Chapter

History, Evolution and Future of Starch Industry in Nigeria

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Abstract

Starch industry has progressed into a business that is worth billions of dollars globally, as they have been found useful in the food, textile, biofuel, plastic and the pharmaceutical industries. Nigeria can be the largest producer of starch in the world. Her major sources are roots and tubers (cassava, yam, cocoyam and potato), cereals (maize, sorghum, millet and rice) and fruits (banana, plantain and breadfruit). Although, all the starch crops are abundantly produced in Nigeria, only less than 1% is processed into high quality starch for industrial processes. This chapter therefore examines the past, the progression and the current state of the starch industry in Nigeria and the roles the government and relevant stakeholders must play in order to revolutionize the industry in Nigeria.

Keywords: starch, cassava starch, rice starch, potato starch, maize starch, industrial uses, history, evolution, Nigeria

1. Introduction

Starch is the most abundant edible polysaccharide derived from plants [1]. They are composed of repeating units of amylose and amylopectin that are susceptible to modification by physical, chemical, enzymatic and other means [2]. Starch in its native form is a multipurpose polymer, and an important raw material that finds useful applications in both food and non-food processes [1, 3]. Native starch is susceptible to retrogradation, syneresis, inconsistent viscosity and unordered gelation, hence, cannot withstand the typical industrial processes such as high temperatures, pH, high shear rate, and freeze thaw variations usually encountered during its use in food and other processes. Thus modification transforms native starch into gels or viscous mass in water at room temperature [2]. Furthermore, their properties are improved to yield starches with enhanced pasting properties, decreased retrogradation, reduced tendency to gel, enhanced freeze-thaw stability, improved paste clarity, and texture, and improved film formation and adhesion. These superior properties are what finds application in the food, textile, cosmetics, agro and pharmaceutical industries. The major sources of starch are roots and tubers (cassava, yam, cocoyam and potato), cereals (maize, sorghum, millet and rice) and fruits (banana, plantain and breadfruit) [4, 5]. However, commercially available starches are cassava, maize, potato, and rice starch and they are gluten-free which can be tolerated by individuals who react to gluten [6]. Even though all the starch crops are abundantly produced in Nigeria, only less than 1% is processed into high

quality starch for industrial processes, while about 10% is used as feedstock, 5% is processed into syrup concentrates for the soft drink industry and the rest (84%) is consumed as food [2].

1.1 Cassava starch

Cassava (*Manihot esculenta*), is extensively cultivated as an annual crop in tropical and subtropical regions, around the South-East, South-South and South-West regions (**Figure 1**), and it serves as an important food crop and a major source of carbohydrate for more than 70% of the Nigerian population, and provide income to over 30 million farmers, industries and traders [7, 8]. Nigeria is the largest producer of cassava in the world, producing over 37 million metric tons with an average yield of 12 metric tons/hectare [9]. Over 90% of these are consumed locally, and used as animal feeds, industrial purposes in pharmaceutical and food industry and only 10% are processed for export [3, 9]. Cassava root contains about 1% protein and 30–35% starch on a dry weight basis, hence, regarded as a starchy food [10]. It is a perishable commodity once harvested with a shelf life of less than 3 days [7]. The greatest potential of cassava as an agricultural crop lies in the production of starch. Two types of starch (sweet and sour) are produced from both varieties of cassava tubers (bitter or sweet). Both forms of starch differ in characteristics and end use. Sweet starch is obtained after an extraction process that separates the starch from other constituents, whereas sour starch is obtained by fermentation following extraction. Sweet starch is used as an adhesive in the textile, paper, and battery industries, while the sour starch is used solely in the food industry [3]. Although cassava starch serves as a cost effective raw material for many industrial processes [1], studies show that 52% of cassava produced is wasted as a result of inadequate production and processing, 43% is consumed as food and 5% is utilized as feedstock [3]. The suitability of cassava starch as a raw material in the food industry is due to its inherent properties such as low gelatinization temperature (71°C), its slow propensity to retrograde, does not have leftover proteinous materials or soil residues, non-cereal flavor, high viscosity, high water binding capacity, bland taste, translucent paste, good stability and reasonably good adhesive strength. It has a rather low lipid profile of less than 0.01%, protein content of 0.15–0.30%, ash value of 0.08–0.15% and phosphorous content of 2.04–2.45 mg/kg. In addition, it is easy to extract, settles rapidly and has a carbohydrate content of 73.7–84.9% [11]. In the paper industry, cassava starch is used as an adhesive; in the cosmetic industry, it serves as a significant raw material in the production of powders, it enhances the recovery and stability of detergents in the soap industry, while it produces a better foaming ability in the rubber and foam industries. In addition, cassava starch can be converted into maltotriose, maltose, and glucose, can be used to make fructose syrups and in the production of gelatin capsules [1]. Although, cassava starch has great potentials, only about 2% of food industries in Nigeria utilize cassava starch and its derivatives [3].

