



# Moving Biofortified Cassava Products Closer to Market in Nigeria

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Food must be acceptable, affordable, and available to consumers and consumers must have the resources, knowledge, and correct mindset to purchase and consume these foods. The narrative of this study centered on moving biofortified food closer to market by looking at awareness, adoption, and consumer mindsets as pillars to achieve market access. Our findings show that in Abia state, Nigeria, consumers are aware of biofortified cassava. This signifies a high market potential and economic opportunity for stakeholders in the supply chain. Unfortunately, consumers lack understanding of biofortified cassava's nutrition value. The high adoption level of biofortified cassava has implications on investment and stimulation of the local economy. The study identified accessibility, purposefulness and innovation as vital mindset drivers to scale market demand, and factors that affect both consumption, production, and marketing of the product. This study provides insight regarding potential priority areas of action for government policy interventions to stimulate demand and supply opportunities. This study also provides evidence that scaling up demand will depend on awareness creation. There is a need to improve communication networks to provide overwhelming product acceptance, adoption, and consumption of biofortified cassava. This will help change remaining myths about agro-biotechnology and the bioeconomy.

**Keywords:** adoption, awareness, biofortified cassava, agro-biotechnology, mindset drivers

## INTRODUCTION

There are many challenges confronting the world, but hunger and malnutrition are two major food issues among policy makers and governments due to their link to food insecurity and health (International Institute for Tropical Agriculture (IITA), 2009; Saad, 2010; Anugwa and Agwu, 2019). Regrettably, Nigeria is one of the countries in the world with serious micronutrient malnutrition issues leading to widespread economic consequences (Agwu, 2011). In Nigeria, more than 14 million people representing 8.5% of the population are undernourished, based on a 2014 report of the National Health Component of the National Strategic Plan of Action for Nutrition (2014–2019). In addition, Nigeria has the highest number of stunted children, estimated at 10 million in Africa; 37 percent of these children under the age of five are stunted, 29 percent are underweight, and 18 percent are wasted. These challenges arise as a result of a combination of poor awareness of dietary requirements, feeding practices, and high levels of poverty (Agwu, 2011; Nwajiuba C. U., 2013). Therefore, given that these issues are food related, the food system is central to the foundation for future progress in ending issues of global poverty, hunger, and under-nutrition (Low et al., 2007), since food remains the most potent weapon to address the Sustainable Development Goals (SDGs).

The majority of the world's response to improving the food system has seen a progression in synergy among key stakeholders. Private agricultural businesses and investors use agro-biotechnology to scale up awareness and demand for nutritious smart solutions to achieve a sustainable food system, as a means of improving health and food security. Although there are different types of biofortification, In Nigeria, conventional breeding practice is the commonest and approved practice. The first set of Genetically Modified (GM) practice is still a subject of controversy to date due to the lack of approval to release transgenic crops to farmers. In sub-Saharan African countries such as Nigeria, certain foods within alimentary culture are mentioned in the context of food security, such as cassava (Nwachukwu et al., 2010). Unfortunately, the conventional white fleshed cassava is not rich in the micronutrient pro-vitamin A to address the double burden of malnutrition (see, Talsma et al., 2016), despite the fact that it is a choice food among more than half a billion people; second to maize in its calorie contribution. Cassava has a comparative advantage over other staples and attracts poor resource farmers who constitute the bulk of suppliers (Moon et al., 2004; Bamidele et al., 2008), hence the need for biofortification improvement. Biofortification, the practice of genetic manipulation of plants for the purpose of increasing the concentration of specific micronutrients, is seen as a food enrichment measure to bridge nutritional gaps in staple food consumption. Biofortification of staple foods such as cassava, rice, beans wheat, maize, and sweet potato thus indirectly target low-income households who cannot afford a more diverse diet (Huffman and McCluskey, 2014). According to Randall and Sanjur (1981), biofortified yellow cassava contains vitamin A and results in public health gains.

Several studies have highlighted the successes of biofortified foods in different parts of the world for bridging micronutrient deficiencies, including Nigeria (Caswell and Joseph, 2007; Kotler and Armstrong, 2008; Loopstra, 2018). Generally, agriculture is seen as an important component of sustainable development, and biofortification is a cost-effective and sustainable food-based intervention that promotes this. However, the progress of scaling biofortified foods is challenged by persistent shifts in consumer preference, mindsets, and perception about the nature of these foods. This shifting trend is in response to changes in the food environment and reflects growing food and dietary transitions due to social, economic and environmental convergences. In recent times, consumer food choice has advanced based on quality attributes such as food safety, nutrition, organic production, fair trade, free range, and locally grown (Creswell, 2014), traceability and sustainability. To a large extent, these factors will continue to determine the future of food demand and its impact on agriculture and food trade. This thinking is critical and reflects the understanding of consumer behavior and perception toward biofortified foods, and by extension, Genetically Modified (GM) foods in many developing countries. Evidence has shown that many consumers are not open to food developed using biotechnology, especially as information regarding the potential risk of these products is still a subject of debate among policy makers and Civil Societies Organizations (CSOs), leading to controversies in consumer

