ANALYSIS VOL. 6(16), 2020

ISSN 2347–3819 EISSN 2347–386X

DISCOVERY Agriculture

An assessment of the quality assurance programme in Nigeria rice processing sector

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Article History
Received: 26 June 2020
Accepted: 08 August 2020
Published: August 2020

Citation
Bello RS, Saliu MI, Olaniyan AA, Bello MB, Ikechukwu GO. An assessment of the quality assurance programme in Nigeria rice processing sector. *Discovery Agriculture*, 2020, 6(16), 144-158

ABSTRACT

A review of the quality assurance programme in the rice processing industry in Nigeria has been carried out and reported in this work. Drawing inferences from reviewed activities, three identified critical factors influencing rice quality include rice physical appearance before and after processing, its cooking qualities, and eating qualities. The patterns of rice consumption in Nigeria are not influenced significantly by the price but its quality in terms of appearance, taste, and cooking characteristics. Appearance has a direct influence on the marketability and success of commercial varieties. Cooking and eating quality are determined by its easiness in cooking, texture, springiness, stickiness, and chewiness of cooked rice. The Nigerian government and institutional agencies' intervention in rice production has significantly increased rice production activities more than its efforts towards ensuring quality assurance of the products during processing. Enforcement of rice quality standards has been left dormant without strong controls for implementation unlike the production and ban on importation policies. Other identified challenges faced in the processing sector include; processing equipment constraints such as the use of outdated milling technology, poor product branding, coupled with evident political interests on agriculture.

Keywords: Rice quality, production, processing, appearance, eating, cooking, acceptance

1. INTRODUCTION

Rice (Oryzae sativa) has become a major life-sustaining food in almost every home today, especially in Nigeria. However, the domestic production of this crop has not been able to meet the consumption demands which is consequent on food shortages. In Nigeria, oil accounts for 70% of the government's revenue, but with the implementation of the diversification of the economy in the direction of agriculture being implemented by recent administrations reduce the strain and risks on the nation's foreign currency reserves due to risks associated with the volatile global oil prices [1]. According to the official statements from the Ministry of Agriculture, rice production in Nigeria was reported to have risen by 19 per cent between 2015 and 2019 cropping seasons [2]. This increase was triggered by the government intervention and supports to rice farmers in the country and more importantly on government policy ban on the importation of foreign rice into the country and the diversification of the country's economy to be more reliant on agriculture to ensure food security and increase agro-export to boost the nation's Gross Domestic Product (GDP).

Under the present administration, the Agriculture Promotion Policy (APP) developed by the Federal Ministry of Agriculture and Rural Development (FMARD) to increase agricultural production, meet domestic consumption, raise living standards, promote exports, and increasing the foreign reserves through the agricultural sector. This strategy was built on the Agricultural Transformation Agenda (ATA), adopting a private-sector participation approach prioritizing the production of domestically consumed crops such as rice with high export potentials. APP launched sets of strategies to increase rice production by increasing farmers' access to improved seed varieties and other inputs. However, National and International research efforts towards improved paddy rice production in Africa particularly in Nigeria is not constant. It is, therefore, needful for the government to focus more attention to support the present initiatives if continuous rice production in the country must be sustained.

Presently, government support for increased rice production in the country, yielding great dividends such as increased land area devoted to crop production and rice farmers' population in the 34 rice producing states which has risen to about 12 million farmers [3].

Pattern of rice consumption in Nigeria

Since the mid-1970s, rice has contributed greatly up to 9% calorie-consumption in Nigerian food and has made it one of the highly consumed staple foods in Nigeria, with a consumption per capita of 32kg. The demand for rice has since increased considerably above domestic production compared to any other African countries [3, 4]. In the past decades, consumption has increased by 4.7%, approximately four times the global consumption rate, and reached 6.4 million tonnes in 2017- accounting for an estimated 20% of Africa's total consumption [5]. As of 2011, the rice household budget accounted for 10% of household food spending, and 6.6% of the total household spending. Considering the significance of rice as a staple food, increasing its production has become a high priority by the Nigerian government in the past decade. Rice consumption is estimated to be rising at 5.1 percent annually in Nigeria and is expected to reach 36 million metric tons (mt) by 2050 [6]. With an average yearly per capita consumption growth of 7.3% a year, consumption has already overtaken domestic production and as a result, importation became the nearest alternative to meet up with demand which had put Nigeria ahead as a leading importer of rice in the world, with an average 8.2% share of imports in the global rice market [7]. Nigerian consumption pattern grew from 3 kg in the 1960s to 15.8 kg in 1981-1990, to 22 kg in 2000, and, by 2007, it rose to an estimated 27 kg [8, 4]. By 2011, the average consumption of rice per capita in Nigeria is over 32 kg a year at an average annual rice production figure of about 2.21 million tonnes of milled product, meanwhile, national consumption estimated at 5 million tonnes of milled rice left a deficit of over 2.79 million tonnes which had been bridged by importation [9].

There has been a paradigm shift in the consumption of locally produced and imported rice. Before now, there was customer drift from the locally produced rice to imported or foreign rice. The difference between local rice and foreign rice is the product quality occasioned by the technology involved in their production. The middle and high-income classes in Nigeria preferred imported rice to the "low-quality" locally produced rice due to poor technology involved in its processing. This factor has attached greater importance to rice grain quality as the demand for either local or imported rice is emphasized on the grain size quality. Therefore, the need for quality improvement of locally processed rice in the competitive Nigeria market has become imperative and cannot be over-emphasized[10].Several factors among others including poor production and post-harvest practices, poor physical and cooking qualities, presence of foreign materials in milled rice has been attributed to the quality variability in locally processed rice.

Nigerian rice quality

Quality assurance and quality protection of rice have always been important to man as evident from the earliest known laws to man was that of food. Presently, governments over the centuries had made legal provisions for the safety and healthiness of man's food [11]. Rice quality is dependent on product characteristics and needs of the customer that bear on its ability to satisfy stated or

implied needs to sustain the product's competitiveness and sustainability demand in the open market [12]. The quality of rice is often assessed the basis of some varietal characteristics such as shape, size, and density affect the quality of rice grain as reported by [13]. A comparative analysis of consumer and customer satisfaction in rice processing and consumption showed that consumers' priorities favoured physicochemical characteristics in the market choice making while rice millers preferred high milling characteristics related to varieties. The consumers judged rice quality based on the size and shape of the rice grain, which can vary from one group of the consumer to another group [14]. For Nigeria to gain control of both the domestic and international rice market and considerably reduce its import bill, efforts must be made to produce premium quality rice. Research reports [15, 10] indicated that the rice produced in Nigeria is of lower quality and grade compare to imported rice owing to the presence of broken and damaged grains, stones, and other impurities. This has resulted in low consumer demands for domestic rice. The low-quality competitive status of the local product in the domestic and international markets is thus discouraging and hampering the development of the rice industry. To achieve high rice quality in the domestic rice production sector, adequately observed and implemented quality assurance programme is a major requirement, which will improve the quality of locally produced rice to international standards, increase quantity, and at the same time bring down the cost to an internationally competitive level. The objective of this work is to review the quality assurance programmes in rice processing drawing on the Nigerian experience.