1.2 Potato starch

Potato (*Solanum tuberosum L.*) belongs to the tuber crops. There are two major types: the Irish potato which are grown through tubers, and the sweet potato (*Ipoema batata*), raised through vines, along the North-Western part of Nigeria (**Figure 1**). The Irish potato was introduced first in Nigeria in the late 19th Century, through missionary activities. Encouraged by the British government during the Second World War in order to feed their troops in West Africa, Irish potato was cultivated extensively and it became an important commodity for both local and

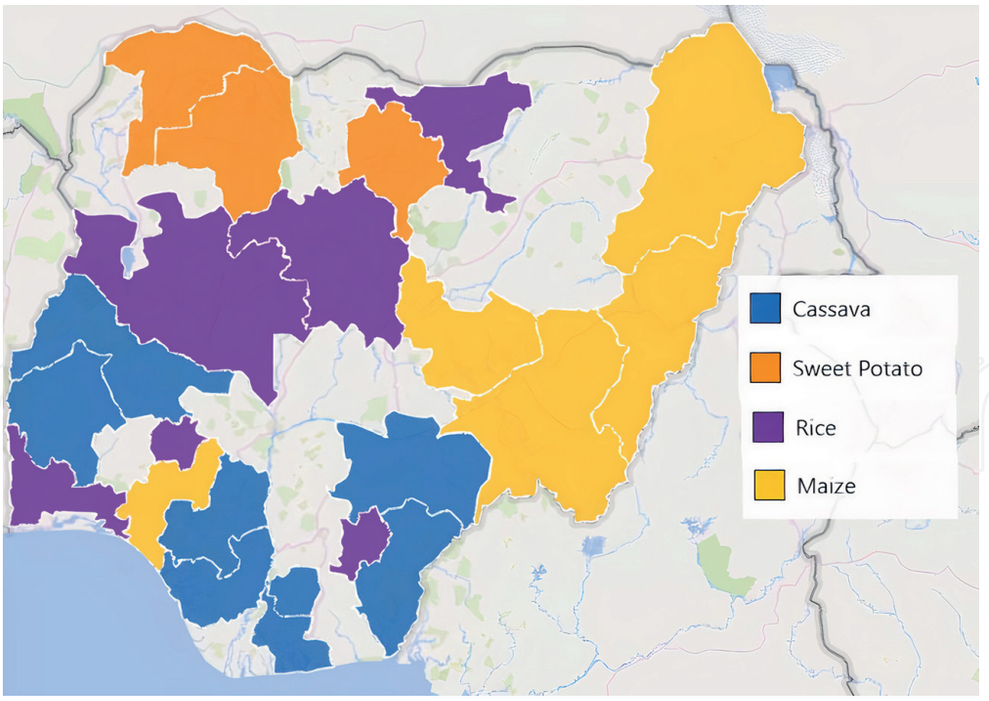

Figure 1.
Map showing regions of some starch-based crops in Nigeria.

international trade [12]. Nigeria is known to be the fourth country in West Africa in terms of potato production; on the African continent, it ranks the seventh. However, little effort is made in its promotion for industrial use, as over 80% are consumed as food [13]. Starch obtained from Potato has been demonstrated as a potential raw material in the pharmaceutical, textile, wood and paper industries as an adhesive, binder, texture agent and filler, and by oil drilling firms to wash boreholes [12]. Sweet potato starch can be utilized in the production of starch syrups, glucose and isomerized glucose syrups, lactic acid beverages, bread and other confectionaries [5, 14]. It can also be used to produce distilled spirits, noodles and isomerized saccharides as sweetener for soft drinks [15]. In addition, they can be utilized in the production of citric acid, ethanol and also used in the paper and textile industries [16]; as stabilizer in the production of yogurt [17]; and as pharmaceutical excipients when modified [18–20]. Potato starch is 100% biodegradable and is utilized as a substitute for polystyrene and other plastics. Hence, can be used in the production of disposable plates, dishes and knives [12].