demand or acceptance/rejection [FAO (Food and Agricultural Organisation), 2011; Creswell, 2014]. McCluskey (2015) and Sayre (2011) observed that perception affects product choice and consumer willingness to pay for such brands in the market. This manifests as consumer skepticism of perceived risk and is assumed to be high over safety and other issues (Kotler and Keller, 2010). Cognitive factors such as belief, risk perception, knowledge and trust in government have emerged as critical elements for explaining the differences in consumer mindset for biotech crops in European countries (Petty and Krosnick, 1995). Perception about GM food and agrobiotechnology have been bolstered by concerns for sustainability and further by the lack of effective policing of regulatory agencies to provide a clear mechanism for biosafety. Although the Nigerian government established the National Biotechnology Development Agency (NBDA) and National Biosafety Management Agency (NBAMA), their roles appear to be minimized, leading to uncertainty and doubt regarding safety concerns. In addition to this, the absence of a mechanism to enhance food transparency as well as a confidence building process such as food certification that consumers would recognize and trust have compounded consumer perceptions of biotechnology. For instance, most countries in Europe and America have a well-functioning labeling and (eco) certification program (Solomon, 2011), which would improve market acceptance of agro-biotechnological or conventional breed products.

The above is further exacerbated by poor awareness of the nature of products such as biofortified foods as a cost-effective food enrichment measure within alimentary culture. Nguema et al. (2010) observed that household food security and awareness levels of the benefits of biofortification affects the decision to adopt such products, and by extension, their market presence. This signals the gap in information dissemination and reflects the opinion (Meenakshi et al., 2010) that information dissemination is poor and cannot direct a high level of participation in product acceptance for both consumers and producers of such agricultural products. According to Kotler and Keller (2010) information about the potential health benefits of such products has a positive and significant effect on consumer willingness to pay.

Although evidence shows that campaigns to educate consumers have intensified, there is a rather limited presence of biofortified foods in most local markets of sub-Saharan Africa (Nguema et al., 2010). In Nigeria, an increase of 68% was achieved between 2014 and 2015 for the number of households which had access to Pro-vitamin A cassava. In 2015, HarvestPlus estimated that 75% of all biofortified harvested roots were planted (Bouis and Saltzman, 2017). Regrettably, only 10 percent of the total estimated production of 7,000 tons of Vitamin A cassava roots harvested was sold in local markets (Ilona, 2014a). This implies that biofortified food consumption constitutes only a few percentages of the total food consumed in Nigeria. This makes it difficult to deepen consumer demand, and by extension supply for these products due to the lack of patronage and market presence. According to Low et al. (2007), food must be acceptable, affordable, and available to consumers, and consumers must have the resources, knowledge and motivation

to purchase and consume these foods. This also applies to suppliers, as demand is one of the factors that influence supply *ceteris paribus*.

According to estimates from the United Nations, Nigeria will be the third largest country in terms of population after China and India by 2050. To reduce the prevalence of malnutrition, Bouis and Saltzman (2017) proposed that one agenda is to reach at least 1 billion people with biofortified foods by 2030. Therefore, one of the major challenges is how to scale up consumer demand, so that biofortified food will command a reasonable market share. Without agro-biotechnology, it might be difficult to feed this growing population and prevent cases of malnutrition from rising. Already there is a growing negative public perception and politicization of this issue. According to Kotler and Keller (2010), how these factors are managed will influence the future direction of agro-biotechnology.

This current study is an attempt to bridge the gap and provide a basis for policy intervention that addresses issues of health, poverty, and adoption of biofortified food as an alternative to fortification. Consumer studies with respect to food have received much attention from researchers, however, not much attention has been placed on biofortified foods in south-east Nigeria. At least part of the difficulty in conducting research in this important area lies in the complexity and diversity for the influence at work in food choice and consumption (Miller and Welch, 2013). This is because such research requires both knowledge of the general concept as well as some deeper cross-disciplinary insight (Simon, 1947) such as the link between agriculture, health, and marketing. Given that data on biofortified cassava supply and demand is lacking, the thrust of this study is to bridge the gap, which will serve as a basis for policy formulation.

## Cassava and Biofortified Cassava in Nigeria

Cassava is an important food staple and cash crop in many developing countries. It occupies both functional and strategic importance to the Nigerian economy. For instance, successive agricultural transformation agendas have identified cassava as strategic for curbing challenges of poverty reduction and accelerating economic recovery, growth, and development in addition to food security in Sub-Saharan Africa [FAO (Food and Agricultural Organisation), 2011]. This became the thrust behind the Presidential Initiative on Cassava in 2003 and Strategic Action Plan for the Development of the Nigeria Cassava Industry of 2006 (Cassava Master Plan, 2006).

Cassava is a basic staple to more than half billion people around the world [FAO (Food and Agricultural Organisation), 2011] and serves over 200 million in Africa, second only to maize in its calorie contribution (Kotler and Keller, 2010). It is a choice food for many families in Nigeria, hence it is cultivated by resource poor farmers who constitute over 80% of all farm holdings in Nigeria (Kotler and Armstrong, 2008; Barkley Inc., 2016).

Africa currently produces more than 50 percent of the world's cassava, with Nigeria producing nearly two-third of total cassava

production in Africa. This makes Nigeria the highest producer in the world; a third more than Brazil and almost double the production capacity of Thailand and Indonesia (International Institute for Tropical Agriculture (IITA), 2009; Ejike, 2016).