2. RICE CULTIVARS CULTIVATED IN NIGERIA

Two broad types of rice have been identified as cultivars mainly cultivated in Nigeria: The African rice (Oryza glaberrima) and the Asian rice (Oryza sativa). Lately, a wide variety of local and improved varieties of rice cultivar has been developed and grown widely in Nigeria. Examples include the West African Rice Development Association's (WARDA) hybrid rice varieties referred to as NERICA i.e. New Rice for Africa, which are interspecific hybrids between the African and Asian rice [18].Scientific innovations in rice research in Nigeria presently have yielded disease-resistant varieties adaptable to differential ecologies, eating value, and needs as well as taste. Activities of agricultural research agencies such as the West Africa Rice Development Association (WARDA), Agricultural Development Programme (ADP), National Cereal Research Institute (NCRI), Baddegi Niger state and International Institute for Tropical Agriculture (IITA), Ibadan Nigeria, etc. have yielded improved rice varieties to farmers. For example, many promising rai- fed upland and irrigated lowland rice varieties, such as (ITA 257, ITA varieties, FARO varieties developed by IITA (Figure), and New Rice for Africa (NERICA) varieties developed in the 1990s, and other improved varieties such as cooperative, IR-varieties as well as P5BRc50 grown in Ebonyi state, developed by Alliance for a Green Revolution in Africa (AGRA) among others had been identified to be widely cultivated [19,18]. These varieties have been tested for growth, yield, nutrient content, and taste and were found to compare favourably to any of the imported foreign rice.

Figure: Rice variety (FARO), [20]

Locally grown rice varieties include Ofada varieties widely cultivated in all the Ofada rice-producing areas of four states of Ondo, Ogun, Oyo, and Osun in the Southwestern part of Nigeria [21]. In the southeastern states of Ebonyi, Enugu, and Abia Nigeria, local rice varieties (Akujie, Igbo, and Mass (I-III), Awilo, Chinyereugo, Onuogwu, Ezichi). In the northern part of Nigeria, there exist remarkable deep-water varieties of O. glaberrima variety which are specific to the unusual flood conditions that occur in the inland Niger Delta, the Sokoto-Rima valley, and other flood plains of the extreme north of Nigeria. The O. glaberrima variety has other local names such as "hakorinmontol" in Plateau/Nasarawa area and jatau (red) throughout Hausa land and the Chad Basin [18].

Concept of grains quality

The quality of grain is not easily defined due to its subjective dependence on the consumer and the grain intended end-use. Quality is a critical and complex property that depends on several factors, such as genotype, cultural factors, and postharvest management

[22]. Clear grain quality is based on a good understanding of consumer preferences; and the choice of the process and storage conditions. The quality of any grain is widely described by the summary of the physical and chemical characteristics of the grain that satisfied consumer needs. Consumers want the best quality that they can afford. Quality has many components or attributes with values that are determined not only by their physicochemical properties but also by the history and cultural traditions of consumer communities [23]. These components include nutritional value, appearance, and cooking and eating qualities based on a combination of subjective and objective factors [1]. These factors can also be classified as intrinsic or induced. Intrinsic factors such as bulk density, size, shape, and composition are genetically controlled, while factors such as yield, foreign matter content, appearance, cracked grain content, cooking, and eating and milling degree are considered induced factors that are generally introduced during postharvest handling.

Rice quality characteristics

Rice quality is distinguished by major indicators according to [24] Food Agency, (1995) and [25]. Rice quality is evaluated based on the characteristics of paddy before and after processing. Several interrelated features that determine the quality of paddy before milling include Paddy moisture content, degree of purity, varietal purity, cracked grains, immature grains, discoloured/fermented grains, and damaged grains. Quality characteristics of milled rice are physically and eating quality (chemically) classified. The physical appearance of rice is simply the outlook of the grains after processing and it is associated with grain length, width, length-to-width ratio (shape), and translucency/chalkiness of the endosperm[26].Good quality variety are characterized with stable grain size and shape which are the prerogatives of consumers. The Standard Evaluation System (SES) for rice [27] provides the following scales for size and shape specifications as presented in Table 1: These scores are recorded for brown rice to evaluate these traits as genetic characteristics avoiding the effect of milling on size and shape.

Table 1: Rice grain classification based on size and shape

Size classification		SHAPE CLASSIFICATION	
DESCRIPTION	**SCORE**	**DESCRIPTION**	**SCORE**
Extra-long length >7.5mm	1	Slender length-width ratio >3.0	1
Long length 6.6 - 7.5mm	3	Medium ratio 2.1-3.0	3
Medium length 5.51- 6.6mm	5	Bold ratio 1.1-2.0	5
Short length < 5.5mm	7	Round ratio<1.1	9

Source: [27]

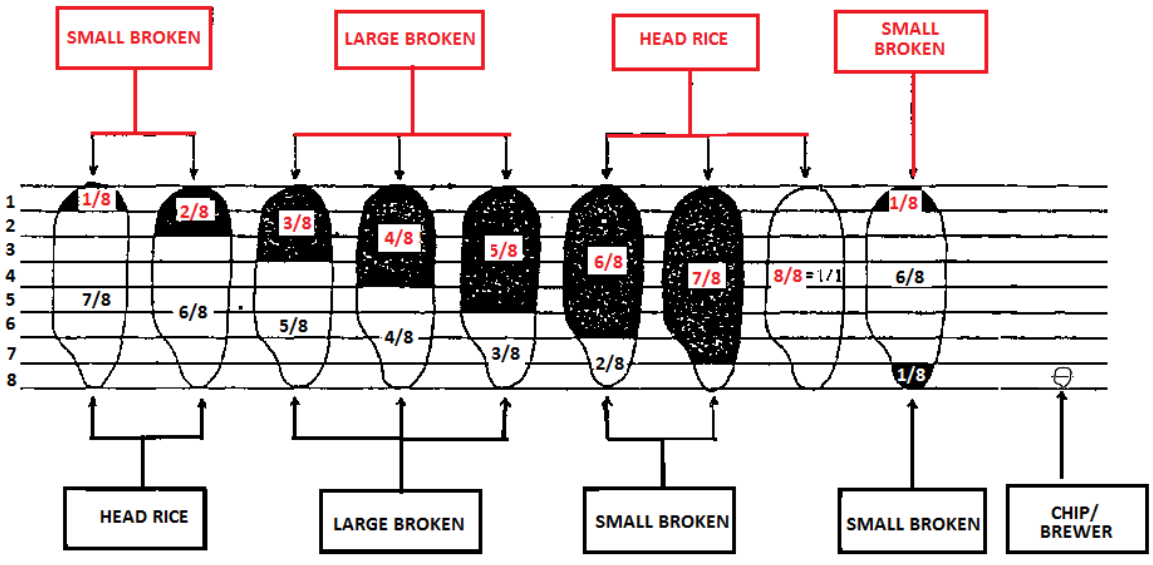

Figure 1: Whole (head) and broken rice

The ratio of length to width is an important aspect to determine the shape of the variety [28]. The appearance always appeals to consumers, so the size and shape, should be top criteria to determining rice quality. Breeders are also expected to be consistent in developing new varieties at commercial scale [29]. When rough rice is milled, kernel breakages naturally occur resulting in different kernel lengths as described in Table 2 and shown in Figure 1.

Table 2: Rice kernel specifications

Kennel nature	Description
Whole grain	Milled rice grain without broken parts
Broken kernel	Single or multiple fractions of different sizes
Large broken kernel	50-75% of the whole kernel size
Medium broken kernel	25-50% of the whole kernel size
Small broken kernel	less than 25% of the kernel size
Chips/brewers	Fragments of a kernel passing through a 1.4mm diameter-hole sieve.

Source: [30]

Cooking and eating qualities

Research results in the past decades indicate that cooking quality is directly related to the chemical characteristics of the starch in the endosperm which include aroma, apparent amylose content (AAC), gelatinization temperature (GT), gel consistency, and paste viscosity as well as nutritional quality and aroma consistency [31, 32, 33, 23, 26]. Rice quality maintenance to meet to meet the diverse interest groups in the rice sub-sector is a major challenge of rice development in many rice-producing areas of the world. Much of these challenges as observed by [23], resulted from the adoption of rice varieties with poor cooking and eating qualities. Though, few research results have been published on the characteristics of locally produced rice like Ofada, Abakaliki, etc. [34, 35, 36].