1.3 Maize starch

Maize grains (*Zea mays*) are widely distributed worldwide, and grown in abundance in the North-Western and Southern-Western parts of Nigeria (**Figure 1**) during rainy seasons, however, they are subject to post-harvest wastes due to inadequate storage and processing. More maize is produced annually than any other grain. About fifty (50) species exist and consist of different colors, textures and grain shapes and sizes. White, yellow and red are the most predominant types. Maize starch or corn starch is the starch derived from the corn (maize) grain. The starch is obtained from the endosperm of the corn kernel and is a popular food ingredient used in the food, textile, pharmaceutical and paper industries. In the food industry, is used as a thickening agent for sauces, gravies, glazes, soups, casseroles, pies, and other desserts [21]. In Nigeria and other African countries, corn starch is used in making corn syrup and other sugars like high-fructose corn syrups, obtained from the breakdown of corn starch, utilized in the soft drink and candy industries. And also in the production

of bioplastics. It is equally the preferred anti-stick polymer used in the manufacture of medical products obtained from natural latex, including condoms and medical gloves. In the food industry, corn starch is used to reduce the cost of production by adding varying amounts of corn starch to foods like cheese and yogurt. In the production of ethanol, corn has the least expensive total cost. Here, the yellow specie of corn is used as it contains about 62% of starch [22]. In the industrial production of glucose, corn starch undergoes hydrolysis by a degradation process using amylolytic enzymes found in abundance in nature. The use of enzymes in this process produces a higher yield of pure glucose, that are more stable and environmentally friendly [23]. In 2004 more than 50% of starch was converted to High Fructose Syrups (HFS).

1.4 Rice starch

There are two main species of rice that are cultivated in Nigeria, the African specie, *Oryza glaberrima* L. and the Asian specie, *Oryza sativa* L., of which 120,000 varieties are known [24]. Rice is the world's second most important cereal crop after maize, based on the volume of production and cultivated mainly along the North-West and South-West regions of Nigeria. Nigeria currently consumes about 7.9 million metric tons of rice annually while production is presently at 5.8 million metric tons. The FAO's report show that rice generates more income for Nigerian farmers than any other cash crop in the country, with small scale farmers accounting for the largest volume in sales of 80% while the remaining 20% is consumed. An average of 7–8 tons of rice can be obtained per hectare. But up to 12 tons per hectare can be obtained depending on the variety of seeds planted. Although rice has been the topic for discussions, it has not benefited from the kind of value-added research required for economic competitiveness on an international scale, in terms of production. Hence, rice producers in the country are peasant farmers who are left to keep the sub-sector afloat against all odds. Industrialists can be encouraged to engage in large-scale production of rice as functional ingredients can be developed from Nigeria local rice cultivars and that these ingredients would stand the world market competitiveness. Of these, rice is starch is the major component of rice constituting about 90% of its dry matter [25]. Another major product obtained from rice starch is liquor, usually called Rice Wine, and it can be made at home or in a processing facility from the fermentation of rice starch that has been converted to sugar. It is widely consumed in Asia, and has an average alcohol content of 18–25%. At the present, this area of investment is yet to be explored in Nigeria [26]. Traditionally, there have been basic attributes associated with rice starch that makes it stand out above other cereal and non-cereal starches. These properties include hypoallergenicity, digestibility, bland flavor, small granule (3–10 μm), white color, greater acid resistance, greater freeze–thaw stability of pastes and a wide range of amylose/amylopectin ratios. These exceptional features are manifested in the different applications of rice starches.

