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Breadfruit Research and opportunities for Future Commercial Development

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Abstract— *African breadfruit (Treculia africana) is a foodcrop tree with enermous potentials for domestic and industrial uses. African breadfruit seeds are highly priced product. Research studies on African breadfruit seeds are mostly basics with limited contribution of information on the commercial opportunities within breadfruit seed industry.This study evaluated the state of research, challenges and prospects of African breadfruit seed industry with the objectives of identifying commercially viable opportunities that should drive future research studies to profit researchers, seed processors and national economy. .Forty-four (44) journal papers comprising of research articles and communications on African breadfruits were randomly selected and reviewed. Other research papers in areas of economic opportunity were also consulted. Focus was on nutritioonal contributions, utilization, research direction, limitations to commercialization and opportunities of African breadfruit seeds. Results showed that research trend in breadfruit seeds is still basic with limited studies on technological advancement for mechanized seed processing, seed propagation and absence of industrial funded studies.Results showed that 13.64%, 47.73%, 18.18%,20.45% were on technology development, chemical composition assays, novel foods/sensory evaluation of formulated Novel foods and supplementation studies respectively. Some product specific machines have been developed for mechanized dehulling of African breadfruit seeds but still at the point of prototypes. These prototypes could be refined through entrepreneurial investments for enhanced efficiency .Few studies (4.05 %) were on commercialization of African breadfruits. The low awareness about the commercial profile of African breadfruit is attributable to fewer available research information on commercial profile of African breadfruit. Globally market opportunities exist for African breadfruit seed oil as domestic oil, bio-lubricants, bio fuels, whole seed meals for confectionaries and animal feedstock.African breadfruit seed flour has important diet therapy properties for the management of some physiological stress conditions. Purpose driven translational studies are expedient to exploit these opportunities. Government, research institutes, universities and entrepreneurs have critical roles for commercial advancement of the breadfruits industry.*

Keywords— African breadfruit, Research trends, Opportunities,uses.

I. INTRODUCTION

African breadfruit (*Treculia africana*) a tree of the moracae family genus treculia is widely distributed globally. The tree depending on age and ecology could reach many meters high with large crownhead.Except for temperature regions, no tropical or subtropical region can hold claim exclusively to its distribution[Nuga and Ofodile,2010)The origin of African breadfruit has been an element of controversy. However, African breadfruit is of the same family but chemically slightly different from breadfruits Artocarpus heterophyllis(Ajayi,.2008)

Scientific literature is awash with information on African Breadfruit tree that it requires no much exposition to the scientific community(Fao.org;Osabor et.al.,2015).

The most important varieties are the africana, inverse and mollis (Nwabueze, 2010).The basic taxonomical differences are reflected in size of tree fruit head, size and colour of seeds, rate of fermentation and ease of seed extraction. Mass of fruithead ranges from 15 to 35kg depending on the age of tree, ecological conditions and spatial concentration of African breadfruit tree(Fao.org.) An average of 200kg seed per tree//year are obtainable from high yielders. The importance of African breadfruits seeds associates with its role in the amelioration of hunger and malnutrition in

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developing nations. Similarly the processing of seeds as consumable food has followed the trend of undelulled whole seed porridge, delulled seed porridge, roasted snack seeds to product complementation and supplementation Enwere,1998; Fassasi et. al., 2003; Nwokocha and Ugbomioko; 2008;Arawande et.al.,2009;Ulocha and Udeagha,2016). Consumption of parboiled seed porridge as main meal or social food identifies more with regions with limited access to carbohydrate and protein staples. The abundance of nutrients in African breadfruit seeds has been documented in literature.

Information in literature point to 52-72% carbohydrate (Nwokocha and Ugbomioko ,2008) 17-22% protein (Fassasi at.al., 2003;Olapade and Umeonura, 2014) 7-9% Fat (Uzo et.al., 2014) with abundance of vitamins and fibre(Adumanaya et.al., 2013).Scientific literature can hardly exhaust the available information on important nutritional and health benefits of *Treculia africana*. Summary of the nutritional and health benefits of African breadfruits exploited globally are found in the report of Ezengige(2015).

