Critical Review of the Economic Feasibility and Cost Analysis of Rice Fortification in Nigeria

Report

WFP World Food Programme

gain Global Alliance for Improved Nutrition

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Acknowledgements

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Abbreviations and Acronyms

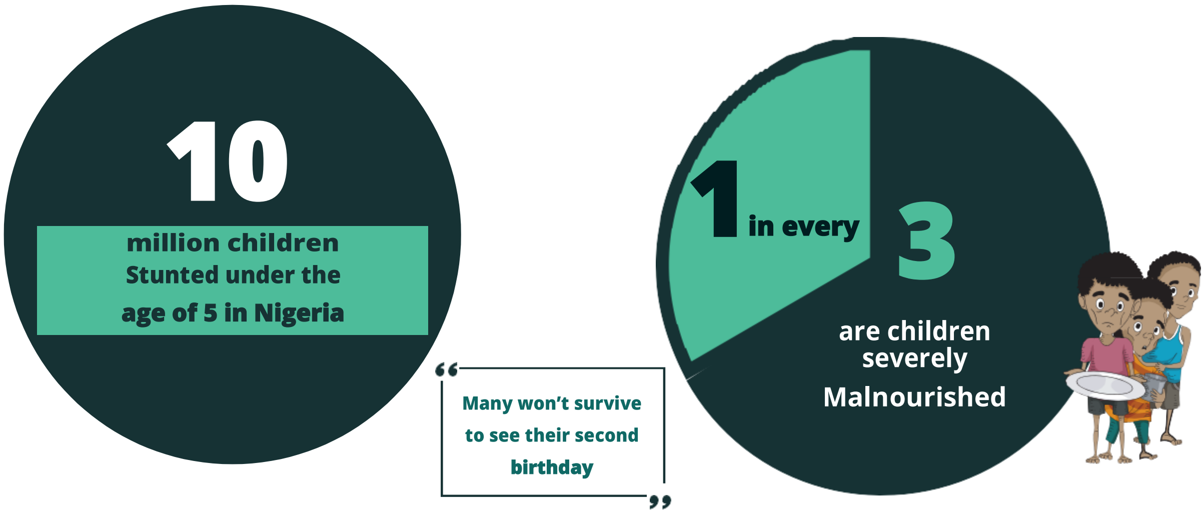
ABP	Anchor Borrowers Program
ATA	Agricultural Transformation Agenda
CAGR	Compound Annual Growth Rate
CBN	Central Bank of Nigeria
FAOSTAT	Food and Agricultural Organization Corporate Statistical Database
FMARD	Federal Ministry of Agriculture and Rural Development
FRK	Fortified Rice Kernel
FFI	Food Fortification Initiatives
GAIN	Global Alliance for Improved Nutrition
GES	Growth Enhancement Scheme
GDP	Gross Domestic Product
IDPs	Internally Displaced Persons
IFPRI	International Food Policy Research Institute KII: Key Informant Interview
MN	Micronutrients
NRV	Nutrient Reference Values
NAFDAC	National Agency for Food and Drug Administration and Control
NAERLS	National Agricultural Extension and Research Liaison Services
NISER	Nigerian Institute of Social and Economic Research
NBS	Nigeria Bureau of Statistics
RIFAN	Rice Processors Association of Nigeria
SON	Standard Organization of Nigeria
SDG	Sustainable Development Goal
UNICEF	United Nations Children's Emergency Fund
USDA	United States Department of Agriculture
VAD	Vitamin A Deficiency
WARDA	West African Rice Development Association (AfricaRice)
WHO	World Health Organization
WFP	World Food Program

Preface

Nigeria has the highest burden of malnutrition in Africa and is second in the world, with an estimated 17 million undernourished children (UNICEF, 2021). The prevalence of poor diets lacking essential micronutrients proliferates because of the rapid national population expansion amidst growing poverty.

As a result, the Nigerian government launched its "zero hunger initiative," aiming to reduce malnutrition by 50 percent by 2030 (USAID, 2019). Meanwhile, the scorecard on proper nutrition shows a downward trend, reflecting pronounced deficiency in essential micronutrients arising from worsening poverty. Some of the evidence that show micronutrient deficiencies was established.

Nigeria has one of the highest rates of under-5 and maternal mortality globally, with vitamin A deficiency (VAD) being a major contributory factor causing about 34% of maternal deaths occurring in Nigeria. It was estimated that Nigeria's maternal mortality rate stands at 917 deaths/100,000 live births (World Bank, 2019). 10 million infants under the age of 5 years in Nigeria are stunted (National Nutrition and Health Survey, 2018) translating to almost 1 in every 3 children suffering from malnutrition with the death of kids estimated at more than two million each year.