Besides the need to make food, particularly cassava, available for human consumption, there is more need to ensure that such food meets specific nutritional content to address the double burden of malnutrition. Over the years, the Nigerian government and its agencies have come up with a number of interventions, such as scaling up educational awareness on nutrition, and mandatory food fortification in certain foods consumed under the direct supervision of the National Agency for Food and Drug Administration and Control (NAFDAC), among other programs and policy support systems. However, these are not enough, as issues of malnutrition deficiencies have exacerbated over the years, calling into question the numerous investments and multisector interventions along the food system.

Although this challenge is domestic, it impacts upon the global food security trajectory that attracted the consideration of the Bill and Melinda Gates Foundation (BMGF) in 2004, as part of their commitment to mitigate diseases/sickness particularly in many developing countries. The Bio-Cassava plus (BCT) program was part of this program (Onuegbu et al., 2017). The concomitant realization is that the conventional white cassava lacks sufficient micronutrients to bridge nutritional gaps that causes diseases in many developing countries. The objective of BCT therefore was to bridge the gaps occasioned by a lack of micronutrients, thereby providing an avenue to complete micronutrient requirements.

This process, according to Nguema et al. (2010), initiated the biofortification intervention in Nigeria starting with the initial process of Biocassava plus (BTC), which started in 2005 through conventional breeding processes. This development further bolstered the development of yellow cassava with increased  $\beta$ -carotene content, shelf life and resistance to Cassava mosaic disease. In doing this, the iron and protein contents were not increased, nor was the cyanide level reduced in Nigeria. The major institutions that carried out the modification are the International Institute of Tropical Agriculture (IITA) and the National Root Crop Research Institute (NRCRI). The interest in cassava is because it is a choice food among Nigeria and is important to people's livelihood, with comparative advantages for cultivation than other crops.

This study aims at placing the issue of innovative food marketing within a larger perspective than a set of repetitive discrete transactions between consumers and other stakeholders within the food system. Considering the above, the study is anchored on the following objectives:

- To examine the level of awareness of biofortified cassava food products and their benefits
- To determine the level of adoption of biofortified cassava products
- To analyze consumer perception of biofortified cassava brands using consumer mindset drivers
- To identify factors which affect consumption and marketing of biofortified cassava products

## MATERIALS AND METHODS

The study was carried out in Abia state. Abia state is one of the five Southeastern states of Nigeria. Others are Imo, Anambra, Enugu, and Ebonyi states. The state with its capital at Umuahia, was carved out of Imo state on August 27, 1991 by the then military administration.

Abia state is located between Latitude  $04^{\circ} 45'$  and  $06^{\circ} 14'$  North and Longitude  $07^{\circ} 10'$  and  $08^{\circ} 00'$  East. It shares common boundaries with states in the south-east and south-south geopolitical zones. It has Ebonyi and Enugu states to the North and to the south, it has Rivers state, Cross River and Akwa Ibom are located at the east, while Imo state is at the western border.

The population of the state according to 2017 estimates by the National Population Commission (NPC) stood at 3,727,300 persons with a relatively high density of 590 persons per square Km, with an annual population growth rate of 3.18%.

For ease of administration and management, the state has 17 Local Government Areas (LGAs), partitioned into three (3) agricultural zones—Aba, Umuahia, and Ohafia. The majority of Abians representing more than 60% of the total population are involved in farming and its allied matters; and have the potential to produce products such as palm oil, cassava, vegetables, palm kernel, yam, rice, cocoa etc; livestock activities like pig and goat rearing and also engage in food processing [Abia State Economic Empowerment and Development Strategy (ABSEED), 2005].

Abia state has a wide spectrum of interest in agricultural, marketing and agribusiness, given its entrepreneurial and industrial understanding. Agriculture and its allied activities remain one of the focal points of successive government in the state, given the advantages it enjoys with the presence of Michael Okpara University of Agriculture, Umudike (MOUUAU), National Root Crops Research Institute (NRCRI) Umudike, Faculty of Agriculture of Abia state University Uturu, National Cereal Research Institute of Nigeria Amakama—Olokoro, Sub-stations of Cocoa Research Institute of Nigeria (CRIN) and Forestry Research Institute of Nigeria. These institutes and others guarantee an unquantifiable advantage and add to Abia state capacity in their agricultural production, implementation, and dissemination of research findings to benefit smallholder farmers and consumers in Abia state and Nigeria in general.

Abia state was selected for this study for several reasons. Firstly, NRCRI was one of the agricultural institutes in Nigeria where the initial field evaluations and trials of provitamin A and iron biofortified plants were conducted by HarvestPlus (Okezie et al., 2011). Secondly, Umudike in Abia state was one of the first six locations in Nigeria under trial for the provitamin A cassava varieties by Nigeria's National Variety Release Committee in 2011. Other places are Zaria, Ogoja, Nsukka, Mokwa, and Otobi. In addition, several studies such as de Steur et al. (2012) observed a prevalence of malnutrition crisis in Abia state due to differences in the socio-economic status of households. This shows evidence of food insecurity among households in the state. According to Nwachukwu and Ezeh (2007), food insecurity, especially among children, manifest in their nutritional status. According to 2014 Nutritional Situation in Nigeria Survey, of all states surveyed, Abia was among the states that showed prevalence of Global

Acute Malnutrition (GAM) below the WHO acceptable threshold of 5%. Other states include Plateau, Niger, Kaduna, Benue, Adamawa, Edo, and Bayelsa, although the upper limit of the 95% confidence interval of each of this prevalence were higher than 5%.