Outlook on rice processing in Nigeria

Rice processing

Paddy or rough rice is a grain of rice that still has its glumes enclosing the kernels, which is an unhulled grain [16]. The knowledge of the physical properties and anatomical composition of rice grain is prerequisite to understanding grain handling at harvest and during subsequent post-harvest activities [17]. Paddy rice processing has remained the major bottleneck to increased national rice supply according to the Nigeria National Rice Development Strategy (NRDS). Before 2015, Nigeria's national rice processing capacity is low and a wide processing gap exists between rice production and processing due to lack of adequate processing capacity. For instance, in 2007 Nigeria paddy rice production capacity was estimated to be 3.4 million tonnes, and only 1.4 million tonnes of this estimate was processed. To bridge this gap, modern rice-processing equipment is required. NRDS also stressed the urgent need to improve processing capacity and promote the use of modern harvest and processing facilities nationwide, supported by adequate training of rice farmers and processors, to overcome the present poor quality of the product market competitiveness to meet rice quality and export standards. The NRDS adopted the value chain approach to address the stepwise improvement of the rice value chain from production to delivery by identifying three priority areas. These include: Processing and marketing, land development and cultural practices, and development of strong input supplies.

Rice parboiling

Critical to rice quality is the parboiling and milling processes. Paddy rice parboiling is a hydrothermal process that changes rice crystalline starch into amorphous starch in an irreversible swelling and fusion process. This is accomplished by soaking in cold and then hot water or steam at low pressure, before drying and milling. There are many methods of parboiling rice, but the central processes are essentially the same. Parboiling process results in physical, chemical, and organoleptic changes in the rice with economic and nutritional advantages [37].Parboiled rice is strongly preferred in Nigeria, where almost all locally produced rice is parboiled. In an assessment of consumer preferences in Benin [38], consumers preferred parboiled rice to non-parboiled rice.

Rice milling

Milling is a significant agro-processing activity in the rice processing sector, employing thousands of traders, millers, and parboilers as the demand for rice has grown over the years [1]. The sector in Nigeria is largely a “cottage industry” in the early-2000s,

consisting primarily of small-and-medium-scale operations [39]. Additionally, there were three government-owned large-scale industrial mills at Badeggi, Uzo-Uwani, and Agbede, which were often not operational due to poor maintenance culture [40]. At the inception of ATA in 2011, the FGN made huge investments to build national capacity for rice production, processing, and marketing. It was noted that these investments, along with concessions from the government, attracted private investors into the rice sector which has resulted in 24 operational large-scale mills by 2014.

Despite these huge investments, the performance of the rice value chain in Nigeria has been less competitive than other major international producers in such as in Asia. [41] found the average paddy production, milling, and marketing costs in Nigeria (Figure 2) to be much higher than those in Thailand. The modern rice milling sector in Nigeria cannot effectively compete with their import competitors without adequate protective tariffs at the border. With the preference for higher-quality imported rice among Nigerian consumers, even in the presence of tariffs, cannot be completely prevented despite the higher premium price relative to domestic rice estimated at 25 percent higher [41]. The higher premium is relative to the amount domestic producers could potentially absorb as additional costs in processing more competitive higher quality rice. As of July 2020, the cost of 25 kg bag of rice which was sold at N4000.00 before Covid-19 now sells for N12,000.00 which is relatively at par with the same measure of the domestic rice.

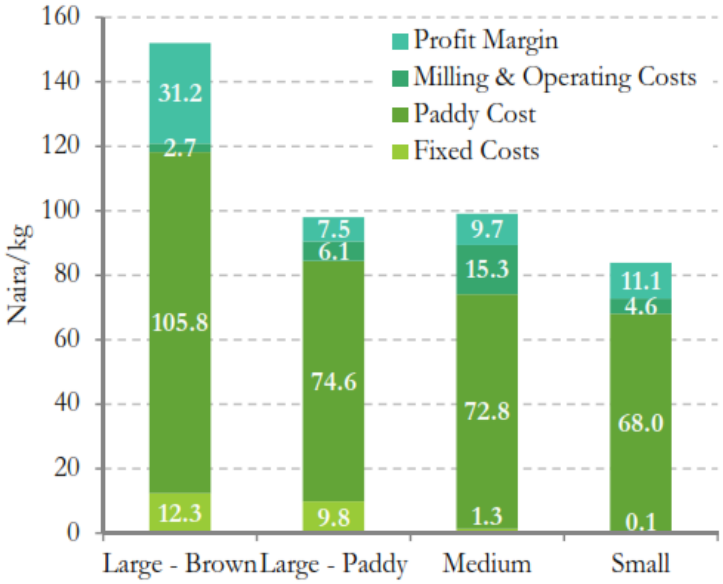

Figure 2. Milling production costs and profit margins by type of rice miller, 2012. Source: [1]

Given these challenges, the government has used tariffs on imported rice as a tool to attract private sector investment in rice milling. For instance, in 2005, the presidential initiative on increased rice production and export attracted two multi-national companies, Olam and Veetee, to establish two integrated rice mills by providing them with a special license that allowed them to import brown rice at a preferential tariff of 50% (rather than 100%) [1]. A similar arrangement was made under ATA to attract private sector investment where investors were asked by the government to provide a Domestic Rice Production Plan (DRPP) to include a large-scale integrated rice milling facility and a plan to set up out-grower schemes and paddy aggregation centers to source local paddy. Nevertheless, the milling of local paddy remains inadequate. As such, most large-scale millers are forced to import paddy and brown rice during off-seasons or when local paddy is scarce to keep up with milling operations throughout the year and to guard against uncertainties related to global price volatility [41. The unstable policy environment for rice production added to the risks associated with declining domestic rice prices, particularly if the government decides to lower the rice import tariff. For instance, government policy reversal within a few years of attracting the two investments affected the operation of the mills. In the case of Olam and Veetee, the FGN revoked the special licenses issued two years after both companies had invested in Nigeria. Similarly, the preferential tariff on DRPP investors was discontinued the following year, with evidence of lack of transparency in the selection process for investors' import quotas resulting in the investors having difficulties sourcing sufficient paddy to meet their mills' capacity. These unstable policy reversals are not favourable to induce investment in an environment where there are risks of uncertainties in policy implementation due to the irreversibility of those investments when executed [42].

Rice milling quality assurance programmes in Nigeria

[1] gave a good report of a study on the impact of the milling sector in Nigeria rice processing and supply chain. The study concluded that the public sector interventions made under the Agricultural Transformation Agenda and partnership of some agencies of government have grown and improved the performance of Nigeria rice milling sector by producing high-quality premium rice among several other improvement programs put in place for rice quality assurance responsibilities. Some quality standards set by these agencies have formed the basis for comparison among varieties concerning acquired quality characteristics such as head rice and brokens, chalkiness, immature kernels, brown rice, and milling recovery. The roles of some of these institutions are reviewed as follows.

