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Consumption Patterns of Starch Crops in Nigeria, Utilization, Skill Set, and Economic Potential of the Starch Sector

Obi Peter Adigwe[1] Judith Eloyi John[2,3]* Simisola Temidayo Oloye[4] Martins Ochubiojo Emeje[3,5]*
1. Director General Office, National Institute for Pharmaceutical Research and Development (NIPRD), P.M.B 21, Idu Industrial Area, Abuja, Nigeria
2. Department of Pharmaceutical Technology and Raw Materials Development, National Institute for Pharmaceutical Research and Development (NIPRD), P.M.B 21, Idu Industrial Area, Abuja, Nigeria
3. Center for Nanomedicine and Biophysical Drug Delivery, National Institute for Pharmaceutical Research and Development (NIPRD), P.M.B 21, Idu Industrial Area, Abuja, Nigeria
4. Department of Industrial and Physical Pharmacy, Purdue University, Heine Pharmacy Building 124, 575 Stadium Mall Drive, West Lafayette, IN 47907-2091, USA
5. Director General Office, Nigeria Natural Medicine Development Agency, NNMDA, No. 9, Kofo Abayomi Street, Victoria Island, Lagos, Nigeria
* E-mail of the corresponding author: juditheloyi@gmail.com; martinsemeje@yahoo.com

Abstract
Starch crops are cultivated in abundance in all geographical zones in Nigeria. Demographics and data on starch were obtained from 718 volunteers through an online questionnaire between March and August 2022 and analyzed using R 4.2.1 at 95 % confidence interval (CI). A significant association ($P < 0.001$) exists between participants and geographical zones. They were mostly 15 - 29 years old (55.43 %), 229 (31.89 %) males, and 169 (23.54 %) females. About 88.02 % were aware of starch crops, while 11.98 % were not. Most of the starch crops are cultivated in the North Central (NC) region (45.09 %; n = 78), Cassava (*Manihot esculenta*) (37.80 %) and potato (*Ipomoea batatas*) (25.00 %) are predominantly cultivated in the Southeast (SE) and South-South (SS); rice (*Oryza sativa*) and maize (*Zea mays*), mainly in the North-East (NE) (28.52 %; 41.35 %), North-West (NW) (20.41 %; 30.77 %), and NC (24.49 %; 13.46 %) respectively; and yam (*Dioscorea spp*.) in the NC (60.17 %). Common applications of starch were food thickeners (37.80 %), livestock feeds (12.80 %), and yeast (11.61 %), which are largely consumed as food (67.16 %). Moreover, 36.78 % prefer the establishment of all industries utilizing starch in Nigeria, with 61.83 % suggesting government interventions than the private sector (38.17 %). However, lack of standardization (43.92 %) was identified as the major challenge of the starch industry in Nigeria. Policy formulations and implementation are necessary to strengthen the starch industry in Nigeria, and to reduce the over-reliance on oil.
Keywords: starch, crops, consumption patterns, policy implementation, standardization
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1. Introduction

Starch crops are grown in abundance throughout Nigeria's geographical zones. Some starch crops include roots and tubers (cassava, yam, cocoyam, and potato), cereals (maize, sorghum, millet, and rice), and fruits (banana, plantain, and breadfruit) (Elizabeth *et al.* 2018). The most utilized are sweet potatoes (NW), maize (NE and SW), cassava (SE, SS, SW, NC), and rice (NW, NC, and SW). There has been tremendous growth in the use of starch in the food, textile, biofuel/chemical, plastic, and pharmaceutical industries worldwide. Even though Nigeria has the potential to become the world's foremost starch producer, reports indicate they are underutilized (Adigwe *et al*. 2022).

Nigeria is the world's largest producer of cassava, which provides carbohydrates to nearly 70 % of the country's residents and income to millions of farmers (Dada 2016). Although cassava is best known for its starch production for industrial use (Tonukari 2004), 50 % is wasted in cultivation, handling, and processing (Uchechukwu *et al.* 2015), while more than 90 % of what remains is consumed locally, and only 10 % is exported. Additionally, the country ranks seventh among African countries in sweet potato cultivation, with approximately 80 % of its production being used for food (Tewe *et al*. 2003). It is advantageous as a raw material in the food, pharmaceutical, textile, wood, and paper industries due to its 100 % biodegradability (Ugonna *et al.* 2013). Besides beverages and bread, starch syrups and glucose are also made with it. However, little is known about its potential as an industrial raw material (Etudaiye *et al*. 2015). Furthermore, the northern and southern parts of Nigeria produce abundant maize, that is wasted due to inefficient storage and processing (Adigwe *et al.* 2022).