With a free sugar content of about 4% there is no doubt that African breadfruit seeds hold good promise for dietary control of type 2 Diabetes(Chinedu et.al., 2018) and other metabolic disease conditions.It's an importance source of protein and amino-acid needed for metabolic wellbeing of humans, Umezuruike et.al.,(2016) reported important contents of Alanine, Isoleucine, lysine, histidine, aseptic acid, glutamic acid, glycine, proline, threonine, tyrosine, phenylannine, methionine and valine. These amino acids occurred in concentrations able to satisfy or meet proportionately the RDA for essential amino-acids for infants and adults(Munro,1978).

Suggestively African breadfruit seed is a proficient alternative to animal protein in human diets and non-ruminant animal husbandry(Akande and Fabiyi,2010;Obas et.al.,2013; Nwosi et. al.,2014).African breadfruit seed with about 5-9% oil content is not an oil seed. However its oil character along with other properties has proven amenable to versatile usage (Nwabueze and Okocha, 2008;Agu et. al.,2010; Umezuruike and Nwabueze, 2016).The flour of African bread fruit seed has successfully been applied in confectionaries, extruded product, and break fast cereals(Balogun and Fatuga, 1986;Ugwu and Ekwu, 1996; Ifediba and Nwafor, 2015) .Though it suffers easy retrogradation of gel, the compact structure of African breadfruit seed starch (Nwabueze 2009),. posits it for tablet formulation in the pharmaceutical industry.

The low bulk density and good gelation value are sustainable attractions for wider applications of African breadfruit flour in food systems. African breadfruits seeds has a poor shelflife with high propensity for moisture absorption and moisture loss with negative effects on it nutrients, processing and storage (Chukwunda et.al., 2012;Ejiofor et. al. ,2012;Nzekwe et. al.,2013).

Trend of Research Studies on African breadfruit Seeds.

After decades of scientific expositions, most research studies on African breadfruit are still basic without any translational value needed to attract international commercial recognition. Available information in scientific literature point to the dominance of local basic research studies designed to satisfy short term objectives. Published reports in Scientific journals are primarily concerned with proximate contents, minerals and vitamins of African breadfruit seed products resulting from different processing methods. Other studies too focused on products formulated with composite blends of African breadfruit seeds and some indigenous grains . Such products were either formulated as breakfast composite diets, extruded pasta products, energy bars, milk, yoghurt, etc.Basic researches with too much emphasis on complementation and supplemention with African breadfruits do not usually solve tangible problems. Thus offer no sufficient motivation for global entrepreneurship. Not much of innovational translational researches that deal with societal growth objectives are found in scientific literature. Purpose driven research studies are pivotal to societal growth. The growth of any society depends to some extent the ability of a nation to put to use important research findings of their Scholars. Most of the research efforts on African breadfruit appeared intended for academic career progression without realtime contribution to commercial breadfruit seed industry. There is the necessity to highlight opportunities within African breadfruit industry calling for purpose driven researches.The allure of basic research is so magnetic that without some prompting researchers basking in the euphoria of short term benefits of basic research would fail to exit their comfort zone of basics to more tangible translational studies.

The specific objectives of this study were

a. To review the current state of research within Africa breadfruit seed Industry.

b. To identity research areas with important economic prospects and

c.To redirect research interests to translational studies inorder to exploit the huge market opportunities present in African breadfruit seed industry.

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This study selected and critically reviewed 44 published papers on African breadfruits on current state of research.The trend of research studies(2000-2018) , results and the relevance of research thrusts to opportunities provided by African breadfruit industry were evaluated . The adaptation of Tables and Figure from past research studies were used to emphasize important points.

II. CHALLENGES AND PROSPECTS OF AFRICAN BREADFRUIT SEED INDUSTRY.

Nuga and ofodile (2010)observed that African breadfruit is an endangered tree of southern Nigeria with consistent decline in gross utilization. Among challenges limiting full exploitation of African breadfruits seeds are

1. Absence of African breadfruit tree plantations to meet the demand for products
2. Depulping and dehulling difficulties of African breadfruit seeds
3. Limited shelf life of unprocessed and processed African breadfruit seeds.
4. Absence of appropriate machines for processing of African bread fruit seeds such as product specific dehuller for African breadfruit seeds.