Source: Federal Ministry of Health, 2013

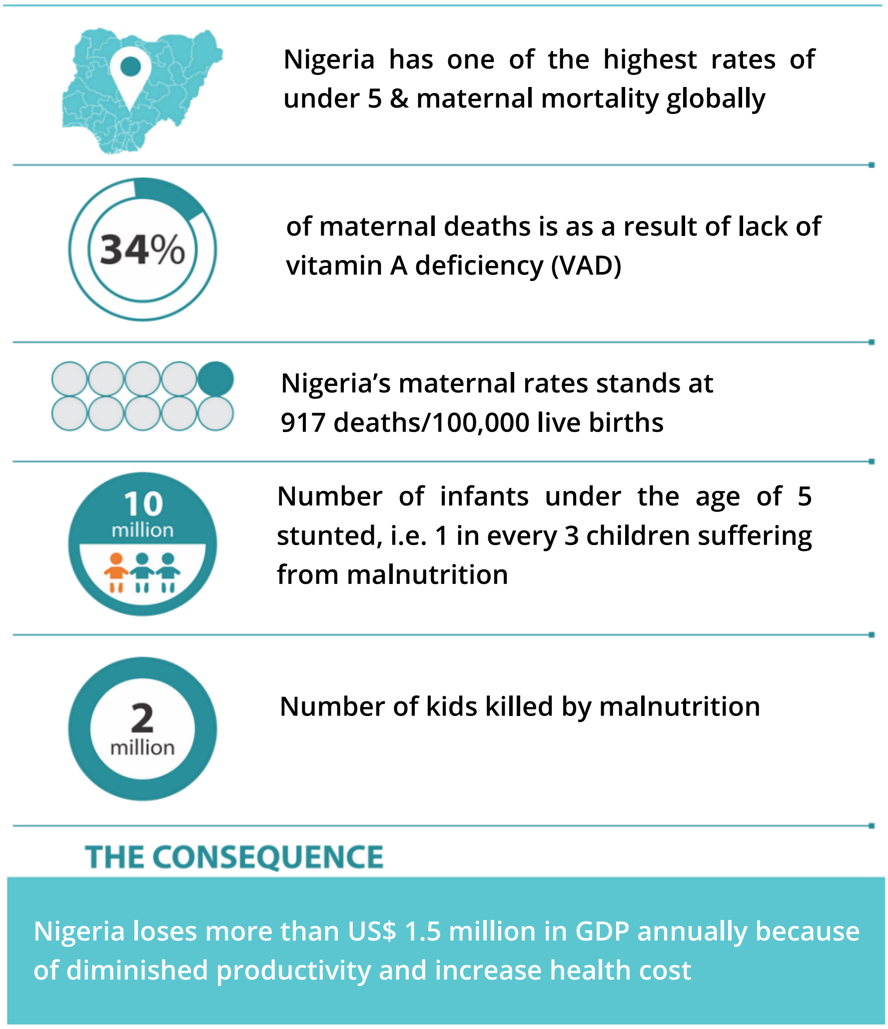
The adverse effect of malnutrition in Nigeria is far-reaching, complicated, and worsening because of rising food prices, climate change causing low agricultural yields, COVID 19 pandemic, civil unrest and deteriorating infrastructures. Malnutrition impacts under-5 children and pregnant women, and disrupts family stability. Among these population segments, mortality rates are increasing significantly, and the prevalence of stunting of cognitive development has become more rampant.

The consequence is that Nigeria loses more than US$1.5 billion in GDP annually because of diminished productivity and increased healthcare costs. As a result, Nigeria is off-track to achieving the SDG2 goal of zero hunger by 2030.

Meanwhile, Nigeria may be the world's third-largest country by 2050. Therefore, the hazard of the massive growth of poorly developed populations may become more problematic. Furthermore, the growing incidence of poor nutrition is related to the worsening poverty that has risen to 47% of the country's population, threatening the prospects for the country's economic development. The global panel on Agriculture and Food

Systems for Nutrition (2016) estimated the impact of poor nutrition as high as US$500 per capita. Such huge costs result from economic growth foregone and loss of investment in human capital associated with preventable child and adult mortality, of which 45% are due to poor nutrition and diet-related non-communicable diseases.

One of the tested options for addressing the malnutrition challenges is fortifying staple foods with vitamins and minerals. Lessons from China, India, and many other developing countries demonstrate that such an option can be cost-effective and a veritable tool to combat malnutrition and save lives. In Nigeria, the fortification of many traditional food products has attained encouraging successes and consumer acceptance.