The poverty index in Nigeria stands at 0.17, with a significant number of people living below the poverty line. According to recent estimates, more than 80 million Nigerians have been affected (UNICEF 2023). Therefore, these crops have the potential to revolutionize the largely underdeveloped agricultural sector, leading to poverty alleviation which is a direct effort of the government's intervention through appropriate legislation, budgeting, and

infrastructure in collaboration with the private sector. By contributing to the economic development of the nation, these crops can reduce the over-reliance on oil, which has served as the major source of foreign exchange till now (Silberberger 2020). Consequently, these actions will lead the country towards achieving the first, second and eighth goals of the Sustainable Development Goals (SDG), which are specifically related to eradicating poverty, improving food security and promoting economic growth and decent work, thereby facilitating a more equitable and sustainable future for Nigerians, as demonstrated in this study.

2. Methods

2.1 Sampling Method

The data for this survey was collected between March and August 2022, using an online questionnaire. The link to the questionnaire was shared on social media platforms (primarily WhatsApp) and responses were collated on an Excel spreadsheet. Participation in the survey was completely consensual, anonymous, and voluntary. Sociodemographic data such as gender, age, marital status, and location, including other information regarding the respondents' knowledge, attitude, and perception of starch, were obtained.

2.2 Statistical Analysis

The responses obtained on an Excel spreadsheet were subjected to statistical analysis using R 4.2.1. Percentage responses were analysed, and Pearson's Chi-squared test at 95 % confidence interval (CI) was computed to obtain the squared values (x^2), degree of freedom (df) and the *P*-values, and the results were displayed as tables and figures.

3. Results

3.1 State of Origin

A significant number of respondents ($N = 718$; $x^2 = 653.91$; $df = 36$; $P < 0.001$) participated throughout the country, with the NC region participating the most, and the SW region participating the least as shown in Figure 1. Although, in terms of states, a high level of participation was observed with 10.17 % (n = 73) from Cross River (SS), 9.75 % (n = 70) and 5.43 % (n = 39) from Niger and Benue states respectively (NC), 9.33 % (n = 67) from Adamawa (NE), 5.29 % (n = 38) each from Enugu and Imo states (SE).