Government intervention programmes in quality assurance

The Nigerian government has made efforts towards self-sufficiency in rice production and quality paddy. In this direction, the Federal government has implemented various agricultural production, quality control standards, exchange, and price control policies, such as restriction of forex for importation of locally produced goods to forex flow out of the country. These policies were intended to boost o domestic production and displace imports, however, they have adversely resulted in price inflation, with the cost of food increasing by approximately 10 percent in 2015 [43]. An off-shoot of this effort was the collaboration of the Standard Organization of Nigeria (SON), Japan International Organization Agency (JICA), and Federal Ministry of Agriculture and Rural Development (FMARD) drafting and publishing a paddy grading standard in October 2017. Complimentary to this is the paddy grading manual developed by JICA in collaboration with FMARD designated as the standard grading method in the SON's standard. Agriculture Promotion Policy (APP), an appendage of the government, equally geared towards rice self-sufficiency in 2018 by increasing annual domestic production by 4 million metric tons to meet an estimated 6.3 million mt of demand. FMARD (2016) estimates showed that ATA produced an additional 1.2 million to 1.5 million mt of milled rice. FMARD (2011) estimated that domestic production was approximately 3 million mt when ATA began. This would mean that the total domestic production of rice should be between 4.2 and 4.7 million metric tons. However, the APP estimates indicated 2.3 million metric tons of milled rice was supplied. These reports showed some discrepancies which require clarifications so that clear estimates of the current state of the rice industry could guide the rice policy-making process in Nigeria.

A researcher found that the large integrated rice milling sub-sector had the potential to compete with imports, but often operated well below-installed capacity due to insufficient access to high-quality paddy [41]. Further demonstrated the dependence of the large-scale sector on import tariffs and imported brown rice to mitigate risks of insufficient supply to remain operational and the importance of access to and price fluctuations. FMARD's plan to plan to facilitate the procurement of 40 new large integrated rice mills in 2016 would have almost tripled the operational number of such mills that are currently in the country. While an expansion of the capacity to mill premium quality rice is necessary to attain self-sufficiency in rice production, this expansion become a potential threat to undermine the government's efforts to increase foreign reserves since large-scale millers will seek to import brown rice to meet their capacity needs [1]. Hence, a comprehensive situation analysis of the rice production and milling sectors in Nigeria is required.

The Nigeria National Rice Development Strategy (NRDS) initiative launched in May 2008 at the Tokyo International Conference on African Development (TICAD IV) was intended to double the production of high-quality rice in Nigeria alongside the Coalition for Africa Rice Development (CARD) goals in sub-Saharan Africa within 10 years. NRDS overall goal was to increase production from 3.4 million tonnes of paddy rice in 2007 to 12.85 million tonnes by 2018. The initiative was implemented with complete African ownership and leadership, as enshrined in the Comprehensive Africa Agriculture Development Program, with strong links to existing structures, programs, networks, and initiatives such as the Forum for Agricultural Research in Africa and the African Rice Initiative jointly developed by the Alliance for Green Revolution in Africa and the Japan International Cooperation Agency.

As part of government intervention initiatives and programme, the Adamawa state government through the Adamawa Agricultural Development Investment Limited (AADIL) supported by a group of con

sultants from Surinam, South America engaged in private agricultural development programme providing input and marketing support services to various farmer groups engaged in the production of rice and other agricultural inputs. This initiative has contributed significantly to the research efforts on the effects of parboiling rice before processing on the quality of rice [44]. The Nasarawa State government intervention programme had equally significantly contributed to rice quality development in studying the post-harvest handling methods and quality control in rice processing in Lafia, Nasarawa state to identifying and solving identified processing problems in Nigeria [15].

This day Newspaper of August 17th, 2016, highlighted the role of Ebonyi state government initiatives towards enhancing the quality of rice production and processing in the state. Ebonyi State as one of the most agrarian states in Nigeria reputed for the

production of the famous Abakaliki rice has made the state so popular and a beehive of commercial rice production hubs in Sub-Saharan Africa. The State ranked 6th highest producer of paddy rice (over 405,000 metric tonnes) having a total land area of over 5,533 square kilometers and a population of over 1,739,136, and the highest processor in Nigeria with over 2,080,000 metric tonnes per annum installed capacity. The state has a total number of 5,000metric tonnes per day installed capacity small rice mills, medium Scale Mills (120 metric tonnes per day) Large scale Integrated Rice Mills (200 metric tonnes per day).These rice milling technologies operate on three major rice technologies (Conodisc/Engleberg, rubber roller, and jet peeler); Five giant modern integrated rice mills, ten medium modern rice mills, and over two thousand small-scale old models Engleberg rice mills located in almost every local government area in the state. It has the highest number of rice processing centers with destoners and posts milling technologies. According to [45], the state in partnership with the International Fund for Agricultural Development (IFAD) under the organizations' value chain development programme (VCDP), received a new rice processing plant to boost the state's 2 million metric tonnes annual milling capacity figure. The facilities include a warehouse, processing, parboiling sections, among other related processing stages of the staple food. These initiatives had significantly stepped up the state's production capacity and improved rice quality delivery.

3. MATERIALS AND METHOD

Primary data were sourced from different published articles, information bulletins, newspaper articles and government brochures on rice production, processing and quality assurance programmes. Secondary data were accessed through on-site assessment and review of government policies on rice quality assurance. Data obtained were peer reviewed to draw inferences on the activities of the government, research institutes, consumer perception and conclusions drawn and recommendations made.

4. RESULTS AND DISCUSSION

General review

Enhancing the grain quality of locally produced rice requires the consideration of some basic factors such as production factors, varietal characteristics, harvest and processing factors, institutional interventions, and market potentials. Each of these factors is discussed in the following sections.

Effects of rice production and recovery factors on rice quality

Three technological processing methods have been identified as critical factors that could affect rice quality along the production chain. Manual harvesting is a labour-intensive process and proper timing of harvesting may be difficult. Appropriate harvesting time is important for grain quality determination. For example, in the large irrigated lowland rice fields in the Sahel, the use of mechanical harvester is a known quality determination factor in rice harvest handling [46]. However, this requires an initial investment and backup systems to maintain the machines. The concern with the traditional harvesting and processing of rice is that hand cutting and laying the cut rice stalks in the soil before moving to the threshing area provides a ready opportunity for the rice heads to pick up mud clods and other foreign materials, which are the major concern with the rice mills in Nigeria. This is occasioned through the introduction of impurities into processed products and inducement of low head-rice ratio during milling. Reducing the number of foreign materials in the paddy would require mechanizing various aspects of the harvest, threshing, and winnowing process. Manual harvesting does not have these potentials to remove all the foreign materials to provide a clean bag of paddy with less than the industrial accepted 1% of foreign material. Processing loses is also another major concern in rice processing. While manually hauling of cut rice to the threshing area provides ample opportunity for substantial grain losses, the whacking threshing usually leaves some 10 to 15% of the grains on the stalks that later can be gleaned away by people scavenging the threshold and discarded piles of straw. The wind winnowing, particularly when done on a communal drying floor simply only moves the light material from one pile to another until it eventually works its way across the drying floor.

Another handling process that could affect rice quality is drying on plastic sheets or tarpaulins. Drying paddy eliminates contamination with soil or other foreign materials. [47] reported that a consequence of rapid drying of harvested paddy is a higher percentage of broken grains, while the recommendable practice is simply to dry paddy in the shade, in an area with the lowest available relative humidity, not in direct sunshine. Where this is impracticable, a suggested possible practice is to have a thick layer of paddy on the ground frequently stirred during the drying process.

Effects of varietal characteristics on rice quality

The selection of appropriate rice cultivar or variety is significant to quality determination. However, there are diversities and wide-ranging requirements for different varieties of rice paddy developed, and it may be difficult to develop varieties that fulfills all the

requirements (high yield potential, resistance to all possible constraints in a target ecosystem, etc.). Most quality traits – such as grain dimensions, grain hardness, whiteness, chalkiness, and absence/existence of aroma – conventional breeding will still be effective for the improvement of these traits. Towards improving the quality of local rice production in Nigeria, it is suggested that the government should adequately fund and equip the four technology transfer stations (TTS) established for the training of extension agents and farmers for increased production in agriculture through the use of adaptable and affordable modern technologies.