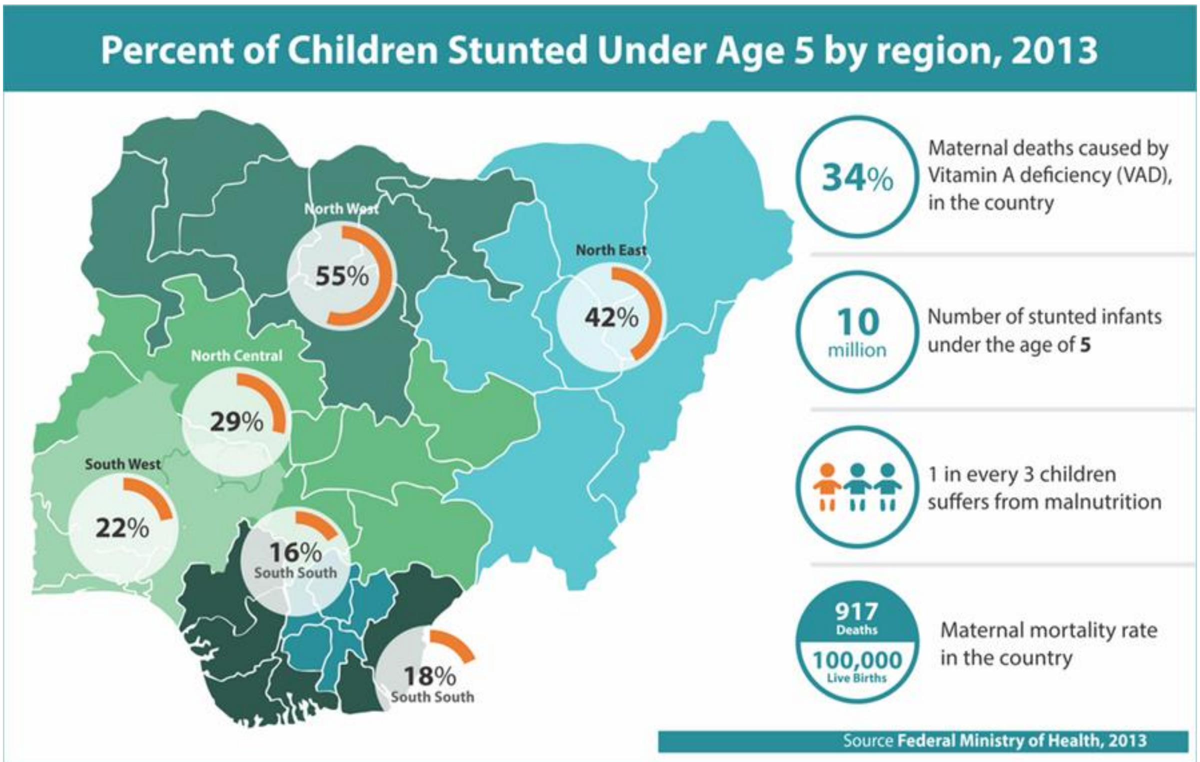
Rice consumption has grown more remarkably than many food products. More than 50% of the Nigerian population eats rice daily, offering huge potential for massive health improvement impact. Unfortunately, enrichment of rice and rice products has lagged the many other food products such as wheat and maize. Until recently, rice was not on the list of food vehicles considered for fortification in Nigeria. Thus, rice fortification presents vast possibilities for dramatically improving health through reduced malnutrition for a significant proportion of Nigeria's over 210 million people.

In this study, we explore the technical feasibility and cost-effectiveness of fortifying rice and examine the potential issues that could aid the economic viability of fortified rice in the country.

Executive Summary

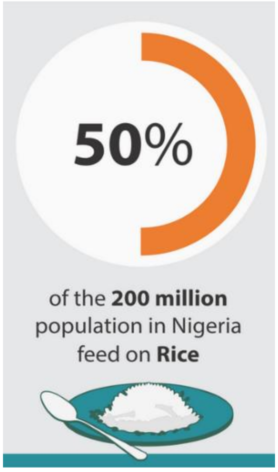
Background – Rationale for Rice Fortification in Nigeria

Malnutrition (hidden hunger) which means deficiencies of vitamins and minerals poses severe health and economic threat to Nigeria. It remains one of the leading causes of high mortality among children under five and pregnant and nursing mothers in Nigeria. For example, vitamin A deficiency (VAD) contributes to causing about 34% of maternal deaths in the country. Ten million infants under the age of 5 years are stunted; translating to almost 1 in every 3 children suffering from malnutrition, the prevalence of micronutrient-induced stunting in Nigeria is higher than the average 30.7% for Africa. The maternal mortality rate in the country stands at 917 deaths per 100,000 live births. Studies showed that about 55.1% of Nigerian women of reproductive age are anemic. According to a report by UNICEF, the costs of under-nutrition in Africa and Asia are equivalent to losing 8-11 percent of GDP every year[1]. It is estimated that Nigeria loses $1.5 billion annually due to malnutrition (GAIN, 2016).