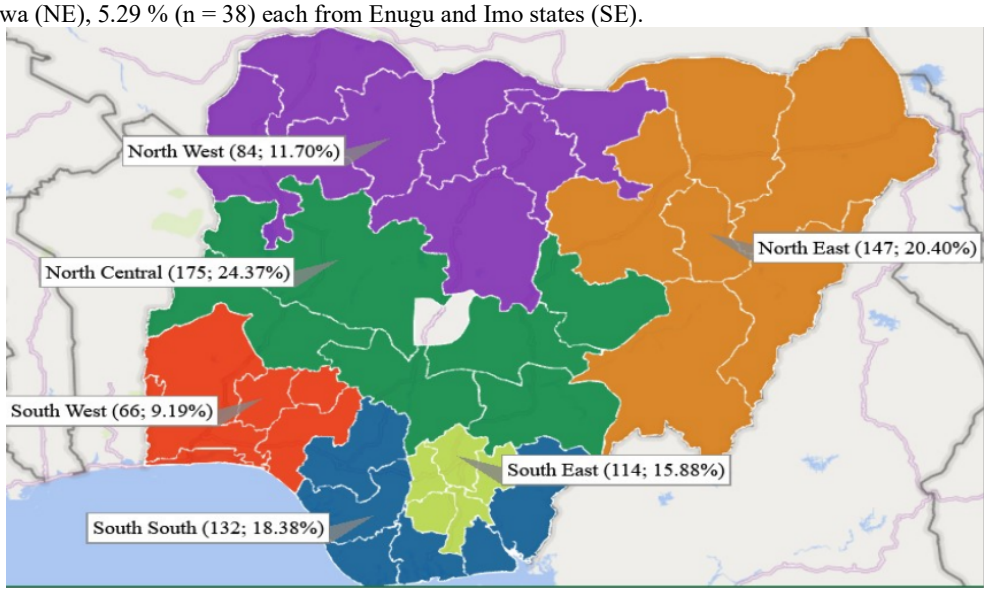

Figure 1. Number of participants according to geographical zone

3.2 Demographic Information

The demographic information of the respondents is shown in Table 1. There is a significant ($P = 0.003$) gender difference (males and females) in the demographics of respondents. Most respondents were aged 15 - 29, with 229 (31.89 %) males, while 169 (23.54 %) were females. The age group also counts for 341 singles (47.49 %), 259 tertiary students (36.07 %), and 629 postgraduate students (87.60 %), and it is closely followed by those in the 30 - 44 age group.

Table 1. Demographic Information of Respondents and their awareness of starch in Nigeria

Demographic information	Number of Observations: N = 718		
	Number of respondents (n)	Percentage response (%)	Chi-square test (95 % CI)
Gender			$x^2 = 8.91$ df = 1 *P*-value = 0.003
Male	399	55.57	
Female	319	44.43	
Age Group			$x^2 = 705.91$ df = 4 *P*-value < 0.001
15 – 29	398	55.43	
30 – 44	199	27.72	
45 – 59	72	10.03	
60 - 74	31	4.32	
75 – 89	18	2.51	
Marital Status			$x^2 = 924.02$ df = 4 *P*-value < 0.001
Single	400	55.71	
Married	274	38.16	
Separated	21	2.94	
Divorced	9	1.25	
Widowed	14	1.95	
Education			$x^2 = 651.57$ df = 4 *P*-value < 0.001
No Education	30	4.18	
Primary	29	4.04	
Secondary	68	9.47	
Tertiary	384	53.48	
Postgraduate	207	28.83	
Starch Awareness			
Yes	632	88.02	-
No	86	11.98	

3.3 Cultivation of starch crops by geographical zones in Nigeria

Our survey shows that 173 (25.71 %) respondents from 28 out of 36 states and the Federal Capital Territory (FCT), reported that most starch crops are grown there (Figure 2), mostly in the NC region (45.09 %; n = 78), with Niger, and Plateau states constituting the majority (16.76 %; n = 29) each. There was a significant association (x^2 = 517.82; df = 136; *P*-value < 0.001) between the most cultivated starch crops and the geographical zones in Nigeria. It was found that cassava (37.80 %, n = 79; 30 %, n = 64) and potato (15.00 %, n = 3; 25.00 %, n = 5) are mainly cultivated in the SE and SS respectively; rice and maize are cultivated mainly in the NE (28.52 %, n = 14; 41.35 %, n = 43), NW (20.41 %, n = 10; 30.77 %, n = 32), and NC (24.49 %, n = 12; 13.46 %, n = 14) respectively; yam is cultivated mainly in the NC (60.17 %, n = 71); while the potato is cultivated in the NW and SS (25.00 %, n = 5) each, and NC (20.00 %, n = 4).