Effects of time of harvest on rice quality

Right harvest time is crucial for grain quality determination; however, this appropriate timing is often compromised because of competing activities or lack of labour for harvesting. [48] reported that the late harvest of rice (45 days after 50% flowering) could decrease head-rice ratio by 7.9% compared with harvesting at 30 days after 50% flowering. Late harvest has negative effect of on the head-rice ratio since lower air humidity during paddy drying decreases head-rice ratio [49], which become more severe in the dry regions.

Effects milling conditions on rice quality

Most low-income rice farmers milled by themselves using mortar and pestle and thereafter winnow in the wind. This process often subjects the grains to breakage; meanwhile, most professional millers use the Engelberg and the 'one-pass' mini machines in milling and supposedly graded the milled rice before its marketing [50]. Engelberg mill developed in 1888 in the USA and is still manufactured comprise of grooved steel rollers in metal casing to dehusk the paddy and then polished the grains by friction during movement between the grooves [51]. The one-pass mini rice mill was developed in Japan in 1956.These machines are still in use today with their low milling efficiencies and quality. New technologies and more effective machines are exceptionally expensive and to within the reach of these low-income farmers, which is consequent on low-quality products and with a lot of broken grains. [15] report on rice milling quality concluded that milling appears to be a primary problem in rice quality assessment. Milling recovery is key to the rice processing method employed in milling technology. For instance, the milling recovery for parboiled rice is perhaps as low as 50%, and most of the rice grains are broken; typically for a rice mill with a grain recovery of at least 60% and more typically 67% of raw rice and substantially more for parboiled rice, going from 71 to 75%.

Effects storage conditions on rice quality

Stored grains may be attacked by weevils or other insects. Storage conditions and duration may affect grain quality. [52] tested four NERICA varieties and one Oryza sativa variety concerning the effect of storage duration (paddy under room temperature and humidity) on some grain quality traits up to 64 weeks and showed that with the elapse of storage time, husking recovery, milling recovery, head-rice ratio, and grain hardness increased, but whiteness decreased; there was no effect on grain chalkiness, but some changes in cooking and eating characteristics caused by extended storage were observed. Little information is available on the effect of existing storage conditions in Africa on grain quality. A study of existing storage practices would help determine which indigenous practices are appropriate for storing rice and what new practices could be introduced. In Asia, some storage technologies to improve quality and reduce damage to rice are available; for example, IRRI has developed a storage bag for crops (not only for rice but also for other crops such as coffee) called the 'Super Bag'. This is a hermetic storage bag and prevents both oxygen and water from entering from the outside – the following positive effects are expected: approximate doubling of the germination life of seeds; control of insects without using chemicals; improved head-rice recovery of stored grain by about 10% [53]. Such a reputable technology could be directly introduced to Africa relatively easily.

Effects of parboiling on rice quality

[52] reported significant interactive effects of paddy storage duration and parboiling on several grain quality traits (grain hardness, husking recovery, head-rice ratio, whiteness, translucency, cooking time, swelling ratio, and gel consistency), but not milling recovery. In consideration of the importance of parboiled rice in Africa, further study will be necessary on this topic. Almost all the rice produced in Nigeria is parboiled before it is milled because consumer prefers its taste and texture when preparing local dishes. This is why Nigerian consumers have a preference for imported Thai parboiled rice among rice imports [9].Concern was expressed on parboiling as causing discolouring the rice due to dirty water used in soaking the rice before parboiling which results in its quality being downgraded. The question is, is the discolouring seen in Yola typical of the discolouration associated with parboiling, greater or less? A comparative assessment made between various samples of parboiled rice by AADIL confirmed that the parboiled quality has a higher priority than the raw rice when compared with rice imported from the USA and Thailand and shows a minimum amount

of damaged grain or foreign material. This result should ideally comply with the international standard of >6% damaged grain. This visual comparison did not show any major differences in colour if anything the local parboiled rice had less discolouration than the USA or imported Thai. The local parboiling procedures in Yola are not a major problem regarding potential quality. Furthermore, AADIL reported that discolouring is a natural part of the process and represents some of the nutrients in the bran being leached into the endosperm resulting in increased nutritional value.

Effects of grading on rice quality assurance

Grading is necessary for the development of quality standards that defined the relationship between grades and prices in the assessment of the value of grains. Quality evaluation or assessment programme aimed at preventing quality deterioration and reducing postharvest losses becomes more uniform when grades and quality standards are introduced. Also, with the acquisition of good crops, quality assurance in the other post-harvest operations becomes more practicable. Setting up modern postharvest facilities alone cannot completely solve quality problems, field grading during procurement is a good practice. At this stage, the quality of all procured grains are inspected and analyzed, as well as its fitness assessed for processing, storage, or distribution. The report of[54] found that Nigerian consumers will choose imported rice over domestically produced rice primarily due to cleanliness, i.e., absence of foreign matter, but will choose domestically produced rice over imported rice based on taste and price. This demonstrates an opportunity for large-scale millers to compete against imports on quality and consumer preference if they can lower the price.

Effects of processing technologies adoption on rice quality

[55] reported a low-level adoption of improved rice processing technologies among the rice farmers in the north-central region of Nigeria, however, a high level of adoption was recorded for rice dehuskers/dehullers (sigma score= 6.0) and improved paddy steaming (sigma score = 5.1). This result could be attributed to the high-level of awareness of these technologies. Awareness of agricultural technology is very important since it stimulates farmers' interest in new ideas and practices. This finding anchors the report of [56] and [57] which stated that the awareness on new research findings and technologies and the adoption of new innovations in agriculture to rural farmers remain a promising strategy for increasing agricultural production respectively. These findings agreed with [58] who also reported high adoption level for improved technologies inAbia State as a result of farmers' awareness that the technologies increase yields and minimize losses. The roles of extension agencies cannot be underplayed on in technology adoption. Four technology transfer stations (TTS) for rice development programme has been identified in Nigeria: these are Dan Hassan in Kano State, Baja in Edo State, Ugwuoba in Anambra State, and Gashua in Adamawa State. These stations established by the federal government in 1989 in different ecological zones in the country have enhanced the training of agricultural students in tertiary institutions in the country, extension agents, and farmers in states across the nation. They have contributed immensely to extension training in technology transfer to farmers in the country for increased food production. These feats of the Federal Department of Agriculture can still be used to improve the quality and quantity of rice production if supported by the government.

Effects of roles of government on rice quality assurance

Government intervention programmes in expanding quality paddy production and milling capacity in the country have been successful along with an increase in capacity utilization in the medium and large-scale milling sub-sectors. As a result, there has been an increase in production of premium quality rice by almost 0.5 million metric tons between 2009 and 2013 [1]. Governmental efforts to improve the quality of rice production in the country must be geared towards funding the procurement of the necessary equipment and technologies required in its production. The quality of Nigerian local rice can be improved by employing technologies to remove particulate and other extraneous materials that may affect customer satisfaction. Subsidies and duty-free importation should be given to rice production and processing equipment for ease of accessibility by low-income farmers. Government procurement of modern rice production equipment and drastic review of ownership policies to farmers could equally increase and improve the quality of rice production in the country.

The Ebony state government in its effort to ensure quality control in rice production, processing and as w ell as ensuring market standard by ensuring usage of standardized measurement for food items in the state, entered into a collaboration with the International Fund for Agricultural Development (IFAD) on Value Chain Development Programme (VCDP) to enforce standard and stop the shortchanging of food consumers by traders who use substandard measurements in the markets. measures intended to use in the enforcement include providing the standard measurement for traders to eliminate excuses for using substandard instruments,

promoting advocacy among the traders, free distribution of standard measuring equipment to traders, as well as sponsoring a legislative bill on the ban of sub-standard measurements and legal backing for the prosecution of offenders [59].