Given that the problem of malnutrition remains considerably high in Abia state and other parts of the country, more effort and a possible least cost solution is required to mitigate malnutrition, which biofortified cassava could provide. With the evaluation and trial of biofortified products in Abia state, there is also a significant number of biofortified farming households available in the different agricultural zones of the states. These farmers play strategic roles in the cassava supply chain. Their number and potential are also of interest to researchers to enhance the pathway to a more sustainable agriculture, with emphasis on biofortification.

Finally, food security is a national issue and Abia state as part of the nation shares the same burden. Its strategic importance in agricultural transformation for Nigeria justifies its choice of location for this study.

The population of this study was comprised of consumers of cassava food products in Abia state, Nigeria. The precise number of biofortified cassava consumers is unknown given that there is no statistical available evidence of the number that consume biofortified cassava in the State. Therefore, the population of this study is infinite.

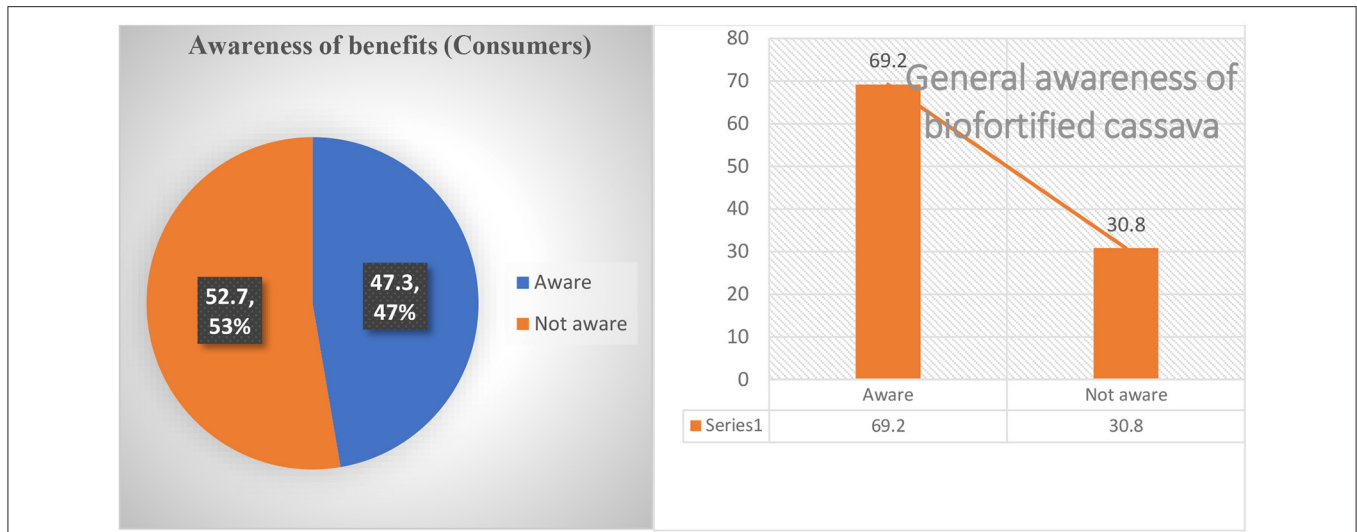
Given an infinite population, as it is the case in this study, Chen (2013) suggested that respondents could be chosen based on their convenience and availability. Therefore, the study adopted a multi-stage sampling technique for selecting location and consumers. Based on the nature of the product of interest, it was considered that responses should be elicited from sources knowledgeable in biofortified cassava to limit measurement error. In this regard, the Agricultural Development Program (ADP) extension agents assisted in the random selection of the respondents as the key informants.

The first stage involved a purposive selection of eight LGAs in the state. They include Aba south, Aba north, Umuahia south and north, Osioma, Bende, Ikwuano, and Isialangwa north. The choice of these LGAs were informed by the nature of characteristics of interest and advice from the Agricultural Development Program (ADP), Abia state office. The second stage involved a random selection of 30 respondents from each LGA. This aggregates to 240 respondents, which served as the sample for the study. To ensure precision and reliability of data, the questionnaire was evaluated by panels of experienced researchers, senior academics and ADP staff to note areas of adjustment in the structure of data collection instrument.

Regarding the reliability of the research instrument, the proposed instrument was subjected to Cronbach's co-efficient alpha to ensure that the instrument gives a reliable and internal consistency result.

Analytically, data were analyzed using descriptive statistics and a 5-point adoption scale model. The level of adoption of biofortified cassava (foods) adopted 5-point adoption categories in line with (Aniedu et al., 2012) and (Anyiro and Onyemachi, 2014). The adoption levels and rating scale





**FIGURE 1 |** Awareness of biofortified cassava product and benefits for consumers. The left side illustrates total consumer awareness of the benefits of cassava. The right side depicts consumer awareness of biofortified cassava.

are Awareness (1), interest (2), Evaluation (3), trial (4), and accepted (5).