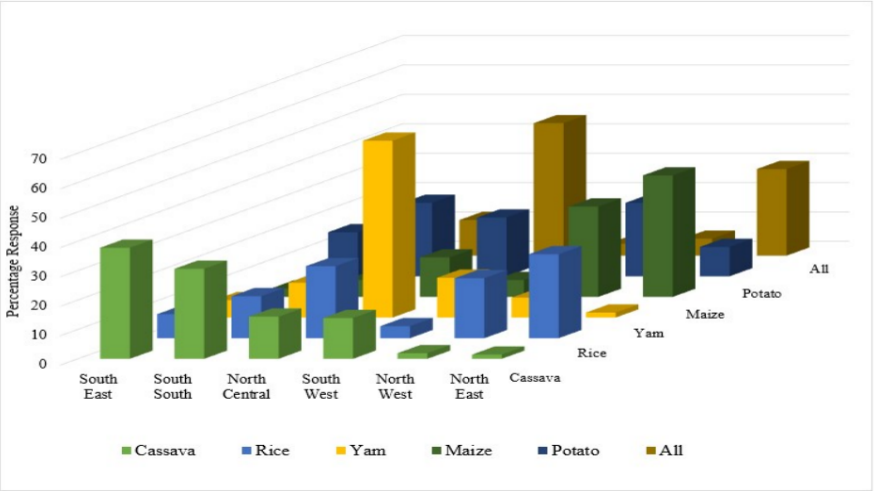

Figure 2. Cultivation of starch crops by geographical zone in Nigeria

Starch has demonstrated versatility in a variety of applications (n = 338; x^2 = 511.18; df = 372; *P*-value < 0.001), such as food thickeners, livestock feeds, ethanol, yeast and glucose syrup production, in the manufacture of plastics, dyes, gums and adhesives, and as fillers and binders in drugs (Figure 3). By state (Figure 4), our study (n = 255; x^2 = 165.55; df = 25; *P* < 0.001), shows that the most common starch applications were: food thickener (n = 127), livestock feeds (n = 43), yeast production (n = 39), glucose syrup (n = 24), and plastics (n = 22), with a significant (*P* < 0.001) majority living in Cross River state (23.20 %, n = 29) who use starch as thickeners, while 20.00 % (n = 5) of them produce glucose syrup. Furthermore, 25.58 % (n = 11), 53.66 % (n = 22), and 47.37 % (n = 9) of respondents in Niger state use starch for livestock feeds, yeast, and plastics respectively.