The Federal Government of Nigeria and several development partners are concerned about these preventable malnutrition problems and attendant consequences, therefore committing enormous resources to improve the nutrition of the country's citizenry. The strategic option for the country includes diversification of food products and prioritization of nutrient enrichment food products that have substantial health impacts.

[1] UNICEF - UNICEFhttps://www.unicef.org › ZAF-Nutrition-brief-2020



Rice is one of the food products massively consumed in Nigeria. It is an essential staple for over 50% of the 210 million population of the country. Therefore, rice offers an excellent window for massive health impact through its nutritional enhancement.

Moreover, rice fortification has a long historical development in many developing countries, although such enrichment benefits are yet to extend to Nigerians, where there is an established urgency to redress the pervasive micronutrient deficiencies.

On the other hand, fortification technologies for the fortification of rice have been perfected and are in use in several developing countries. In Nigeria, there are elevated discussions proposing a shift from the production of unfortified rice to fortified rice.

Objectives

In this study, we explore the technical feasibility and cost-effectiveness of fortifying rice and examine the potential factors that could aid the economic viability of fortified rice in the country.

Methodology

The assessment of the cost of rice fortification in Nigeria was held between March and April 2022. The study relied on discussions with many informants and responses from the questionnaire developed in Google form and administered to some key players in the rice sector. These include the rice millers, research institutes, regulatory agents, rice dealers, and consumers. The team also extensively reviewed scientific publications and research papers focusing on rice. As a result, the team has good reviews on the rice production and milling industry, rice consumption levels and availability, rice fortification technology, and the barriers to rice fortification. Likewise, we collected secondary data from different sources.

Key Findings and Assumptions/benchmarks

The study revealed that rice fortification is not yet a common practice in Nigeria. Although some local capacity exists to speed up the adoption of rice fortification, a few hurdles would need to be addressed to enable a phased transition into rice fortification in Nigeria.

Three critical barriers that need to be resolved include:

- Low/lack of access to fortified rice kernels (FRK) and its cost implication,
- Lack of technologies (appropriate machines/tools) to facilitate FRK production, and
- Lack of adequate personnel to drive the process.

Hence, the availability of FRK and access to the equipment (blending machine) are the most significant cost factor in the rice fortification flow line. There are two strategic options for securing FRK namely; importation from other countries and local production.

Overall, rice fortification standard in India provides for the inclusion of nine micronutrients in FRKs. The Indian government incentivizes three mandatory micronutrients (B12, Folic acid and Iron), while the inclusion of other six MNs (zinc, Vits. A, B1, B2, B3 and B6) is encouraged. The range of micronutrients covered in the NAFDAC food fortification Regulation of Nigeria is similar to that of India. However, the study adopted seven micronutrients from the India standard which are Folic acid, Vitamin B12, Iron, Vitamin B3, Zinc, Vitamin B1, and Vitamin B6, and excluded Vitamin A (because it is already added to all the other food vehicles that are currently fortified) and Vitamin B2 (because of impact on the colour of FRK and Nigeria's public health requirements). Hence 7MNs fortificants (instead of 9 MNs as used in India) were adopted in this cost analysis both for locally produced FRK and imported FRK.

In this study, we explored two scenarios to elicit and compare possible estimated cost of rice fortification in Nigeria:

- ➔ **Scenario A:** Cost of rice fortification using locally produced FRK, based on fortification standard of India: (7 MN fortificants at blending level of 1:100);
- ➔ **Scenario B:** Assuming Nigeria was to import the same composition of FRKs (7 MN fortificants) as in scenario A from India at blending level of 1:100.

Estimated Cost of Rice Fortification using locally produced FRK in Nigeria

We discovered that the total estimated cost of producing FRK in Nigeria using the adopted 7 MN fortificants at a blending ratio of 1:100 is between **USD$1.31-1.73/kg**, of which the **cost of raw materials accounted for 96-97% of the total cost** while utilities and maintenance, energy and personnel costs are negligible - each being less than 1% of the Total Cost (TC).

The estimated cost of rice fortification under this scenario ranges between **US$22.64/MT** and **US$26.84/MT** (lower and upper concentration limit respectively) at the dilution rate of 1:100.

It is important to note that economies of scale would be expected to reduce the overall production cost over time thereby making local production of FRK continuously more cost effective.

Estimated Cost of Rice Fortification in Nigeria using FRK imported from India (Based on the same composition of FRKs as in scenario A above)

At the moment of the research (in Q1 2022) The ex-factory cost of FRK with the composition of the adopted 7MN in India was estimated between **US$1.0 – 1.5 per kg**. But when the cost of duties, VAT, freight is factored in, it translates to about **US$1.20- 1.70 per kg** of fortified rice kernels respectively.

