tr>
<td>3</td>
<td>Breakfast bars</td>
<td>It prevents melting during transportation.</td>
</tr>
<tr>
<td>4</td>
<td>Butter/Margarine</td>
<td>Avoids product oxidation. Oil oxidation reduces oil quality and results in off flavour and smell. It also enhances consistency, texture and structure.</td>
</tr>
<tr>
<td>5</td>
<td>Cake</td>
<td>It improves shelf life and texture of cake. It also makes cake to be softer, airier and increase volume and moistness.</td>
</tr>
<tr>
<td>6</td>
<td>Cereal</td>
<td>It promotes crunchiness and freshness of cereal.</td>
</tr>
<tr>
<td>7</td>
<td>Chocolate</td>
<td>It gives a smooth and shiny appearance to chocolate. It also prevents it from melting in warmer temperatures.</td>
</tr>
<tr>
<td>8</td>
<td>Crackers</td>
<td>It enhances buttery flavour and texture.</td>
</tr>
<tr>
<td>9</td>
<td>Crisps/ Doughnuts</td>
<td>It is used in frying potato chips/crisps/ doughnuts.</td>
</tr>
<tr>
<td>10</td>
<td>Dried nuts</td>
<td>It is used in roasting nuts.</td>
</tr>
<tr>
<td>11</td>
<td>Canned soup</td>
<td>It preserves processed meals.</td>
</tr>
<tr>
<td>12</td>
<td>Fast food</td>
<td>It promotes processed food taste, and makes it less greasy.</td>
</tr>
<tr>
<td>13</td>
<td>Frozen meals</td>
<td>It is a natural food preservative. It prevents stickiness of meals.</td>
</tr>
<tr>
<td>14</td>
<td>Ice cream</td>
<td>It increases the product melting point; and promotes a thicker consistency, smoothness and creaminess of the product.</td>
</tr>
<tr>
<td>15</td>
<td>Infant formula</td>
<td>It gives a creamy texture to the product.</td>
</tr>
<tr>
<td>16</td>
<td>Instant noodles</td>
<td>It is used for frying the product.</td>
</tr>
<tr>
<td>17</td>
<td>Microwave popcorn</td>
<td>It gives a creamy flavour and aids the kernels to pop.</td>
</tr>
<tr>
<td>18</td>
<td>Peanut butter</td>
<td>It binds nut oil with the nut solid part.</td>
</tr>
<tr>
<td>19</td>
<td>Pizza bases</td>
<td>It averts dough from sticking and improves crispiness and texture of pizza base.</td>
</tr>
<tr>
<td>20</td>
<td>Salad dressing</td>
<td>It is a natural anti-oxidant as a result of its stability and has reasonable content of vitamin E.</td>
</tr>
<tr>
<td>21</td>
<td>Whipping cream</td>
<td>It is stable even at warmer temperatures.</td>
</tr>
</tbody>
</table>
CONCLUSIONS

Food is one of the basic necessities of life. Though, efforts have been made to enhance the quality and quantity of world food production and supplies, food insecurity still remains dominant in Nigeria, especially in the northern parts of the nation.

The rural communities are more prone to this menace. Thus, serious attention must be given in this regard. However, with the availability of sustainable food products made from oil palm and its derivatives, the menace could be curtailed.

REFERENCES


[14.] Wikipedia. 2020. Palm Kernel Oil. Available through:


FAO (2012). *Palm Oil Processing*. Available through:


[16.] Myphotojourney. 2020. Oil Palm Tree Plantation. Available through:

http://myphotojourney.co.uk/palm-tree-plantation-malaysia/ [Date accessed: 12th November 2020].

[17.] Etawau. 2017. The Oil Palm Tree. Available through:

https://www.etawau.com/oilpalm/elaes_guineensis [Date accessed: 3rd September 2020].

[18.] John, D. 2021. Mechanizing Palm Oil Crop Production Available through:

https://tractorexport.com/mechanizing-palm-oil-crop-production/ [Date accessed: July 19th 2021]

[19.] Justin Stoltzfus. 2020. The Six Most Amazing AI Advances in Agriculture. Available through:

https://www.techopedia.com/the-6-most-amazing-ai-advances-in-agriculture/2/33177 [Date accessed: 15th May 2021].


[22.] Kathleen, W. 2019. How AI is Transforming Agriculture. Available through:

https://www.forbes.com/sites/cognitiveworld/2019/07/05/how-ai-is-transforming-agriculture/?sh=2a0e9e4b4ad1 [Date accessed: July 19th 2021].


https://doi.org/10.1007/s00371-021-02116-3 [Date accessed: 13th May 2021]


https://internetofthingsagenda.techtarget.com/definition/drone [Date accessed: July 19th 2021]

[25.] Farmbaze. 2020. Extraction of Palm oil from Palm fruit. Available through:

https://farmbaze.com/uncategorized/extraction-of-palm-oil-from-palm-fruit/ [Date accessed: 13th May 2021]


[29.] TNAU (Tamil Nadu Agricultural University) 2008. Seed processing: Equipments. TNAU. Agritechportal, Coimbatore. Available through:

http://agritech.tnau.ac.in/seedcertification [Date accessed: 23rd March 2021]


Edet et al.: Development of Sustainable Products... /Agr. Eng. (2022/1). 15-33


RAZVOJ ODRŽIVIH PROIZVODA IZ ULJA PALME, JAČANJE NACIONALNE SIGURNOSTI HRANE: PREGLED

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Apstrakt: Sve veća nesigurnost u proizvodnji hrane u Nigeriji primećuje se u gotovo svim delovima i oblastima nacionalne proizvodnje hrane. Cini se da je nesigurnost hrane globalni izazov koji ima mnogo povezanosti sa porastom potražnje za energijom, rastom broja stanovnika, klimatskim promenama i konkurencijom za zemljište, hranu i vodu. Seoska naselja su mnogo podložnija neredovnom snabdevanju hranom, niskom kvalitetu hrane, neuhranjenosti stanovništva i visokim cenama prehrambenih artikala, pa nekada i rasprostranjenom nedostatku hrane. Ova situacija je stvorila ozbiljnu zabrinutost za nacionalnu bezbednost sa aspekta hrane u Nigeriji.

Međutim, dobra dostupnost poljoprivrednih i prehrambenih proizvoda može ublažiti ovako opisane i pretpostavljene pretnje u ovoj oblasti. Dakle, u pokušaju da se opisana situacija promeni, ovaj rad predstavlja pregled razvoja nekih održivih proizvoda od palminog ulja za jačanje nacionalnih prehrambenih bezbednosti i sigurnosti u oblasti hrane.

Ukratko, dat je pregled osobina uljane palme, klasifikacija, trenutna i buduća mehanizacija u ovoj proizvodnji, pre svega prerada plodova od grozdolok ekstrakcije sirovog palminog ulja i drugih dodatnih proizvoda, primena proizvoda; kao i kapacitet proizvodnje palminog ulja od 2010. do 2020. u Nigeriji.
Pored toga, u radu se analizira nutritivni sastav palminog ulja i ulja palminog jezgra, obrazlaže upotreba palminog ulja i njegovih derivata u razvoju održive hrane i sličnih drugih proizvoda. Zatim se razmatra koncept održivog korišćenja palminog ulja, neki prehrambeni proizvodi od palminog ulja i njegovi funkcionalni dodaci. Posebno je naglašen razvoj nekih odabranih prehrambenih proizvoda sa palminim uljem kao jednim od glavnih sastojaka.

**Ključne reči:** Uljana palma, održivi proizvodi, nacionalni, hrana, bezbednost

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