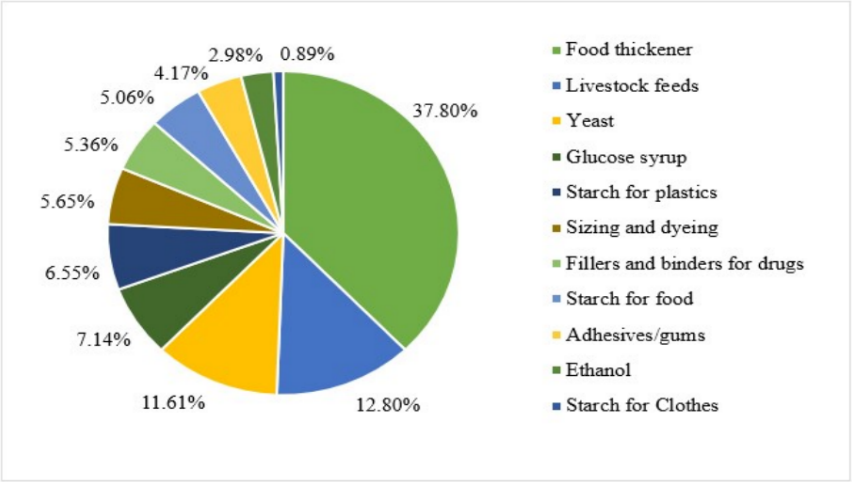

Figure 3. Common applications of starch in Nigeria

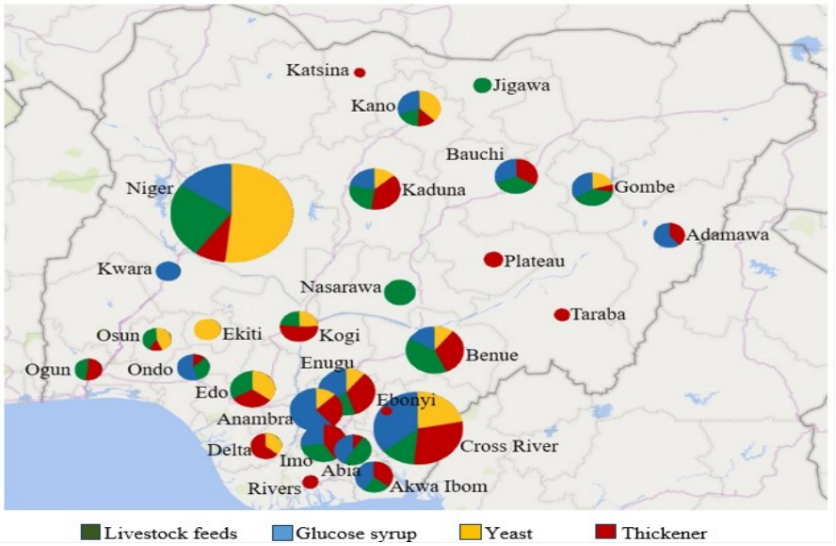

Figure 4. Major starch products produced by state

3.4 Starch products and its utilization in Nigeria

In Nigeria, there is a significant association (n = 339; $x^2 = 87.15$; df = 36; $P < 0.001$) between starch products produced and their utilization. Our study shows that 67.16 % of respondents produced starch-based products mainly for local consumption, with 19.53 % and 10.65 % using them for research and commercial purposes, respectively. However, only a handful (2.66 %) exported the products, as shown in Figure 5a. Those who commercialized their products were those who produced livestock feeds (20.93 %), ethanol (20.00 %), glucose syrup (16.67 %), plastics (27.27 %), yeast (7.69 %), and fillers (16.67 %), whereas participants who used fillers and binders in drugs (50.00 %), yeast (35.90 %), adhesives/gums (28.57 %), glucose syrups (25.00 %), and ethanol (20.00 %), used them for research purposes. A mere 9.30 % of respondents produced livestock feeds and plastics (13.64 %) for export (Figure 5b).

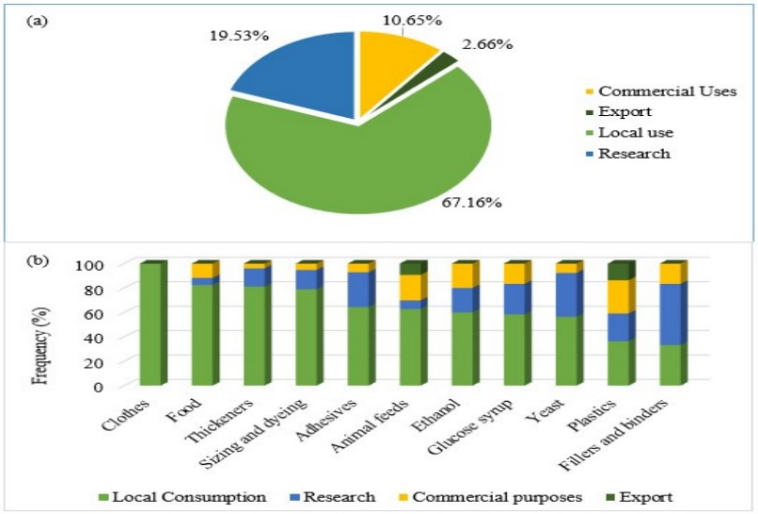

Figure 5. Starch products utilization in Nigeria

3.5 Stakeholders and their responsibility for the establishment of the starch industry in Nigeria

Two hundred and nine respondents (61.83 %; $x^2 = 111.89$; df = 2; *P*-value < 0.001) indicated that the government should be responsible for the commercial production of starch in Nigeria, of which 67.46 % suggested the Federal government (Figure 6a). In comparison, 129 respondents (38.17 %; $x^2 = 17.12$, df = 1, *P*-value < 0.001) suggested the private sector, of which 68.22 % proposed the industrialists (Figure 6b).

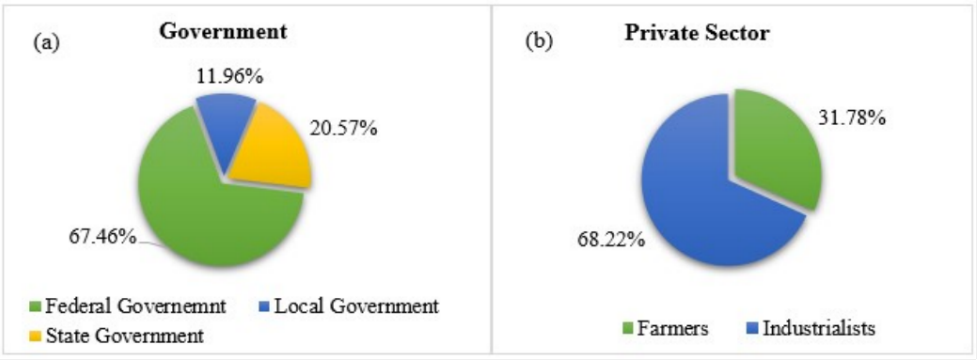

Figure 6. Stakeholders responsible for the commercial production of starch in Nigeria: (a) the government; (b) the private sector

3.6 Preference for the establishment of starch industries in Nigeria

Figure 7 shows that 36.78 % (n = 128) of the respondents preferred the establishment of starch industries in Nigeria. Although, 25.29 % (n = 88) and 15.80 % (n = 55) prefer the food and pharmaceutical industries, respectively, 8.05 % (n = 28), 6.32 % (n = 22), and 4.89 % (n = 17) prefer the textile, export, and biofuel industries (n = 339; x^2 = 248.84; df = 6; *P*-value < 0.001).