The study revealed that the estimated cost of fortification (using imported FRK) at blending ratio of 1:100 ranges between **USD21.51** and **USD26.51** per ton (lower and upper concentration limit respectively).

The cost of imported FRK is subject to market fluctuations of prices and availability of vitamins and minerals as well as international freight which vary on a weekly basis. It is therefore important to stress that prices discussed herewith reflect the context of market prices in Q1 2022.

Theoretical Cost Comparison of the Cost of Rice Fortification using locally produced FRK and Imported FRK – Nigeria Context

Based on the above scenarios we discovered that:

- The increase in the retail rice price after fortification is estimated between **2.14%** and **2.53% using locally produced FRK** to fortify rice.
- While it is estimated between **2.01%** and **2.5% using imported FRK** to fortify rice.
- The retail price increment in both scenarios is less than the global range of **3-6%: if the cost of promotion of fortified rice is considered, the probable cost of fortified rice would likely be between 2% to 3% over that of unfortified rice in Nigeria if India standard of micronutrients were adopted.**
- The study also revealed that the fortification cost per person is less than **USD 2 (1.34)/year** at per capita rice consumption of 50kg/person/year.
- Within Nigeria context, the cost of the imports (as shown above) is marginally lower than our calculated cost estimates if Nigeria were to produce the FRKs. Different factors (cost of extruder, labour, energy etc. difference in the countries) may have influenced these results. However, the marginal differentials in the comparative cost between calculated production cost and import cost of FRK may be indicating that investing in local production may be cost- effective in the long run, once demand for fortified rice has been generated through both public and private distribution channels. Also, Nigerian estimated cost of FRK will certainly go down as volume of production increases, and efficiencies are gained over time; .
- Therefore, encouraging local investments on the fabrication of the extruder and using cheaper energy sources can further reduce the cost of producing the FRK locally and followed with its blending into milled rice (this is supported by lessons from Bangladesh).
- Once rice fortification gains widespread acceptance, scaling production would likely orchestrate a reduction of the unit cost of FRK such that local production could become more competitive.
- It is worthy of note that an increase in the concentration and number of the MNs, will lead to a proportionate increase in the cost of FRK, but will achieve a greater health benefit. Therefore, FRK compositions should be determined through a national consensus of technical partners and stakeholders, depending on the desired health/nutrition improvement target in Nigeria.
- Finally, factors[2] within the Nigeria context that could stimulate the sustainability of rice fortification include the capacity of the rice milling industry to accommodate the additional cost of fortifying rice, the efficiency of channels for acquisition and distribution of FRK, rice consumption patterns, consumer preferences, market size, and the regulatory and policy environment.

[2] World Food Programme: Rice Fortification – World Food Programme. Available at https://studyres.com/doc/17263100/rice-fortification---world-food-programme

Recommendations

The study makes the following recommendations:

1. The established rice-based food preparation practice exposes rice to rigorous washing, and rinsing before and during cooking, which makes FRK production using the Hot Extrusion method appropriate for Nigeria.
2. There is high diversity in the micronutrient mix and concentrations in countries where rice fortification is implemented at large scale such as India, China or Costa Rica from which Nigeria could learn from in formulating its rice fortification standard. However, the country needs to activate its nutrition alliance consultative technical committee to develop appropriate guide and outreach programmes to fast-track the nation's transition to rice fortification in conjunction with the ongoing fortification efforts of other key staple foods.
3. The estimated cost of FRK production in Nigeria and its importation shows that it is economical for the rice sector to explore both avenues of securing adequate quantities of FRK to support the rice fortification programme of the country. At the early stages of the transition, reliance on FRK imports may be critical until local capacities for FRK production are developed.
4. Based on the cost analysis, it is technically and economically feasible to proceed with rice fortification in Nigeria. The estimated average additional cost of fortifying rice in Nigeria will likely be between 2-3% over unfortified rice.
5. Drawing lessons from other countries such as India, Costa Rica and China, the following micronutrients could be considered to be included in fortified rice in Nigeria: vitamin B1, niacin, vitamin B12, folic acid, zinc (zinc oxide), and iron (as micronized ferric pyrophosphate). However, it is recommended that the micronutrients to be included for rice fortification in Nigeria should be determined through a national consensus of technical partners and stakeholders, depending on the desired health/nutrition improvement target in Nigeria.
6. The country would need also, to update the Food Fortification Regulations. The NAFDAC Act 2021 on food fortification regulations is silent on rice fortification.
7. In-order to engender cost-efficiency and sustainability, Nigeria would need to develop local capacity for the fabrication and maintenance of the extruder. In this regard, the manufacturing experience of Federal Industrial Research Organization (FIRO) and the National Center for Agricultural Mechanization (NCAM) at Ilorin may be useful.
8. Direct and indirect interventions of the Government at all levels is highly recommended for the success of this project and these may include:
    - Public advocacy for rice fortification in Nigeria,
    - Promulgation of national policy to back mandatory fortification of rice in Nigeria,
    - Provision of credit facility (structured financing) for existing rice milling industry or new Company that want to embark on sole production of FRK in Nigeria,
    - Waiver of Government policy that may not favour or support importation of FRK (a short-term measure, until local capacities are developed).