The mean adoption level was determined using

$$X_s = \sum X$$

$$N \text{ ----- (1)}$$

$X_s$  of each was computed by multiplying the appropriate frequency response with its corresponding nominal value and dividing the sum with the number of respondents to the item.

In summary, the equation will be

$$X_s = \sum fn/nr$$

Where  $X_s$  is the mean of the scores

$\sum$  = summation

$f$  = frequency

$n$  = adoption nominal value

$nr$  = number of respondents

the decision criteria will be based on

$$X_s = 1 + 2 + 3 + 4 + 5 / 5 = 3.0$$

Therefore, any mean score of 3.0 and above was deemed to have adopted the product of interest, while any mean score of <3.0 was assumed as having not adopted biofortified cassava.

## RESULTS

### Awareness of Biofortified Cassava Products

The analysis of **Figure 1** shows that although most of the respondents are aware of biofortified cassava products; many are however not aware of its nutritional value. This can perhaps explain the challenge to develop a demand for the product, as consumers see the product as just another variant of cassava or new improved variety. This result highlights the challenge of marketing to create communication strategies that increase awareness of both biofortification and its value in

nutrition and wellness. The result inadvertently implies that the communication strategies adopted are not powerful enough to steer up overwhelming awareness, knowledge leading to adoption and demand.

Interestingly, our observation also shows that most producers are aware of biofortified cassava and its benefits. This result evokes many questions such as the low level of marketing efforts and the poor presence of this product in the market. This could be due in part to a convergence of factors such as the institutional support system, land tenure, and other challenges which are mentioned in the context of low productivity in many developing countries (Moon et al., 2004; Smed, 2012; Ejike, 2016).

### Categorization of Biofortified Cassava Value Added Products and the Level of Adoption

**Table 1** analyzed the respondents' adoption level of biofortified cassava value added products. There are different biofortified cassava value-added innovations by producers. In this study, seven (7) major types were identified. They are *garri*, cassava bread, cassava fufu flour, high quality cassava flour, cassava starch, cassava cake, and cassava chips. The results in **Table 1** illustrates the process of adoption of these biofortified cassava variants among consumers in Abia State. From this result, the mean adoption score ranges between 3.53 and 3.80 with an overall mean cut-off score of 3.65. Given the benchmark of a mean cut-off of 3.0, it can be inferred that biofortified cassava variants are highly adopted in the study.

This study is consistent with a study on cassava value-added innovation by Anyiro and Onyemachi (2014). This result is expected given that cassava is a choice food among Nigerians, contributing to the basic diet of millions of people (Nwachukwu et al., 2010). The dependence on this important staple makes consumption in various value additions very possible. The higher

**TABLE 1** | Level of adoption of value-added biofortified cassava products.

Types of biofortified cassava foods	Awareness	Interest	Evaluation	Trial	Accepted	Total	Mean
Garri	88 (88)	52 (104)	18 (54)	6 (24)	37 (185)	455	3.76
Cassava fufu flour	88 (88)	54 (108)	24 (72)	12 (48)	23 (115)	431	3.56
High quality cassava flour	88 (88)	52 (104)	25 (75)	11 (44)	25 (125)	436	3.60
Cassava starch	94 (94)	46 (92)	26 (78)	12 (48)	23 (115)	427	3.53
Cassava bread	95 (95)	40 (80)	25 (75)	22 (88)	19 (95)	433	3.58
Cassava cake	86 (86)	42 (84)	36 (108)	17 (68)	20 (100)	446	3.69
Cassava chips	76 (76)	57 (114)	26 (78)	18 (72)	24 (120)	460	3.80

\*Overall mean adoption is 3.65.

Figures in parenthesis are the likert scale value.

Cut-off score = > 3.0 = adopted; < 3.0 = did not adopt.

mean value for *garri* is in line with *a priori* expectation given that *garri* is an important by-product of cassava, with high market potential and demand among people, especially in Southeast Nigeria ( $\bar{X} = 3.76$ ).

The high mean for high quality cassava flour adoption demonstrates consistency with the Presidential Initiative on Cassava in 2003 and the Strategic Action Plan for the development of the Nigeria cassava industry of 2006 to make cassava one of the key bread components. It has a mean value of 3.60 above the benchmark.

The high rate of adoption of biofortified cassava value-added products in the area could be attributed to sustained communication efforts of stakeholders such as Development partners (Harvest Plus), Agricultural Development Program (ADP), National Root Crops Research Institute (NRCRI), nutrition experts, media platforms, and other stakeholders that have continued to push for improve awareness, sensitization, and adoption.

Generally, the adoption of any innovation resembles the decision-making sequence to which the consumer requires adequate information to make informed decisions. In doing this, the individual is constrained by several factors in the environment. This reflects the burden of bounded rationality theory -the idea that the level of information and the time available limits an individual's ability to decide (Onuegbu et al., 2017). Looking at the different adoption process, the difference in responses of the respondents depends on how much they know about the innovation in addition to convergence of social, economic, and environmental factors (Pambo et al., 2014).