2. History of starch industry in Nigeria

In Nigeria, in 1940, starch began gaining popularity when cassava starch was produced in response to the demand by the British government during an outbreak of war. In May 1940, starch samples from cassava roots were sent to the Ministry of Food and to Starch Products Limited in London for further experiments [27], and 300 tons of starch was purchased. Following the successful sale of starch and its increased demand by the British government, 10,000 tons of starch was further exported in July, August, and September 1940. However, in

October, 1940, there was a drawback in the export of starch due to lack of quality, as a result of delay in processing cassava roots, inadequate washing of the starch after settling, the use of dirty water or dirty utensils, the use of exposed peeled roots to the atmosphere for undue time before grating, storage of starch with high moisture content [27].

By June, 1941, the Ministry of food in London purchased starch "irrespective of quality"; and by September the UK was buying the entire production obtainable [28]. Trade continued in 1942, with the demand of monthly supply set at 300 tons by the Ministry of Food, this continued into 1943, and from January to April, starch was produced in large quantities and became a priceless commodity [27]. In April, 1943, exportation of starch from Nigeria was abolished as a result of a new demand for palm products by the UK. Therefore, in 1943, Nigeria was required to ensure the maximum production of palm products, and to achieve this sole objective, a strategy was implemented to stop the production of starch [29]. Likewise, the oil and kernel producing areas in Nigeria were barred from producing starch, instead, they were encouraged to cultivate cassava enough for local consumption [27, 30]. In May, 1943, the purchase of starch for export ceased and the notice on prohibition was repeated in 1944 and 1945 [27, 31]. Since then, low quality starch was refined and sold locally to be consumed as food or adulterated with cassava flour or garri and sold in the markets [32].

3. Evolution of starch industry in Nigeria

Starch industrial application has evolved into a multibillion dollar business worldwide and as such, many more industries, mostly within Africa, have now developed multipurpose applications for starch especially cassava starch. The demand for starch in Nigeria alone has recently been estimated to be around 67,100 tons per year and the amount of fresh cassava roots needed to produce that amount of starch is 350,000 tones [1]. The production of cassava has been stagnant since independence to the mid-1980s. however, an increase in production was observed from the mid-1980s to early 1990s where it remained constant again until 1999, at the beginning of the civilian era, where an increase was observed. Although, the Nigerian cassava market is centered on consumption patterns, an industrial market is now evolving (where cassava starch is used in the food, pharmaceutical and other industries) that needs to be explored and utilized. Starch derived from cassava for industrial purposes reveals a great potential for increased earnings for cassava farmers. Howbeit, in order to achieve global competitiveness on the production of cassava, the Obasanjo administration in 2002 established an ordinance on cassava production that led to a 73% growth, an excess in cassava production, which eventually led to wastage and massive financial loss due to poor storage, inadequate distribution and underdeveloped downstream sector [33, 34]. This led to investments in new factories (MATNA foods in Ondo state, built in 2005, Dutch Agricultural Development Company Nigeria Limited, Benue State, built in 2006, and Ekha Agro Farms, Ogun State, a glucose syrup factory built in 2007). These companies used improved production and processing machineries to enhance cassava starch production and also in the production of glucose, sweeteners and ethanol that could meet international standards. [33]. Likewise, the annual production of rice in Nigeria increased from 2.8 million in 2010 to 4.9 million metric tons in 2019, while rice importation decreased by about 60% within the time frame, indicating Nigeria's readiness to achieve self-sufficiency. The improved development warranted product diversification of rice to other value-added products like ethanol, glucose syrup, and starch by making use of the underutilized native rice varieties that had

undesirable physical features (short grain length, poor color, etc.), poor cooking quality (soft and sticky grain), and poor consumer acceptability [35].

4. Prospects of starch industry in Nigeria

Native starch is undesirable for many industrial applications, irrespective of the source. They are susceptible to retrogradation, syneresis, undesirable viscosity and gelation as a result of their inability to withstand high temperatures, pH, high shear rates, and freeze thaw variations when used for food and other applications. Hence, the need for modification by physical, chemical or biological means to yield starch with improved pasting properties, decreased retrogradation, decreased tendency to gel, increased paste freeze-thaw stability, improved paste clarity, film formation, adhesion and gel texture [36].