CHAPTER ONE

1.1. Background

Many people are vulnerable to micronutrient deficiency which makes them predisposed to many diseases, causing higher morbidity and mortality rates. Malnutrition (hidden hunger) affects over 2 billion people of all age groups, but the young children, women of childbearing age, and pregnant and lactating women are more at risk. Micronutrient deficiency in the world remains a major threat to the world population especially in the developing and under-developed countries resulting in severe health and economic condition[3]. The estimate is that among the 15 major causes of the global burden of disease, about 7.3 percent of which arises from micronutrient deficiencies linked to iron, vitamin 12, folic acid, and vitamin A[4],[5].

Recently, Nigeria was rated first in Africa and second in the global malnutrition burden with an estimated 17 million undernourished children (UNICEF 2021 Report). Malnutrition is the major cause of high mortality among children under five, pregnant and nursing mothers in Nigeria. It is not surprising that Nigeria accounts for the second highest number of stunted children in the world[6]with 32% of children (10 million) under the age of 5 in Nigeria are stunted, which translates to almost 1 in every 3 Nigerian children suffering from malnutrition. Economically, Nigeria loses about $1.5 billion yearly due to diminished productivity consequent upon malnutrition.

1.2. How can Nigeria Effectively and Sustainably Address this Challenge Cost Effectively?

The Government of Nigeria and its partners are aiming to reduce the prevalence of micronutrient deficiencies in the country through fortification of a range of food vehicles such as salt, wheat and maize flour and vegetable oil which are routinely consumed by a large population of the country.

In Nigeria, discussions are increasingly pointing to the consideration of rice as a medium for fortification with micronutrients, which warrants determination of the feasibility and cost elements of such an undertaking.

[3] https://www.bbc.com/future/bespoke/follow-the-food/the-hidden-hunger-affecting-billions/

[4] L. Allen, B. De Benoist, O. Dary et R. Hurrell, «Guidelines on food fortification with micronutrients, World Health Organization and Food and Agriculture Organization of the United Nations, 2006

[5] Food and Agriculture Organization of the United Nations, "The State of Food Security and Nutrition in the World 2018 - Building Resilience to Climate Change for Food Security and Nutrition," FAO, Rome, 2018

[6] https://www.unicef.org/nigeria/nutrition

The World Health Organization (WHO) consensus statement has underpinned the public health importance of specific micronutrient deficiencies and evidence of the benefits of increased micronutrient intake. Because the rationale for the fortification of maize and wheat flour also applies to rice, the recommendation is to fortify rice with iron, folic acid, vitamin B12, vitamin A, and zinc as well as thiamin, vitamin B6 and niacin, as polished rice has low levels of these micronutrients[7].

But food habits in the country are shifting because of the changing lifestyle and income growth of increasing the population. Rice is now a popular part of the diet of a huge number of people across the regions and income strata of Nigeria. Due to the high demand in rice consumption, a strategic focus on rice as vital food vehicle for the deployment of micronutrients to ameliorate the pervasive deficiencies seem justified. Rice fortification has enormous potential to substantially increase micronutrient intake in countries where rice is a staple food.

While fortification can increase micronutrient intake among populations that consume rice as a staple food, fortification levels need to be such that they substantially contribute to micronutrient intake, are safe at higher levels of consumption in the population, and the fortified rice must be palatable, have a long shelf-life, and be indistinguishable from unfortified rice[8].

The actual combinations and levels of these micronutrients in fortified rice in sovereign nations are contingent upon the provisions of national consultative forum and alliance on food nutrition and health programs, drawing from the World Health Organization (WHO) and Food and Agriculture Organization (FAO) guidelines on food fortification with micronutrients[9].

Because the fortification of rice is not yet a practice in Nigeria, formulation of the relevant standards to drive the process has only recently been initiated by WFP/GAIN in collaboration with key stakeholders in the country.

This study adapts the rice fortification frameworks/standards of India, and China in our analysis. The preference for the use of the rice fortification standards from these countries stems from the similarities in the prevalence of micronutrient deficiencies, the huge population at risk of MN deficiencies, a high preponderance of obtaining relevant information on the subject from the countries, and the history of massive trade on rice which Nigeria has with the two countries.