African breadfruit plantations. The huge demand for African breadfruit seeds is unsatisfied due to absence of large African breadfruit tree plantations.. Establishment of commercial plantations is faced with the problems of late plant maturity and large financial outlay needed for establishment of plantations. To address the problem of plantation, propagation efforts had adopted two major methods comprising of seedling nursery method and use of biotechnology In nurseries seedlings are raised in seed pots followed by budding, cutting and grafting(Nzekwe et. al.,2013) In the biotechnological method, rhizobacterium Pseudomonas was employed to fast pace propagation of stem cuttings in the seed nurseries. Rhizobacterium Pseudomonas species of bacteria was used to prime and reduce root development of stem cuttings of African breadfruit from 63 – 49 days (Odozie, 2017).Development of new fast growing varieties of the crop is gaining momentum as observed in the Research effort of Forestry Research Institute. Nigeria

To achieve the goals of commercializing African breadfruit industry, African breadfruit plantations must be established to bridge the widening gap between demand and supply. The plantation project though expensive can be made real by the Synergetic Private-public Partnership of national governments, Research Institutes, specialized Agriculture Universities and astute entrepreneurs. The profitability of raising African breadfruit tree plantation is not in doubt (Nzekwe, 2010). Nzekwe and associates evaluated the 4 year gestation period and economic yield of African Breadfruit at a spacing of 10 by 10 meters within the tropical conditions of Nigeria.

Their findings showed a two hundred percent annual return on investment over produce period of 10 years. In seed only study Mojekwu et.al. (2017) reported a 20-30% gain on each Naira investment during each harvest season by rural traders. The reports of Mojekwu and Nzekwu study groups were clarion pointers to the profitability of African breadfruits that required redirection of efforts to achieve.For nations with elaborate agricultural policies the returns on investment could be enormous.

Depulping and Dehulling. Depulping of breadfruit heads for seeds follows long period of delay. Seeds of African breadfruit are extracted from fruit heads after 6-9 days fermentation. In commercial consideration, it is a lot of stoppage time in production planning. Recent technological studies have explored the use of biochemical or bacteria agents for breakdown of the pulp for seed extraction as is consistent with modern starch solubilization process in the brewery industry. New technologies capable of shortening fermentation time or elimination of that phase of depulping are more urgent than the development of mechanized depulpers for fermented fruitheads.

These efforts at tackling depulping problems are still neophyte in their development of technologies to harness higher seed extractions without compromising the nutritive value of the depulped product. Depulping problem is not as intractable as dehulling. Dehulling which is a major pre utilization requirement is faced with the problems of appropriate mechanization ,drawbacks of seed structure and determination of optimal conditions for process variables..The African breadfruit seed is thick hulled with an easily hydrated endosperm separated by a thin adhesive inner seed coat. Prior to dehulling the seeds are parboiled or roasted. Maximization of dehulling yield of seeds involves tasking skills beyond the easy comprehension and practice of regular breadfruit seed processors. During processing moisture migrates from parboiling medium through the hull to the endosperm. While in roasting it is the reversal of moisture movement. In both processes mass flow rates must be properly timed as to achieve the desired result. Too much moisture in the endosperm turns the kernels into mash,while excessive loss of moisture from the kernel to the environment

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leads to excessive fragmentation of the kernels and hulls ,resulting to less acceptable products (Nwabueze, 2009).

Employing Response surface methodology complemented with Central Composite Rotable Design ,Nwabueze (2009) sucessfully optimized the dehulling variable conditions for parboiled seeds .Such findings denote important innovations over the adaptation of grain attriction mills and when extrapolated are applicable to commercial dehulling of African breadfruit seeds. However the technical sophistry of their findings is beyond the skills of local processors. Thus requiring the co operation of Extension officers of Ministries of Agriculture, Research Institutes and Universities for knowledge transfer.