4.1 The food industry

The food industry is one major industry that utilize starch and starch-based products. Modified starches have been used as sweeteners, and to improve the texture of gums and pastes, and also to obtain products that thicken in cold water without the addition of heat [2]. They are also used as binders to solidify the mass of food to prevent it from drying out during cooking especially in sausages and processed meats; and as a stabilizer in creams, due to its high water-holding capacity [37, 38]. As thickeners, they are used in soups, baby foods, sauces and gravies. In addition, glucose produced from starch are also used in the production of caramel that are extensively utilized as coloring agents in foods, confectionaries and liquor [39]. Glucose syrup is a solution of glucose, maltose and other nutritive saccharides obtained from edible starch. Although, glucose syrup is not adequately produced in Nigeria as 800 million naira was used to import glucose in 2003 [4]. However, a surge in private sector investments in the large-scale production of starch as reported by the Federal Ministry of Agriculture, Nigeria was observed and companies like the Nigeria starch mills, and the glucose factory in Ogun State began to invest in large-scale production of cassava and processing of its by-products by utilizing improved techniques in the machineries used to peel, grate, dry, fry and mill the raw materials [40].

4.2 The pharmaceutical industry

In the pharmaceutical industry, starches are one of the most important excipients that have been widely used in the formulation of tablets. They are inert, inexpensive and have been utilized as fillers, binders, disintegrants and glidants. The use of modified starch improves the physicochemical properties of the tablets and other pharmaceutical formulations [36, 41]. Over 1500 tons of starch hydrolysates are used in the pharmaceutical industry annually and about 80% of starch are imported [8]. In addition, crystalline and liquid glucose are imported for the production of cough syrups, yet, this high demand for starch-based products can be met from the inexpensive and high quality starch found in cassava that is richly available in Nigeria [1].

4.3 The textile industry

In the textile industry, modified starch (oxidized starch) is employed in the sizing and dyeing of fabrics to improve the weight, clarity and hardness of the

fabric [1, 36]. Cassava starch is the most preferred for this application as it gives a better finishing compared to other starches. In addition, modern laundries use soluble starch, incorporated into a suitable propellant sprays for application during steam ironing. In the early 1990_s only about 700 tons of cassava starch was produced per annum because the starch was considered to be of low quality. However, maize starch was imported for use in the textile industry which was later replaced with over 67,000 tons of cassava starch [8]. Again, the downturn of the economy during the military era led to the near collapse of the textile industry which further decreased the market prospect for cassava starch. Nevertheless, this industry can be restored if successive leadership can establish and promote the starch industry [42].

4.4 The plastic industry

Starch has been used in the production of plastics since 1970s based on their biodegradability, renewable nature and freely abundant. Starch is easily dispersed in cold water, however, it thickens when heated to its near boiling point to form a colloidal suspension that gels when cooled. Polymer blends in the presence of plasticizers like water and glycerol, can be distributed or transported to normal plastic converters, which can process the blends to products using normal injection or blow molds [43]. Such biopolymers (consisting of 40% starch and 60% low-density polyethylene) using cassava starch has been produced and commercialized [1]. There are roughly 30 plastic companies in Nigeria, among which are: The Black Horse Plastic Industry Limited, OK Plast Limited, Abbey-Fem Plastics, Celplas Industries Nigeria Limited, among others. Since Nigeria is the largest producer of cassava, the utilization of cassava starch by these companies to produce biodegradable biopolymers is achievable. This will not only protect the environment from the harmful effects of petroleum derived plastics, but will also generate an economic alternative for cassava agriculture [44, 45].

4.5 The biofuel/chemical industry

In the production of alcohol, starch is hydrolyzed by a two-step process to glucose and then is further diluted and converted to ethanol by the action of yeast [3]. Bioethanol is a form of soi-disant-renewable energy that can be manufactured from agricultural crops like corn, potatoes, cassava, rice and sugar cane [46, 47]. Cassava starch has a much higher yield (150 L/ton of fresh roots) than sugar cane (48 L/ton), a source that was previously used in the production of ethanol without much success in Nigeria. However, difficulty in the local production of cassava in 2001 halted the production of ethanol and since then, all the ethanol used in Nigeria was imported. Although current interests in investment in the Nigerian ethanol industry is increasing, encouraging small industrial production using cassava will lead to the economic growth of the industry [8]. Other starch-derived products such as D-glucose and maltose, butanol, acetone, glycerol acetic, citric, itaconic, gluconic and lactic acids can also be produced from these starch-based crops by the process of fermentation when the starch is modified [2]. According to **Amenaghawon et al.** [48], the projected yearly production of citric acid is about 1.4–1.5 million tons and this is expected to increase to about 3.5–4.0% yearly. Of this amount, roughly 70% is used by the food industry for its pleasant acid taste, high solubility in water, its chelating, antioxidant and buffering actions. Approximately 12% is used by pharmaceutical industries as liquid elixirs, flavoring agents, anti-coagulant and as preservatives while 18% is used by other industries (cosmetics, toiletry, detergent, textile, oil recovery, paper).