Studies in China, India and Bangladesh and many other countries across the world have shown that fortifying rice with requisite micronutrient is a cost-effective way of tackling malnutrition. The return on each dollar properly spent in nutrition programs generates an average of $16 in terms of well-being and economic gain[10].

It is upon this background that GAIN in partnership with WFP is conducting a country level assessment on rice fortification in Nigeria as part of the advocacy towards the inclusion of Rice as a fortified food vehicle in Nigeria.

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[7] Saskia de Pee (2014) Proposing nutrients and nutrient levels for rice fortification. Annals of the New York Academy of Sciences. https://doi.org/10.1111/nyas.12478

[8] ibid

[9] Allen, L.H., B. de Benoist, O. Dary & R. Hurrell, Eds. 2006. Guidelines on Food Fortification with Micronutrients. Geneva: World Health Organization/Food and Agriculture Organization

[10] Development Initiatives, «Global Nutrition Report 2017: Nourishing the SDGs, » Development Initiatives, Bristol, UK, 2017

CHAPTER TWO

2.1. Methodology

The assessment of the cost of rice fortification in Nigeria was held between March and April 2022. The study relied on discussions with a reasonable number of informants and responses from the questionnaire developed in Google Form administered to some key players in the rice sector.

These include the rice millers, research institutes, regulatory agents, rice dealers, and consumers. The team also extensively reviewed scientific publications and research papers focusing on rice. As such, the team assessed rice production and milling industry; rice consumption levels and availability, the rice fortification technology; barriers to rice fortification, among others.

Likewise, secondary data were collected from different sources, including the Klynveld Peat Marwick Goerdeler (KPMG); United State Department of Agriculture (USDA); the International Food Policy Research Institute (IFPRI), the Central Bank of Nigeria (CBN); USDA/FSI/GAIN; West African Rice Development Association (WARDA, AfricaRice), and Statista.

Purposive random sampling techniques were used to select the respondents. Thus, ten (10) rice retailers; Fifteen (15) rice wholesalers; Fifty (50) rice consumers; three (3) regulatory agencies, three (3) research institutions, and fifteen (15) rice millers (5 -large scales, 5 - medium scale and 5 small scale millers) were purposively selected across different geographical zone within the country to ensure a fair representation and coverage.

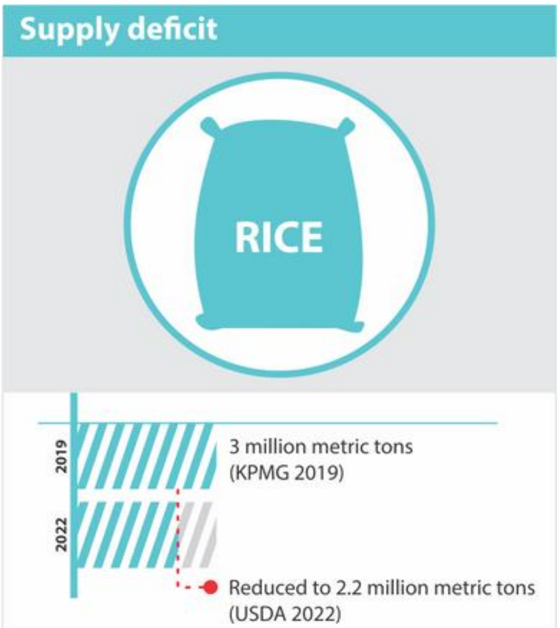
In addition, the critical informant interview involved the State Coordinators of National Home-Grown School Feeding Programme, a Nutritionist who works in the Ministry of Health, some officials of the regulatory bodies: Standard Organization of Nigeria (SON) and National Agency for Food and Drug Administration and Control (NAFDAC).

The study also examined the feasibility of different scenarios drawing from the situation analysis conducted.

The data collected from the field were analyzed using descriptive statistics with Microsoft Excel and Stata 14.0. Cost analysis and projections for rice fortification leveraged on preferences recorded in the survey.

CHAPTER THREE

3.1. Nigeria Rice Landscape Overview



Rice is one of the primary staple foods in Nigeria, consumed across all geo-political zones and socioeconomic classes in Nigeria, with consumption per capita of 50kg (USDA/GAIN, 2022). However, only about 57% of the 6.7 million metric tons of rice consumed in Nigeria annually is locally produced, leading to a supply deficit of about 3 million metric tons (KPMG, 2019), which further reduced to a 2.2 million tons deficit in 2021 (USDA,2022). Consumption has increased 4.7% in the past decade, almost four times the global consumption growth rate. In 2017, the country consumed about 6.4 million tons accounting for about 20% of Africa's consumption (PWC, 2017). An average Nigerian spends 6% of its total income on rice consumption as at 2011.