The IFAD-VCDP State Programme Coordinator (SPC)reported that series of enlightenment programmes, especially at the Abakaliki mill hub on standard measurements usage, and the distribution of weights-instruments millers to commence standard measurement usage while conducting interactive meetings with policy-makers, stakeholders among others, with massive supports from the state ministries of commerce and industry, women affairs and child development among others, also coupled with training opportunities on the intricacies of using standard measurements especially existing laws against the usage of sub-standard measurements in the country. In all of these efforts, the real-market survey around Abakaliki rice mills, open markets within the high rice-producing areas within the state showed a very low level of compliance with the use of standard measurements. This programme however suffered some setbacks due to poor implementation.

Effects of regulatory agencies on rice quality assurance

Regulatory agencies have a lot of roles to play in enhancing quality standards of food products such as rice and positioning the product in proper perspective before consumers. Regulatory agencies for goods and services in Nigeria include the Standards Organization of Nigeria (SON), National Agency for Food, Drug Administration and Control (NAFDAC), Nigeria Agricultural Plant Quarantine Service (NAQS), and Consumer Protection Council (NPC) among several others [60]. Regulatory agencies such as the technology transfer station, strive to ensure quality control of made-in-Nigeria rice through training of farmers, awareness creation, amelioration of the sub-standardization and inferiority of made-in -Nigeria goods, confiscation and fines as sanctions for defaulters, giving orientation and sensitization on the regulatory provisions of made in Nigeria goods and the legal consequences.

Effects of roles of institutional agencies on rice quality assurance

The strategies outlined by the NRDS seek generally to create a better policy environment for rice sector development and specifically address some identified challenges in each step of the rice value chain [8]. One such challenge is the inability of the sector, given current processing capacity limitations and quality-control practices, to ensure clean milled rice of international standard quality, free from impurities and other foreign materials. As a result, locally processed rice is uncompetitive, not only in the international but also in the domestic market and the average Nigerian is reluctant to consume locally processed rice and rice products [4]. The shortfall in the country's capacity to processes its annual paddy rice production and the corresponding shortfall in table-ready milled-rice production had led to a wide gap between demand and production, amounting to over 1 million tonnes. Successful implementation of the NRDS, as laid out in the program document [8] is therefore essential for improving processing capacity and the quality of Nigerian paddy rice.

Adamawa Agricultural Development Investment Limited (AADIL) in collaboration with the state government made significant contributions to the quality assurance programme through research and development. For instance, AADIL identified some discrepancies in locally produced rice and international standards. They reported the presence of foreign materials above the one percent (1%) from internationally accepted limit, but not in a significant amount. Another significant contribution is the grain damage in milled rice. The village milled had 50% damaged grain. The rice milled in Yola was at least 20% damaged grain. This would normally be considered unacceptable, as reflected in the 30% discount in retail value for local rice compared to imported rice in Adamawa. A comparison involving Thai Jasmine brought from the USA as the international standard was compared with the milled rice from the village and town mills as well as samples from neighbouring Cameroon. As expected, the Thai Jasmine rice appeared up to the international standard of >6% damaged grain. However, the village milled rice had over 70% damaged grain reflecting the difference in potential milling recovery between parboiled and raw rice, as both came from the same mill and were milled sequentially with minor adjustments to the mill. Even that milled in the town had approximately 50% damaged grain. The surprise was the sample from Cameroon that had on 20% damaged grain which is becoming marginally acceptable.

Nassarawa rice quality assurance experience as reported by [15] affirmed that processing methods, especially pre-parboiling and post parboiling activities have a substantial influence on the physical characteristics of milled rice. The pre-parboiling and post-parboiling handling methods and technologies used in Nigeria appear to contribute to the undesirable physical qualities of the locally processed rice. Manual methods of paddy rice handling are generally slow, ineffective, and time-consuming. They expose the rice to contamination by stones and other foreign materials and initiate deterioration of the grains, resulting in discolouration, cracking breakage, and damage. This was further compounded by poor parboiling and milling methods, lack of adequate equipment, and disregard for proper quality-control practices, such as cleaning, sorting, grading, and packaging. Comparing the processed rice with imported rice from Thailand and Japan, the Lafia 1, Lafia 2, and Assakio, rice processed in Lafia contained more broken grains (about 16% to 38%) and cracked grains (2.6% to 4.4%), as well as 0.1% to 0.5% foreign matter, 1.4% to 4.7% red

streak, and 3.1% to 6.7% damaged grains respectively compared to 0.7% and 2.2% broken grains and 0.07% and 0.01% cracked grains in Thailand and Japan, respectively, and 0% foreign matter, red-streaked and damaged grains. However, the cooking characteristics of the locally processed rice were not uniformly affected by the processing methods. The locally processed rice except for Assakio generally had better swelling ratios than foreign rice. However, because acceptability and price are based primarily on the physical appearance of the rice grains, Nigerian processing methods still need to be improved if the local rice is to compete well in both local and international markets.

Consumer rice-consumption criteria

A rice market survey in Nigeria has shown that the rice market is predicated on two major factors: rice taste and cost. According to the statistics from a rice consumption survey conducted in 2003 by USAID, annual per capita consumption of rice in urban areas is above 47kg with cities like Lagos, Abuja, and Makurdi having per capita consumption of 64, 64, and 72kg/annum. This is against the annual national average of 27kg in 2007 [5]. According to [5], three distinct rice market segments exist in Nigeria, and each market segment has its rice-consumption criteria. Urban consumers emphasize cleanliness, swelling capacity, taste, and ease of preparation and have low sensitivity to price. Another segment accepts lower quality rice but is more price-sensitive and prefers the taste of local rice. The third segment is the institutional/foodservice market. These consumers purchase processed milled rice in bulk and then cook and sell. They are concerned mainly with cleanliness and swelling capacity and therefore prefer imported brands. The majority of imported rice is of high consistency in terms of size, (shape) variety, colour, and cleanliness; this has favoured the preference of Nigerians for imported foreign rice. However, [4] submitted that the choice of rice in Nigeria is not influenced substantially by the market price but by its quality in terms of physical appearance, taste, and cooking characteristics.

5. CONCLUSION AND RECOMMENDATIONS

Conclusion

A critical review of the quality assurance programme in the rice processing sector of Nigeria agricultural sector has been carried out and the following conclusions made.

1. Rice quality characteristics associated with quality assurance evaluation in Nigeria include rice physical appearance after processing (i.e. size and shape consistency, purity, chalkiness, grain colour and translucency) and its cooking and eating qualities (i.e. aroma, water-uptake ratio, elongation ratio, swelling ratio and cooking time).
2. Preference was given to imported rice in Nigeria than locally produced one mainly because of high consistency in terms of size, shape (variety), colour, and cleanliness.
3. The patterns of rice consumption in Nigeria is not influenced greatly by price but appearance which has a direct influence on marketability and success of commercial varieties. Generally, most consumers prefer translucent rice to chalky ones. Preferences for grain size and shape and colour varied across different localities in Nigeria.
4. The Nigeria government has made concerted contributions towards policy formulation towards rice production and improved processing technology adoption, which has considerably increased the production volume of rice in Nigeria.

Some challenges to rice quality assurance include

1. Equipment constraint and use of outdated milling technology, product quality constraints (branding), financial constraint, the insincerity of government in driving rice import policy wholistically, coupled with political interferences on agriculture.
2. Inadequate government and institutional agencies intervention in controlling rice quality characteristics in the processing sector which will have made significant contributions to quality enhancement more than the efforts towards ensuring quality assurance in production. Rice quality standards control is left dormant without strong control instruments for the implementation of policies on rice quality assurance. Other identifiable challenges faced in the processing sector.