The present low level of mechanization for dehulling of African breadfruit is an important setback for the commercialization of African breadfruit seed industry. The absence of appropriate machinery has been responsible for low levels of output, hygiene and quality. Difficulties of mechanized dehulling are traceable to seed shape, the strong adhesive inner seed coat , process orientation of seeds during pretreatments and the difficulty of using gravity for kernel-hull separation . The kernels and hulls are of similar weight following parboiling of seeds. The seed architecture and process considerations for dehulling of African breadfruit seeds were fully described in the findings of Nwabueze (Nwabueze, 2009; Igwilo et. al., 2017).

III. RESEARCH RESULTS ON AFRICAN BREADFRUIT INDUSTRY

Development of African breadfruit seed Dehullers. Information in literature identified some innovative machines developed specifically for dehulling of African breadfruits seeds. The developed prototypes are innovative and translational in character.. Their design concepts emphasized seed architecture, principles of particles flotation, friction , wet and dry state conditions (Nwogbo et. al., 2008;Aniebomo et. al.,2013;Anosike et. al.,2016).These innovative designs aimed to eliminate drudgery, poor hygiene with optimum product and quality outcomes ,efficient separation of mixed(hulls and kernels) stocks using air classification and automation of operations .Their dehulling efficiencies though low could be improved through process modifications .The reported 100% separation by Anosike and associates study is less convincing within the field of mechanical engineering.

African breadfruit seed oil in food and Non food Systems. Most scientific discourse today is centered on climatic change and the need to reduce the degradation of the earth's ozone layer arising from unhealthy emissions.

This global concern focuses on the development of renewable source of energy, environmental friendly lubricants .bio diesels among others. Global industrialization is assumed to be responsible for most climatic changes. Machines and equipment used for production of goods must be lubricated for optimum performance, Wears, tears due to friction are managed through the application of lubricants. Lubricants that are sourced from mineral oils, hydrocarbons , contribute to global warming, acids rains, oxide and poor human health(Habereder et.al.,2009).In the light of these vegetable oils are receiving increased global attention in all aspects of industrial and domestic usages.

African breadfruit seeds as Raw materials for livestock feeds. Between 1990 and now global demand for vegetable oils had quadrupled(Appalasami and de vries, 1990 Satistica, 2016).Protein oilseeds and soybean meals constitutes 75 % of all protein used in animal feed production globally(ifif.org ;Gilbert, 2016).Animal byproducts in feeds are banned in the E U for health concern following the Bovine Spongiform encephalopathy and Variant Creutzfeldt Jacob disease..Fishmeal is expensive and accounts for just 7 million tonnes in feed formulation. Global demand for non animal products for feed production is faced with limited supply.

Machine lubrication and biofuel potentials of African breadfruit seed oil. Though not an oil seed, African breadfruit with oil contents of 9-15% (Ugbomioko and Nwokocha,2008) is higher than the oil content (4.78%) of corn (Enwere, 1998) from which oil has been extracted over a long period of time. Placed against industrial specifications for mineral lubricants, African breadfruit seed oil is premium with high operational thermal range, sludge retardation properties, efficient flow and cost effectiveness. The oil of African breadfruit can be converted to clean bio diesel (Adewuyi et. al,.2012). Using Bertram equation (en.m wiki pedia.Org/wiki/Heat of combustion).

$$-\Delta HC(cal/g)=11.380(IV)-9.15(SV)$$

1

With Iodine value IV (16.70) and Saponifiable value SV(350.10) the estimated yield of energy from African breadfruit seeds is 33.6 MJ/kg.. This value is 3.1 MJ less than energy yield (39.7MJ/kg) of soybean oil

African breadfruit seed oil with viscosity index of 183 is superior to soybean oil in efficiency .Petrol based diesel is about 45.3MJ/kg.[Adewuyi et al.2012].

The advantage of roasted of breadfruit seed oil as bio-degradable lubricant over mineral oil (Table1) draws from its physiochemical characteristics. These

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characteristics fall within or superior to industrial specifications(Igawrilow 2004;Adhavaraya et.al., 2004;Xu et. al.,2014; Gerpen and Knothe ,2015;Meza ,2016).