This also represents a challenge for market penetration through segmenting, targeting, and positioning the product as a cost-effective nutritious alternative to food fortification. Information that is provided to consumers can play an active role in their perception and adoption of products; this is especially true for products with unobservable attributes (Oteh and Nwachukwu, 2014). Furthermore, this result together with evidence in **Figure 1** lends credence to the established fact that consumers do not evaluate and adopt products the same way. The study highlights the value of marketing information in the right quality and quantity to create a positive consumer attachment or attitude toward the product (Nwajiuba A. C., 2013). This result implies that consumers will no doubt adopt new products that

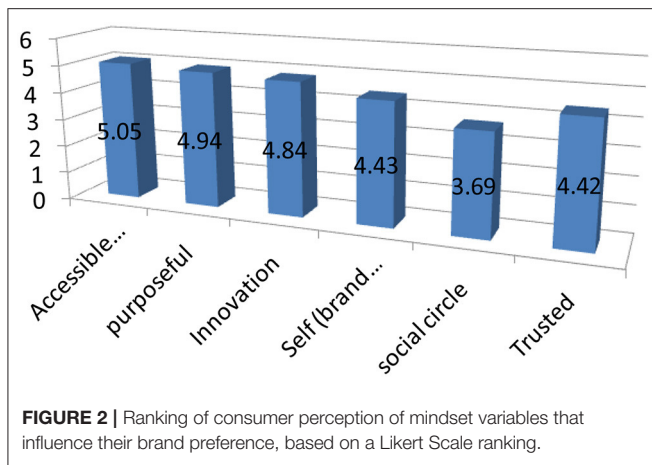
mesh with societal norms or collective cultures. It also shows that not all people adopt an innovation at the same rate. Some do so quite rapidly, and others never do at all. This informed the reason for placing consumers in approximate adoption categories—early and late adopters.

The role of marketing therefore, is to identify the key segments of the market with the tendency to be among the first to adopt a product and work on with them to design a message which creates the right appeal, as well as develop and manage communication strategies.

## Consumer Perception of Biofortified Food From the Lens of Mindset Drivers

There are multi complex phenomena that influence how consumers perceive and acquire products and services, especially when there are alternatives. These factors are significant social and marketing issues. Barkley Inc. (2016) developed the mindset map to shine light on how consumers navigate through these elements to shape their beliefs and behavior about brands. These mindsets indicate variable(s) that may influence consumer information processing at one or more stages of the perceptual process. This is because perception is basically fueled by the volume of information available to the decision maker. According to Okello et al. (2017), much of perception research in consumer behavior is driven by the information-processing view, which has traditionally been a dominant paradigm within cognitive psychology. These mindset variables represent certain cognitive values to which the consumer focuses during a search for information. The key expectations from this result are to identify mindset drivers that trigger product acceptance and preference; and also, to determine which mindset will have the greatest impact on the activities of producers.

**Figure 2** shows a ranking of consumer perception of mindset variables that influence their brand preference. The analysis is important and draws several conclusions. First, the study tries to understand how consumers generally think and perceive biofortified food products. The focus of this section is to understand how products can begin to navigate and influence consumer choices. The following mindset drivers were tested—trust, purpose, innovation, social circle, self, and accessible. How consumers perceive these mindsets determines the success of a brand or product. Secondly, this mindset is also expected to



elucidate what drives product acceptance and preference. Our expectation is that through this result, a company will know where it will have the greatest impact.

Our findings show that among the mindset variables, accessibility is most important. In many societies, consumers are interested in products that are readily available. This result is expected considering that food accessibility is an important component of food security and a vital link in this study. The result is consistent with the findings of Barkley Inc. (2016), who observed that consumers across all segments and countries identified accessibility as the biggest driver across industries. The study observed that accessibility refers to both physical and digital channels. Consumers today are interested in products with greater convenience. Therefore, the task of marketing is to improve availability strategies by bridging the gap between the needs of the producer and the market.

Interestingly, the result of accessibility shows that not all products follow the marketing orientation sequence faithfully. From the perspective of marketing orientation, accessibility implies sales orientation, which emphasizes availability of product rather than quality in most cases. Another variable of interest in the ranking is purpose, which addresses the issue of sustainability by considering people, planet, and profit. This result highlights the importance consumers attach to improving their communities through their consumption and other activities that reduce environmental impact. In recent times, many consumers are identifying with products are sustainable. This result implies that consumers look to their brand to make their communities better by not destroying the future and provide them with resources vital to impact their world. [International service for the Acquisition of Agri-biotech Applications (ISAAA), 2007], observed that many consumers today identify with companies who display a green commitment and thus patronize their brands. There is evidence that many consumers think that the agriculture and food industries are not transparent. In recent times, consumers are demanding far more information from food companies about food safety. For example, a 2016 white paper published by marketing and advertising firm Sullivan, Hizdon and Sink revealed that only

one third of consumers trust information from agriculture and food manufacturing sectors. This figure is compounded by a lack of traceability and transparency in the food supply chain. Many consumers are demanding to know how foods are produced. Other studies show that consumers are interested to know and have access to food production information. A study by Barkley Inc. (2016), revealed that trust in both manufacturer and retailer are positively related to food safety perceptions.