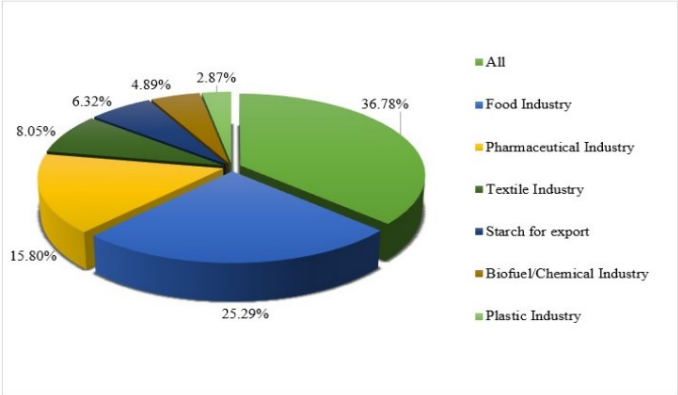

Figure 7. Focus on the Industrial Development of Commercial Starch in Nigeria

3.7 Challenges facing the establishment of starch industries in Nigeria and government responsibility to improve it

A total of 337 respondents (*P*-value < 0.001) identified the major challenges plaguing the starch industries in Nigeria to include the lack of standardization (n = 148), insecurity (n = 71), lack of electricity (n = 64), and unused arable lands (n = 47). Only 0.30 % (n = 1) of the respondents indicated funding as a challenge as shown in Figure 8a. Therefore, to improve the starch industry in Nigeria, respondents have suggested that the government should implement programs and policies (19.78 %; n = 125), train industrialists to process high-quality starch (HQS) for export (18.99 %; n = 120), train farmers to cultivate high-yielding starch (HYS) crops (16.77 %; n = 106), provide the necessary utilities (15.66 %; n = 99), stop the importation of starch into Nigeria (14.40 %; n = 91), convert unused lands to starch crop cultivation (7.91 %; n = 50), and give waivers for equipment (5.70 %; n = 36) (Figure 8b).

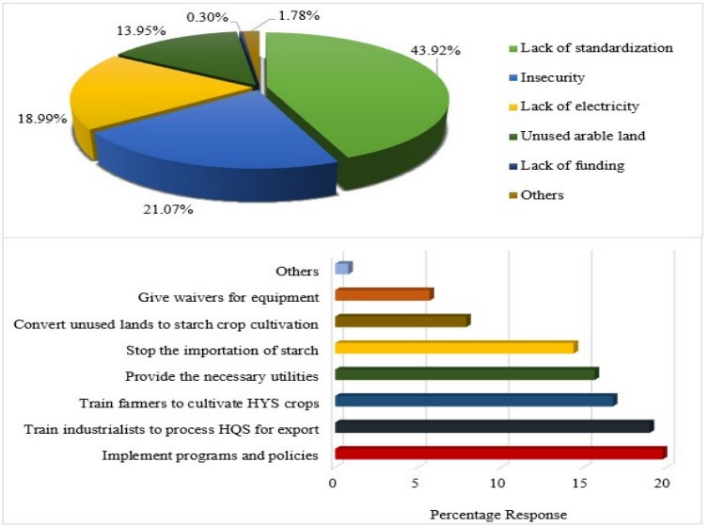

Figure 8. (a) Challenges of the starch industry in Nigeria: (a) challenges; (b) government responsibilities

4. Discussion

Young people (15 - 49 years) and mostly singles (n = 400) are more interested and open to information. They constitute the majority of the tertiary and postgraduate group and are more accustomed to social media as they are among the most technology-savvy people in the country, utilizing Facebook and Twitter to connect with friends, share information with others, and conduct business online.