African breadfruits oil may not compete favourably in the oleochemical market but its physiochemical properties remain unsurpassed in biolubricant and biodiesel segments[Appalasami et.al.,1990;Umezuruike and Nwabueze ,2017)

Table 1. Lubrication indices of African breadfruit seeds oil compared with industrial standards.

Parameter	Indices	Standard values (++)
Viscosity index (20o)	183	170-200
Total acid value mgKOHg^{-1}	01.0	1.0-1.0
Free fatty acid %	0.94	1.1-1.4
Saponfication value mgKCHg^{-1}	257.10	186-198
Non saponifiable matter gKg-^{1}	1.99	19
Iodine value wii,	16.70	94.126
Perioxide value mEgKg^{-1}	1.10	1.0

Umezuruike and Nwabueze(2017).++ Mechanical engineering team USA

Nutritional and Health Benefits of seasonal compositions of African breadfruit seeds. The health and nutritional benefits of African bread fruit associates with its span of seed formation and fruiting season.The fruiting season which cuts across the months of October to May could be classified into early, middle and late seasons.

Controversies exist among scholars (Lafond et. al.,2005; Petkova and Antova, 2015)on the effect of climatic condition on nutrient circulation in crops. However there are no divergent views on the summative impact of ecological conditions on nutrient content of grains.Findingsprobably linked photosynthesis, condensation, phosphoration ,probably soil conditons, nutrients dynamics and others accounted for the changes in chemical characteristics of African breadfruit seeds in season.

The seasons impacted changes in chemical composition positively correlate with prevailing climatic conditions(Lafond et.al.,2005).For African breadfruits the variations in proximate, minerals and anti-nutrient factors carry with them potential exploitable health and nutritional benefits(Umezuruike and Nwabueze ,2018).

Table 2 shows the seasonal changes in anti nutrient content of African breadfruit seeds.The anti-nutrients could present non-pharmaceutical vehicles for management of hyperlipidemia,obesity and other physiological stress conditions of cancer, diabetes cardiovascular diseases. At low concentrations the beneficial impacts of phytate, saponin and phenol are probably potentiated through inhibition on digestion , bioavailability and adsorption of nutrients by complexes formed with starch, protein and minerals.Diets produced with early season seeds have the highest potential of nutritional adequacy.Midseason seeds had antinutrient contents that were lower than tolerable limits for antinutrients. Which suggested that diets from midseason seeds would be very usefull for management of obesity, diabetes and hyperlipidermia due to their moderate anti nutritional activities. The cost advantage of non pharmaceutical therapeutic management of certain stress conditions with African breadfruit products is not in doubt.

Table.2: Seasonal variations in Anti-nutrient of African breadfruit seeds g/100g

Factor	Early season	Mid season	Late season
HCN	0.48	0.75	1.26
Phytate	0.80	1.60	2.30
Oxalate	6.10	8.53	8.07
Tannin	1.89	1.96	1.17
Alkaloid	0.47	0.40	0.33
Saponin	1.65	1.90	2.56
Phenol	0.77	0.57	1.80

Umezuruike and Nwabueze(2018).

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EXPLOITABLE OPPORTUNITIES REQUIRING TRANSLATIONAL RESEARCH.

Within the milieu of challenges and options of African breadfruit industry bright light appearing in the horizon of African breadfruit reveals important unexploited market opportunities for whole seed crushing for oil production to satisfy domestic and industrial uses, whole seed milling as raw materialsfor confectioneries compounding of Animal feeds. The annual global production of compound feed stands at about one billion tonnes with estimated profit of US$400 billion (Ififi.org).By 2050 the world population was projected to hit 9 billion plus, resulting in food stress and a projected 70% demand for animal protein expectedly to be supplied primarily through bovines, pigs and poultry (FAO.org) .This scenario suggests an expanding market opportunity for African breadfruits. The absence of information on experimental feeding of bovines, pigs and poultry using only African breadfruit seeds mandates a refocus of research efforts. Also the dominance of China as a global player in animal compound feed industry (Figure 1) and her increasing presence in African market points to the growing market for African breadfruit produce.