The low trust issue shown in this result indicates that a nation's level of development affects perception and demand. While many countries have scaled up the hierarchy of need, many households in the study area are still at a basic level. Hence, trust or safety is not necessarily an important determinant of their product decision. The mean and third place of innovation lends credence to the fact that many consumers do not accept innovation early on. Although most consumers value innovations, they are not quick to consider them in their product decisions due to risk and uncertainty. Again, this result is justifiable given that consumers may equate efficiency and quality with high cost. At the basic level of the need hierarchy, many Nigerians in the study area are more concerned with food availability and quantity than quality. The least important mindset variable in this study is the social circle in food brand product decision-making. This result implies that consumers in the study area do not consult people in their social circle in making decisions about products within alimentary culture. This is because cassava is a product with both cultural and economic identities for such local consumers. Cassava defines consumers' identity; hence they do not need validation from their social circle to identify with their culture.

## Factors Militating Against Consumption of Biofortified Cassava Products

Regarding biofortified cassava products, this study identified challenges that mitigate against its consumption. Using the mean values, the study ranked the responses to ascertain the most important constraint and identified inaccessibility of the product ( $\bar{X} = 2.72$ ), poor awareness ( $\bar{X} = 2.1$ ), inaccessibility of nutritional information ( $\bar{X} = 2.59$ ), high cost of the product ( $\bar{X} = 2.50$ ) and food safety issues ( $\bar{X} = 2.40$ ). The analysis is presented in **Table 2**.

## Constraints Encountered in the Production and Marketing of Biofortified Cassava by Producers

The analysis of **Table 2** shows that finance is mentioned as the most important constraint to the production and marketing of biofortified cassava. The other factors that influence production and marketing include administrative bureaucracy, small farm holding, and lack of incentive from the government. All together, they influence both production and marketing of biofortified cassava products in the study area. The result is presented in **Table 3**.

Factors negatively influencing consumers against biofortified cassava products were analyzed using descriptive statistics and the results are presented in **Table 3**. The results show that there are many factors of interest based on ranking. The value

**TABLE 2 |** Factors mitigating against consumption of biofortified food products.

Constraining factors	Mean	Rank
Inaccessibility of the product	2.7164	1st
Poor product awareness	2.6300	2nd
High cost of the product	2.5025	4th
Poor nutrition knowledge	2.2587	7th
Inaccessibility of nutritional information	2.5871	3rd
Negative sensitive about biotechnology	2.1642	9th
Food safety issues	2.4000	5th
Pricing issues	2.2239	8th
Taste and preference for conventional white cassava	2.3200	6th
Smell and color is awful	1.9450	10th

Source: Computation from field survey, 2019.

**TABLE 3 |** Constraints against production and marketing of biofortified cassava by producers.

Variables (Constraints)	Mean	Rank
Inaccessibility of biofortified inputs	2.7067	6th
Poor product awareness	2.7568	5th
High cost of input materials	2.5467	7th
Poor product knowledge	2.2222	12th
Inaccessibility of information from seller	2.5135	8th
Negative sentiment about biotechnology	2.1757	13th
Food safety issues	2.3333	10th
Poor demand from consumers	2.4595	9th
Lack of incentive from government	2.8000	4th
Small farm holdings	2.8400	3rd
Lack of extension services	2.3014	11th
Administrative bureaucracy	2.8630	2nd
Finance	3.0270	1st

Source: Computation from field survey, 2019.

recorded by inaccessibility is in line with *a priori* expectation. This result therefore collaborates with the findings of Saltzman et al. (2017), who observed a near unavailability of the product in most local markets. Evidence shows that only about 10% of what is produced by farmers are brought to the market. This implies that most of these farmers lack commercial orientation to supply the market or there is lack of demand of this product by consumers.

The poor awareness of the product lends credence to the fact that you may design a good product, price is attractively, and distribute the product through the right channel, but without effective communication, consumers will not know about the product (Kotler and Armstrong, 2008). This implies that the current communication machinery is ineffective to provide consumer awareness and increase knowledge about biofortified cassava products. Other factors that could be responsible for poor market awareness include a lack of proper brand differentiation between ordinary yellow cassava and biofortified cassava, which is also yellow. The high  $\bar{X}$  value for nutritional information

justifies the importance of product information in making brand decision or food choice.

The high cost of the product could be because of two factors in which one has already been established—unavailability of the product and/or increase demand of biofortified. From the perspective of economics, an increase in demand for a product can lead to an increase in price and vice versa (Jhingan, 2004). Another point could be poor infrastructural facilities, leading to market failure (Rocha, 2007) among other factors. This could be addressed through efficiency of resource use and marketing activities.

There is evidence that many consumers in recent times are conscious about the impact of food consumption on their health and well-being, and many are not open to conversation about agriculture and biotechnology (see Werner and Markus, 2003; Caswell and Joseph, 2007). Food safety issues are still a subject with several plugs, leading to wide restrictions on the consumption of certain products, especially as conflicts between NGOs and scientists over the benefits of these products continue to generate media trials and controversies. While this concern is the fifth most important factor, it reflects the many unvoiced constraints for consumption of food with biotechnological semblance.

The least constraining factor is that smell and/or color of the food product is awful. From this result, it could be inferred that consumers do not consider the color and smell as any different from their traditional cassava product. The small differentiation in terms of smell provides an unquantifiable advantage, which could lead to product rejection. It could also mean that the new brand meshes well into existing consumer preferences and by extension, their culture and lifestyle.