4.6 Other starch-based products

Other uses of starch are in the production of adhesives; starch (converted to dextrin) is the major raw material in the manufacture of glues and adhesives [1, 42]. In the 1990s, 58,000 tons of adhesives were used in the wood, cable, paper and printing, packaging and footwear industries in Nigeria. Regrettably, they were imported either as adhesives or as dextrin. [49–52] demonstrated the potentials of using cassava starch as a raw material in the large-scale manufacture of adhesives in Nigeria. Hence, expanding the starch industry for use in the manufacture of adhesives for these industries would put over 60,000 tons of cassava into use for this industry alone in Nigeria [8]. In the soap and detergent industries, starch is used as a filler to obtain a better yield and enhance the shelf-life of the products; in the production of sugar syrups, starch is subjected to enzyme hydrolysis using α-amylase. Cassava, corn and rice starch have been used in the production of fructose and glucose syrups, and in the manufacture of gelatin capsules [42, 53]. The food and beverage industries in Nigeria depend heavily on glucose syrups and crystalline sugars, and cassava starch are used in the production of candies, in the soft drink industries and in traditional medicines. However, the syrup concentrates are currently imported as cassava starch derivatives (hydrolysates e.g. glucose, sucrose, fructose, maltose, and syrup) are not presently developed in Nigeria [1, 8]. In the production of yeast, starch is enzymatically hydrolyzed to glucose and this leads to the production of certain yeasts that utilize this glucose to produce microbial cellular substances. According to Taiwo et al. [3], this aspect of producing yeast from simple sugars is yet to be exploited in Nigeria, as majority of the yeast used in the food and beverage industries are imported.

5. The future of starch industry in Nigeria

To achieve sustainable progress in the starch industry in Nigeria, the government, private sectors and key stakeholders must of necessity put all hands on deck to ensure the improvement of the agricultural sector in Nigeria [54]. This can be achieved by implementing programs and policies that will foster the production of starch producing crops, conversion of unused lands into cultivation of starch-based crops, establishment of industries for local production of starch, and improvement in the processing and storage of starch-based crops [1], Thus, the local industrial products will not only meet local demands but also have the potential of becoming a source of income generation. This demand will aid in the improvement of industry, national and international standards, quality and global supplies leading to a gradual approach to export-oriented production. In addition, private investors may be encouraged to participate in improving the production and conversion of these crops to high quality starch and derivatives, by supporting market linkages, organizing trainings for farmers, support and development of processor groups, build capacity in quality and standards in product development and intellectual property rights [55]. Government on the other hand can strengthen the policy on the development of starch and starch-based products from the available sources that can be effectively used in the food, feed, textile and pharmaceutical industries [56]. Infrastructure especially electricity supply, railway transport, and water supply can also be improved to achieve success [57].

6. Conclusion

Nigeria is endowed with starch crops, and ranks third after wood and vegetable oil. it is highly beneficial and an invaluable commodity to the pharmaceutical,

textile, food, paper, adhesive, drinks, beverages and the confectionery industries. It can compete favorably on international scale, however, starch in Nigeria is underutilized. The cassava starch is preferred over the corn starch in Nigeria as it is the driving force for the conservation of foreign exchange and to reduce import dependency. The opportunities in the starch industry is incredible and the demand for starch is on the rise, this can create income-generating opportunities for youths and small-scale farmers in the country. Hence, efforts should be made by the government and relevant stakeholders to convert starch-based crops from low-yielding famine crops to high-yielding cash crops in order to foster the economic development of the country.

Conflict of interest

The authors declare no conflict of interest.

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