Nigeria has an estimated population of over 220 million people. Because starch is a common commodity that is well-known in the country, we expected a high level of participation, however, participants' reluctance, view of social media, lack of understanding, or bias in the sampling method may have decreased participation, especially in NW and SW regions (John *et al.* 2023).

Starchy foods are the most commonly consumed staple meals in Nigeria, including tuwo (rice or corn meal) and masa (waina, made from rice), usually taken with vegetables and traditional soups in Northern Nigeria; garri (eba), fufu and abacha (cassava), often eaten with vegetables, egusi, or other locally made soups are popular in NC and Southern Nigeria. Furthermore, pounded yam (often eaten in the NC), amala (from yam or cassava), and agidi (from fermented corn flour) served with stews or bean cakes respectively, are the staples of the SW region. In contrast, potatoes are prepared as porridge or fried with peppered sauce, and the floor obtained from it is eaten with soups. These consumption patterns of starchy crops are expected because Nigeria is the world's largest producer of cassava, and the fourth-largest producer of potatoes in Sub-Saharan Africa (Olutosin & Sawicka 2019). Furthermore, rice is the most commonly eaten grain in Nigeria, while maize is the most important cereal crop in Saharan Africa (SSA) (Fora/Cornstarch/FMR/165390, 2016; Nextzon 2017).

The NC region of Nigeria is home to the two major rivers (Benue and Niger). In this region, these crops are cultivated all year round due to the irrigation practices of the people living in that area (Sunmonu *et al.* 2022). Additionally, more than 90 % of the world's yam production occurs in the yam belt of West and Central Africa, with Nigeria contributing 68 %, making it the world's largest producer of yam. However, cultivation has largely been subsistent, with just enough for local consumption (Otegbayo *et al*. 2014). Hence, it is no surprise that more of our respondents in the NC cultivate yam than in other regions. This supports the study conducted by Chiaka and colleagues (Chiaka *et al*. 2022), that yam was the dominant crop cultivated in the NC region, maize in the NE, rice and maize in the NW, and cassava in the SE. However, contrary to their report, we have more respondents indicating that maize is cultivated more in the SW than the SS, possibly because of the low responses obtained from those regions.

Starch makes up about 28 – 80 % content in maize, 81 – 89 % in rice, 24 – 74 % in cassava, 60 – 80 % in potato, and about 80 % in yam. Because it is completely biodegradable, it is used as thickeners, binders, disintegrants, stabilizers, texture modifiers, gelling, and bulking agents in food, feed, pharmaceutical, and other allied industries (Otegbayo *et al*. 2014). In the pharmaceutical industry, it is used in solid dosage forms, as carriers in novel drug delivery systems, as modified starch, and in producing glucose syrups for oral liquid formulations. Our study also revealed that the three most common starch applications in Nigeria are food thickeners, animal feeds, and yeast. The food industry uses yeast as a fermenting and leavening agent, for the production of ethanol, wine, and beer. Although, yeast is produced from starch-based crops using low-cost methods, such as hydrolysis with mineral acids and enzymes, there existed the Nigerian Yeast and Alcohol Manufacturing Company (NIYAMCO), Nigeria, which was founded in 1973 to manufacture alcohol and alcohol-based products. However,

in 1990, it was privatized, resulting in reduced capital expenditures, and the country now depends heavily on imported yeast, for its manufacturing purposes (Taiwo 2006). Similarly, Nigeria currently has over thirty-one livestock feed manufacturers, over sixty pharmaceutical and medicine manufacturers, seventy plastic product manufacturers, and over two hundred food and other food manufacturing companies, which rely heavily on starch as their primary raw material, however, these companies rely on imported starch for their manufacturing purposes.

In Nigeria, farmers cultivate just enough starch crops for their immediate needs, by cultivating their backyards, vacant land, or around their houses to feed their families. Our study reflects this as the majority of our participants produced starch crops mostly for consumption. Ikhayere reported that Nigerian farmers' subsistence farming practices contributed to the underdevelopment of the agricultural sector in Nigeria (Ikhayere 2022). On the contrary, Fan and Rue (2020) believed that subsistence farmers hold the keys to economic development if they receive the right orientation, are adequately trained, with increased access to markets and information, financial capital, infrastructure, and smallholder-friendly technologies that will not only help to commercialize their products but also increase their earning power. In addition, formulating new policies and implementing existing ones aimed at increasing the outputs of these farmers, as well as lowering or abolishing interest rates will facilitate the export of starch and starch-based products (Amao *et al.* 2021). Above all, women's participation in agriculture should be greatly encouraged as they make up about 43 % of the global workforce (SOFA & Doss 2011).