Recommendations

To ensure quality assurance in rice processing, the following recommendations are hereby made;

1. The government must finance the procurement of necessary equipment required quality-driven programmes.
2. The 3-tier institutional framework; the federal government, state government, and all regulatory agencies should be proactive in the enforcement of quality standards protocol on all medium and large scale mills in Nigeria as a pilot project for quality standardization. All mills in the country should produce standard or close operations.

Funding:

This study has not received any external funding.

Conflict of Interest:
The authors declare that there are no conflicts of interests.

Peer-review:
External peer-review was done through double-blind method.

Data and materials availability:
All data associated with this study are present in the paper.

REFERENCE

1. Johnson M and IMasias, 2017. Assessing the state of the rice milling sector in Nigeria: the role of policy for growth and modernization. Nigeria Agricultural Policy Project. Research Paper 59 June 2017. http://foodsecuritypolicy.msu.edu/
2. Oduntan JB, 2019. Improving the Quality of Rice Production in Nigeria Through Technology Transfer. The Nigerian Voice, May 2, 2019. Accessed June 1st 2020.
3. Erhabor, P.O.I. and Ojogho, O., 2011, Effect of quality on the demand for rice in Nigeria. Agric. J., 6 (5), 207-212.
4. Bamidele, F.S., Abayomi, O.O., Esther, O.A., 2010. Economic analysis of rice consumption patterns in Nigeria. J. Agric. Sci. Technol. 12, 1-11.
5. USAID, 2009. Nigeria Rice Value Chain Analysis. Retrieved on 28 October 2011 from www.microlinks.org/ev_en.php.
6. Federal Ministry of Agriculture and Rural Development (FARMAD). 2014. "Nigeria's Agricultural Transformation Agenda (ATA): Turning Nigeria into a Global Powerhouse in Agriculture." PowerPoint Presentation. Accessed on December 5, 2016. https://issuu.com/oaktv/docs/20130614_ata_score_card_without_fig
7. Gyimah-Brempong, Kwabena, Michael Johnson and Hiroyuki Takeshima (eds.). The Nigerian Rice Economy: Policy Options for Transforming Production, Marketing and Trade. Philadelphia: University of Pennsylvania Press.
8. NFRA, 2010. National Rice Development Strategy (NRDS): Implementation Document for the NRDS in Nigeria. Federal Ministry of Agriculture and Rural Development, Abuja, Nigeria.
9. Ogunbiyi MO, 2011. Assessment of Postharvest Handling and Quality Control Practices of Rice in North Central Nigeria: A Case Study of Lafia, Nasarawa State Journal of Developments in Sustainable Agriculture 6:143-163 (2011)
10. Danbaba, N., Anounye, J.C., Gana, A.S., Abo, M.E., Ukwungwu, M.N., 2011. Grain quality characteristics of Ofada rice (Oryza sativa L.): Cooking and eating quality. Int. Food Res. J. 18, 629-634.
11. Jango-Cohen J., 2005. The history of food. Twenty-first century books. pp. 4-8, CDB9267FR3Z6, 2005.
12. Bello R.S., 2013. Fruits and Vegetable Technologies: Management Options. Dominion Publishers Services, Ebonyi Nigeria. ISBN-13: 978-149-047-910-197-8; https://www.createspace.com/4 June 2013 (218 pages)
13. Juliano B.O. and Perez C.M., 1990. Grain quality characteristic of export rice in selected markets. Cereal Chem. (67) 21: 192-197.
14. Khush G.S., C.M. Paule and Dela Cruz N.M., 2009. Rice grain quality evaluation and improvement at IRRI. In Proceedings of workshop on chemical aspects of Rice Grain quality, IRRI, Los Banos, Philippines pp. 22-31.
15. Marcus OO, 2011. Assessment of Postharvest Handling and Quality Control Practices of Rice in North Central Nigeria: A Case Study of Lafia, Nasarawa State. Journal of Developments in Sustainable Agriculture 6:143-163
16. Sampang, R.L. 1992. Paddy and milled rice grading. In: Semple, R.L., Hicks, P.A., Lozare, J.V. and Castermans, A. (eds) Towards Integrated Commodity and Pest Management in Grain Storage. Food and Agriculture Organization of the United Nations, Rome, Italy. http://www.fao.org/docrep/x5048e/ x5048E02.htm (accessed May 2012).
17. Belsnio B., 1980. The anatomy and physical properties of the rice grain. In The anatomy and physical properties of the rice grain Paddy and milled rice grading Laboratory test methods for paddy and milled rice grading NFA standard specification for milled rice (Second revision) TRED • SQAD No. 2; 1980. (Accessed June, 2020).
18. Oko A. O., Ubi B. E., Efisue A. A.2012. A Comparative Study on Local and Newly Introduced Rice Varieties in Ebonyi State of Nigeria based on Selected Agronomic Characteristics. International Journal of Agriculture and Forestry: 2012; 2(1): 11-17. DOI: 10.5923/j.ijaf.20120201.03
19. Obeta N.A., A.N. Ukom and O.I. Ossai, 2019. Production and quality evaluation of instant rice from three local rice varieties in Ebonyi state. Asian J. Applied Sci., 12: 52-60.
20. Federal Ministry of Agriculture and Rural Development (FARMAD), 2016. Varieties of rice.
21. Danbaba, N., Anounye, J.C., Gana A.S., Abo, M.E. and Ukwungwu, M.N., 2016.Grain quality characteristics of Ofada rice (Oryza sativa L.): Cooking and eating quality International Food Research Journal 18: 629-634 (2011): https://www.researchgate.net/publication/283846834