In addition to the above, the result of factors that negatively influence production and marketing are presented in **Table 3**. The results illustrate that finance is a major component of consumer acceptance. The link between finance and Small-Scale Enterprise (SME) agribusiness enterprises survival and growth was established in a study by Oteh et al. (2016). Finance is an important factor of production growth and hinders the ability of producers to discharge their financial obligations. This is in line with *a priori* expectation. In advancing the way forward, Nwakor et al. (2010), advocated for access to loan and lines of credit for producers. Administrative bottlenecks is another major challenge. This reflects the depth of government ineptitude, participation and mobilization mechanisms that promote and encourages local production (Onuegbu et al., 2017). Removing administrative bureaucracy means dismantling hindrances that affect policy coherence to adoption of agricultural biotechnology.

Small farm holdings are a disincentive to commercialization. Oteh and Nwachukwu (2014) observed in their study of commercialization of cassava production that farm size is one of the key blocks militating against commercial agriculture. The influence of land holding on productivity has been established. Land size indicates the potential to produce surplus for the market (Martey et al., 2012). Nwajiuba A. C. (2013) observed that more than 80% of all farm holdings in Nigeria are small farm holding limiting capacity of producers to commercialize



their production with a spill-over effect on product availability and marketing.

There is need for a high level of support from the government and its agencies to encourage production and consumption of biofortified foods. The need for institutional support such as incentives, strategy, policy, training, and information provision, which are vital in pushing demand and supply for biofortified food products cannot be over-emphasized. Ilona (2014b) highlighted the fact that lack of support and poor capacities of producers and even breeders limit their ability to deliver Vitamin A cassava. According to Dong and Lin (2008), proper economic incentives such as price subsidy or price reduction could encourage producers or consumers to produce or consume healthier foods.

In terms of poor product awareness, several studies such as Bouis and Saltzman (2017) and Okello et al. (2017) observed that household food security and awareness levels of the benefits of biofortification can impact the decision to adopt the product for both consumers and producers. This result reflects the gap in an information dissemination mechanism, which is a major challenge to product innovation in most parts of Africa. This also highlights that extension service agents and marketing personnel are not adequately mobilized to bridge information that presents this challenge that hinders consumer/suppliers willingness to consume and adopt innovative practices. A study by Onuk et al. (2010) found that the high level of awareness of different *striga* tolerant maize varieties reflects communication innovation to producers in the study area. Therefore, adoption of a new technology relies more on awareness (Apata et al., 2008; Kotler and Armstrong, 2008).

Other constraints to production and marketing identified in the study includes food safety issues, negative sentiment about agri-biotechnology, inaccessibility of input material, poor demand from consumers, poor product knowledge, and others. Most of these challenges are directly linked with poor knowledge and awareness of the product. Information and awareness are an important vehicle to drive demand and supply for this product. The last constraint, negative sentiment about biotechnology, reflects the conflict of interest, lack of government policy to manage the conflict associated with biosafety, and health arising from debate between policy makers and civil society organizations leading to controversies in demand. This is a challenge for marketing which requires behavior change communication and solid marketing tools to deepen demand and supply.

The fact that this constraint is the last implies that substantial campaign and scientific evidence has continued to change this negative narrative given regulatory approvals by government agencies allowing the introduction, utilization, marketing, and consumption of these products by households.

## DISCUSSION

Malnutrition is a global crisis which affects every dimension of humanity. These challenges are further exacerbated by a global broken food system, but there are opportunities for businesses to

deliver nutritious smart solutions to people who cannot afford a more diverse diet. Our study can be perceived as a dialogue that addresses the marketing-consumption cycle of biofortified cassava products. The narrative of this study is centered on scaling up a nutritious food system by looking at demand dynamics. The study provided information, dialogue, market, and decisions that creates a push or pull strategy. Our study provides evidence of the high market potential and adoption of biofortified cassava but makes a case for improved positioning of its nutritional value to strengthen consumer acceptance, penetration, and consumption. This will help to change attitudes and create a positive shift in the food system.

This study provides insights and guidance on potential high priority areas of action for private investment. An important factor is instruction in changing local mindsets about biofortified food products. This requires policy intervention and incentives across the food supply chain, as well as programs aimed at increasing demand to guarantee returns on investment.

Our study provides actionable indicators for policy makers to focus on to improve the food system. Importantly, it answers the question of important elements in most informal market operations. Availability is perhaps a single most important attributes responsibility for cheap, highly processed, and nutrient poor foods which is common in many developing economies. From this evidence, we can replace these cheap products with a more improved nutrition smart cheap alternative that is consistent with local preference.

Our study also provides insight into potential market demand for biofortified cassava. This will increase investment and open new economic opportunities and improve local economies. The spiral effect of this includes employment opportunities, improved health, and nutrition security.

Finally, the study recognizes that in recent times, the conversation around global agricultural transformation has changed focus, expanding around health, and nutrition. Marketing is a key link in managing expectations in the food ecosystem by providing a necessary link between the farm, market and consumers. The key role of marketing is to generate adequate demand through communication that helps build food literacy. This is vital in creating market opportunities for many producers.

Our future depends on our food and understanding of how consumer dynamics can change and bring tremendous economic opportunities to the food ecosystem.

## DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/supplementary materials, further inquiries can be directed to the corresponding author/s.

## AUTHOR CONTRIBUTIONS

All authors listed have made a substantial, direct and intellectual contribution to the work, and approved it for publication.

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**Conflict of Interest:** The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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