As part of our goal, we hope that the Federal government will adjust existing programs and policies in a way that facilitates their implementation and improves the production of starch and starch-based products in Nigeria, enhancing the yield of starch crops by providing farmers with basic amenities and security. On the other hand, the state government should collaborate with local governments to identify starch crops in their states, take proactive steps to establish at least one starch-based industry within the state, and ensure these starch crops are converted into value-added products by standardizing and commercializing them with the intent of exporting them domestically and internationally. They should also identify the subsistence farmers within the state, and encourage women and youth participation in farming through capacity building, providing them with infrastructure, farm inputs, manpower, and improved seed varieties for maximum yield. In addition, they should provide an enabling environment for the commercialization of their farm produce, and ensure the state government buys them off to avoid wastage.

The private sector can maximize its involvement by finding individuals with skills in converting starch crops into starch-based products, training them and providing low-risk credits and tax waivers to facilitate the commercialization and export of such products. The Standards Organization of Nigeria (SON), through its Micro, Small, and Medium Scale Enterprises (MSME) desk can provide the information and training for individuals to certify their products to meet the necessary standards for commercialization and export. The agencies and parastatals in Nigeria saddled with the responsibility for R&D in raw materials, sourcing, standardization, and exports should also facilitate the improvement of starch and starch-based products in Nigeria, as well as enhance its output for commercialization and exportation. In particular, the National Institute for Pharmaceutical Research and Development (NIPRD), in collaboration with the Pharmaceutical Manufacturers Group, and industries should provide R&D solutions for the production and commercialization of pharmaceutical-grade starch, both for local manufacturing companies and for export; the Raw Materials Research and Development Council (RMRDC) should ensure adequate utilization of these raw materials; the Institute for Agricultural Research (IAR), through the Federal Ministry of Agriculture and Rural Development (FMARD), should ensure sustainable food and nutrition security, provide agriculture-based employment opportunities to the youths and low-risk credits to farmers. Furthermore, the Nigerian Export Promotion Council (NEPC), which recently launched the Youth for Export Programme (YEP) aimed at empowering youths in skills for export, should periodically organize conferences to link stakeholders to address unmet needs, while the Manufacturers Association of Nigeria Export Promotion Group (MANEG) should ensure the promotion of these starch-based products to expand forex earnings for Nigeria. Above all, the Nigeria Natural Medicine Development Agency (NNMDA) can foster collective efforts in the utilization of starch-based products, especially in livestock feeds which are an important input in animal agriculture. These agencies and their collective efforts can facilitate and reposition the Agricultural sector as the cornerstone of the Nigerian economy, foster economic development of the nation, and promote product diversification to reduce the over-reliance on oil.

5. Conclusion

Over 88 % of Nigerians are aware of starch and starch crops, which are cultivated in abundance throughout the country, however, they are largely subsistent. Our study reveals that most of the starch crops are cultivated in the NC region of the country, and starch obtained from these crops is mainly used for the production of thickeners, livestock feeds, and yeast, with approximately 67 %, 11 %, and 3 % of them consuming, commercializing, and exporting their products respectively. Furthermore, lack of standardization (43.92 %) and insecurity (21.07 %) were the most cited challenges of the starch industry, although, 36.78 %, 25.29 % and 15.80 % of the respondents prefer that all starch-based industries, especially the food and pharmaceutical industries respectively, should be

the focus for the establishment of the starch sector in Nigeria. This study, therefore, reveals the urgent need for the government to establish the starch industry in Nigeria, implement programs and policies, and encourage the private sector (industrialists) to engage and train farmers. Additionally, there is a need to provide youths and women with financing and incentives while creating an enabling environment for immediate commercialization and exportation of starch and starch-based products to generate forex that will boost the Nigerian economy.

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