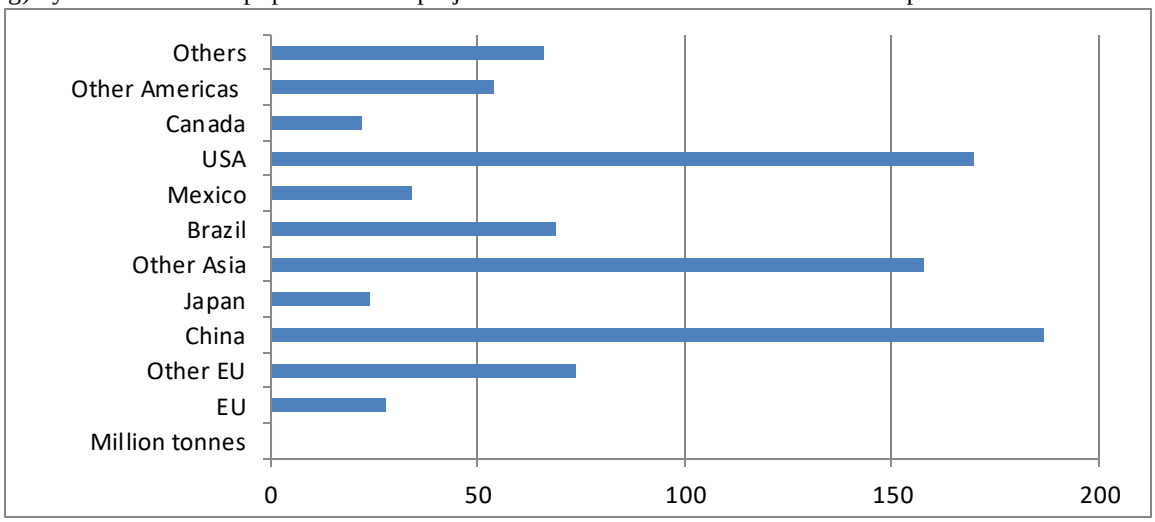

Fig 1: Overview of 2017 Gobal compound feed production(ifif.org)

A report by OCED/FAO (FAO.org) predicted a decline in global consumption of vegetable oils. However the rising awareness about healthy living has shifted lifestyle attention to healthy oils with high fractions of unsaturated fatty acids and mega 3 and Omega 6 contents. Coupled with the declining exports of soybean oil from USA ,there appears to be no better a time than now for lesser known oil seeds to enjoy an economic boom. Harnessing these opportunities through purposeful research efforts are as expedient as finding the solutions to global economic and food insecurity. These opportunities of course require extensive cultivation of African breadfruit trees in plantations, translational researches and optimization of appropriate technological variables. Until appropriate process and market driven technologies are developed for African breadfruit, market opportunities offered through oil extraction, whole seed milling and animal feed production remain attractive. Sustainable translational studies should be the priority of researchers of African breadfruits. The realization of the importance of Innovative findings as powerhouse of global entrepreneurship should form the hindsight of African breadfruits researchers who aim to reap the rewards of their efforts.

IV. SIGNIFICANCE OF STUDY.

This study discovered the existence of profitable commercial opportunities within the African breadfruit seed industry. Exploitation of the opportunities would be beneficial to individuals and national economy. It is expected that this study having shed more lights on the economic options would stimulate translational studies in areas many researchers had failed to explore. Such that those untapped potentials of African breadfruits would be adequately exploited.

V. CONCLUSION

The pace of translational research in the profitable areas of African breadfruit seed industry is slow.Without due attention to the identified opportunity options, it would be difficult to harness the full benefits of African breadfruits as

entrepreneurs would be unwilling to invest in arears were there is limited information on return on investment. Reearch opinions are that African Breadfruit tree is not too tall a tree for the full harness of its potentials. But excessive concentration of efforts on basic research studies only without due attention toexploitation for future commercial development of breadfruit implies unpreparedness of our researchers to address the challenges of global opportunities for breadfruit seeds.There is the necessity to redirect our research interests to profitable opportunities. Instead of just claiming ownership to worthless findings domiciled at internet archives.

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