22. Fofana, M., Futakuchi, K., Manful, J.T., BokossaYaou, I., Dossou, J. and Bleoussi, R.T.M. 2011. Rice grain quality: a comparison of imported varieties, local varieties with new varieties adopted in Benin. Food Control2, 1821–1825.
23. Tan, Y.F., Li J.X., Yu, S.B., Xing, Y.Z., Xu, C.G., Zhang, Q., 1999. The three important traits for cooking and eating quality of rice grains are controlled by a single locus in an elite rice hybrid, Shanyou 63. Theor. Appl. Genet. 99, 642-648.
24. Food Agency, 1995. Rice Post-Harvest Technology. The Food Agency, Ministry of Agriculture, Forestry and Fisheries, Tokyo, Japan.
25. Manful, J. 2011. Developing rice varieties with high grain quality in Africa: challenges and prospects. In: Innovation and Partnerships to Realize Africa's Rice Potential. Proceedings of the Second Africa Rice Congress, Bamako, Mali, 22–26 March 2010. Africa Rice Center (Africa Rice), Cotonou, Benin. Available online at: http://www.africarice .org/workshop/ARC/1.20%20Manful%20ed2.pdf (accessed May 2012).
26. Asante MD, 2017. Breeding Rice for Improved Grain Quality. Ch 5. In advances in international rice research. Pp 69-89. http://dx.doi.org/10.5772/66684
27. IRRI, 1996. Standard Evaluation System for Rice. International Rice Research Institute, Los Baños, Philippines.
28. Normita M. and Cruz, D., 2002. Rice Grain Quality Evaluation Procedures. Graham R. A Proposal for IRRI to establish a grain quality and nutrition research centre: IRRI discussion paper series No. 44 Los Banos, Philippines: International rice research institute 15Pp.
29. Adair C.R., Brachell H.M., Jodon N.E., Johnston T.H., Thysell J.R., Green V.E., Webb B.D. and Atkins J.G., 2006. Rice Breeding and testing methods in the U.S. In U.S. Department of Agric. Rice in the U.S.: Varieties and Production. USDA Agri. Rs. Serv. Handbook, 289, pp. 19-64.
30. Dhankhar P., 2014. Rice Milling. IOSR Journal of Engineering. Vol. 04, Issue 05 (May. 2014), V4, PP 34-42
31. Little, R.R., Hilder, G.B and Dawson, E.H., 1958. Differential effect of dilute alkali on 25 varieties of milled white rice. Cereal Chemistry 35: 111
32. Webb, B.D. 1980. Criteria of rice quality in the United States. In: B.O Juliano (ed.). Rice chemistry and Technology. Am. Assoc. Analytical Chemists, Minnesota, U.S.A. pp. 403-524.
33. Unnevehr, L.J., Duff, B. and Juliano, B.O. 1992. Consumers demand for rice grain quality: Introduction and major findings. In: L.J Unnevehr, B. Duff and B.O Juliano (eds.). Consumer demand for rice grain quality. IRRI, Philippines and IDRC Canada. pp. 5-20.
34. Oyegbayo, B.O., Osamuel, F. and Fashakin, J.B 2001. Effect of parboiling on the physicochemical qualities of two local rice varieties in Nigeria. The Journal of Food Technology in Africa 6 (4): 130-132.
35. Ebuehi, O.A.T. and Oyewole, A. C. 2007. Effect of cooking and soaking on the physical characteristics, nutrient composition and sensory evaluation of indigenous and foreign varieties in Nigeria. Africa Journal of Biotechnology 6 (8): 1016-1020.
36. Adebowale, A.A., Sanni, S.A., Karim, O.R and Ojoawo, J.A. 2010. Malting characteristics of Ofada rice: Chemical and sensory qualities of malt from Ofada rice grains. International Food Research Journal 17: 83-88.
37. Choudhury, N.H. 1991. Parboiling and consumer demand for parboiled rice in South Asia. In: Rice Grain Marketing and Quality Issues. Selected papers from the International Rice Research Conference, 27–31 August 1990, Seoul, Korea. International Rice Research Institute, Manila, Philippines, pp. 47–54.
38. Mhlanga, S. 2010. Economic analysis of consumer based attributes for rice in Benin. MSc thesis, McGill University, Montreal, Canada.
39. Lançon, Frederic; Olaf Erenstein; S.O. Akande; S.O.Titilola; G. Akpokodje; and O.O. Ogundele. 2003a. Imported RiceRetailingand Purchasing in Nigeria: A Survey. West Africa Rice Development Association (WARDA) and Nigeria Institute for Social Economic Research (NISER), Cotonou, Benin. Accessed on December 5, 2015. http://pdf.usaid.go v/pdf_docs/Pnadb848.pdf
40. Ezedinma, C. 2005. Impact of Trade on Domestic Rice Production and the Challenge ofSelf Sufficiency in Nigeria. Ibadan, Nigeria: International Institute of Tropical Agriculture. Accessed on Dec 5, 2016. http://africarice.org/workshop/RicePolicy/Chuma.E/Chuma.E. Nigeria.Paper.pdf
41. Johnson M and A Ajibola. 2016. "Post-harvest Processing, Marketing, and Competitiveness of Domestic Rice." In Gyimah-Brempong, Kwabena, Michael Johnson and Hiroyuki Takeshima (eds.), The Nigerian Rice Economy: Policy Options forTransforming Production, Marketing and Trade. Philadelphia: University of Pennsylvania Press.
42. Asiedu, Elizabeth. 2002. On the Determinants of Foreign Direct Investment to Developing Countries: Is Africa Different? World Development 30 (1): 107-119.
43. Central Bank of Nigeria (CBN), 2015. Statistical Bulletin Vol. 26, December 2015 Abuja: Central Bank of Nigeria
44. Richard L. T., 2011. Improved Quality of Rice Processing (NIG 225), Winrock International. Available at: https:lamar.colo state.edu/rtinsley/Author.htm
45. Businessamlive, 2020. Rice millers in Ebonyi get processing mill plants to ramp up production output. https://www.bus inessamlive.com/rice-millers-in-ebonyi-get-processing-mill-plants-to-ramp-up-production-output/
46. Rickman JC, Diane M,Barrett DM, 2007. Nutritional comparison of fresh, frozen and canned fruits and

vegetables. Part1. Vitamins C and B and phenolic compounds. J. Sci.Food. Agric 87: 930–944.
47. Rhind, D., 2002). The breakage of rice on milling: a review. Tropical Agriculture 39, 19–28.
48. Futakuchi, K., Watanabe, H., Efisue, A. and Sobambo, B.A. (2001) Milling characteristics of WARDA lowland varieties in different harvesting dates. Japanese Journal of Crop Science 70(Extra issue 2), 283–284.
49. Aguerre, R., Suarez, C. and Viollaz, P.E., 1986. Effect of drying on the quality of milled rice. International Journal of Food Science and Technology 21, 75–80.
50. Sakurai, T., Furuya, J. and Futakuchi, K. (2006) Effects of industrial amassment on the improvement of efficiency and quality: a case study for rice millers in Ghana. In: Sonobe, T. and Sawada, Y. (eds) Market and Economic Development. Toyo Keizai ShinpouSya, Tokyo, Japan, pp. 151–179.
51. Satake Cooperation, 2006a. History of rice mills. Tasty 33, 2–4.
52. Bleoussi, T.M.R., Fofana, M., Innocent, B. and Futakuchi, K., 2011. Effect of parboiling and storage on grain physical and cooking characteristics of the some NERICA rice varieties. In: Innovation and Partnerships to Realize Africa's Rice Potential. Proceedings of the Second Africa Rice Congress, Bamako, Mali, 22–26 March 2010. Africa Rice Center, Cotonou, Benin.
53. IRRI, 2005. Grain storage: the IRRI super bag. Rice Fact Sheets. International Rice Research Institute, Los Baños, Philippines.
54. Lançon, Frederic; Olaf Erenstein; S.O. Akande; S.O.Titilola; G. Akpokodje; and O.O. Ogundele. 2003b. Rice Processing in Nigeria: A Survey. West Africa Rice Development Association(WARDA) and Nigeria Institute for Social Economic Research (NISER), Cotonou, Benin. Accessed on December 5, 2015. http://opf-labs.org/format-corpus/govdocs1-error-pdfs/error_set_2/219789.pdf
55. Adejoh S.O., Madugu N., Shaibu U.M., 2017: An Assessment of the Adoption of Improved Rice Processing technologies: A Case of Rice Farmers in the Federal Capital Territory, Abuja, Nigeria. Asian Research Journal of Agriculture, 5(4): 1-9.
56. Abubakar B.Z, Anyo AK, Buhari U. 2009. The roles of mass media in disseminating agricultural information to farmers in BirninKebbi Local Government area of Kebbi State. A case study of state Fadama II Development Project. Journal of Agricultural Extension. ; 13(2):95-110. 16.
57. Agbamu J.U. 2006. Development communication in rural development communication. Asian Institute for Development Communication Kuala, Lumpur, Malaysia. ; 11(1):3549. 17.
58. Agwu A.E. Adoption of improved oil palm production and processing technologies in Arochukwu Local Government Area of Abia State, Nigeria. Agro-science: Journal of Agriculture, Food, Environment and Extension. 2006; 5(1):25-35.
59. Arinze A, 2019. Ebonyi state, IFAD-VCDP to enforce standard measurements for grains. https://www.von.gov.ng/ebonyi-state-ifad-vcdp-to-enforce-standard-measurements-for-grains/. Date assessed June 12, 2020.
60. Oteh, O.U., Agwu, N.M., Okpokiri, C., Aniuga, C. and Ani, L.O, 2018. Rice Production and Marketing in Nigeria: Assessing Regulatory Agencies' Role in Positioning made in Nigeria goods. Nigerian Agricultural Journal, Vol. 49 No. 2, October 2018. Pp. 143-151