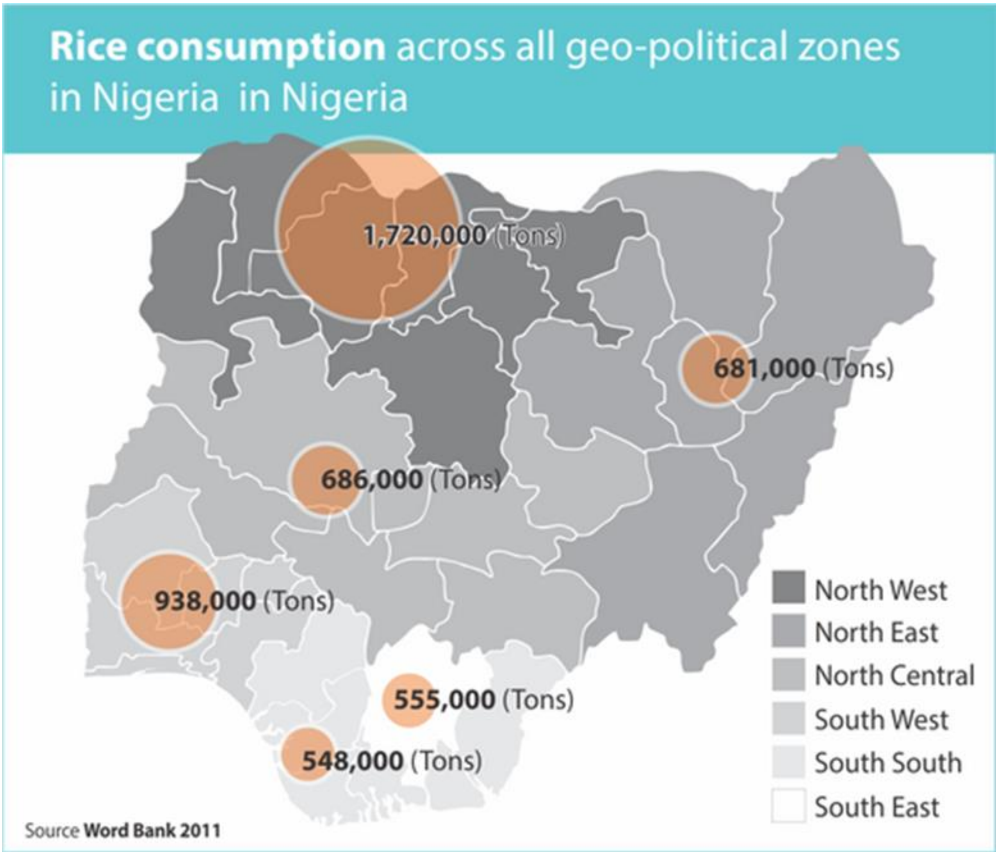
Nigeria is the largest rice (paddy) producer in Africa, with an average production volume of 8 million metric tons[11]. In 2019, Nigeria ranked as the 14th largest producer of rice globally (with China being the top producing country) and the 6th highest consumer of rice in the world (KPMG, 2019). Revenue generated from the rice segment amounts to US$3.813m in 2021. Meanwhile, the rice market grows annually by 13.78% (CAGR2022-2026) (Statista, 2022).

At the same time, Nigeria's projected untapped rice market is about $4.5 billion by 2025 (GEMS4 2017 rice report).

Rice consumption is across all geo-political zones in Nigeria because of changing lifestyles and food habits. The geographical rice consumption data are 686,000 tons for the North-Central, 681,000 tons for the Northeast, and 1,720,000 tons for the Northwest. While Southeast, South-South, and Southwest consume

[11] National Agricultural Extension and Research Liaison Services (NAERLS), Agricultural Performance Survey of 2012 Wet Season in Nigeria, 2020

555,000, 548,000, and 958,000 tons of rice respectively (World Bank, 2011). Based on these levels of rice consumption data, initial deployment of fortified rice is likely to produce a higher health impact in the Northwest.



Meanwhile, the most affected zone by malnutrition in Nigeria is the northern part of the country and more among women and children (UNICEF, 2022). Although WHO (2022) reported a 68.3% value for anaemia in children, women of reproductive age and pregnant women have a value of about 48.4 and 57.8, respectively. Clinical Vitamin A deficiency in women and subclinical vitamin A deficiency in preschool are about 7.7 and 29.5, respectively.

So, fortification of rice would be beneficial across these population segments that are most vulnerable to nutrient deficiency/malnutrition, which include:

- Mothers and women of childbearing age between 15-49 years Children under five
- School-age children/adolescent girls leveraging the school feeding program to promote healthy diets
- Internally displaced persons (IDPs)

CHAPTER FOUR

Findings

This section summarizes the report's findings, focusing on rice production and milling infrastructure, rice consumption and fortification practices, technologies used for rice and cost associated with rice fortification in Nigeria.

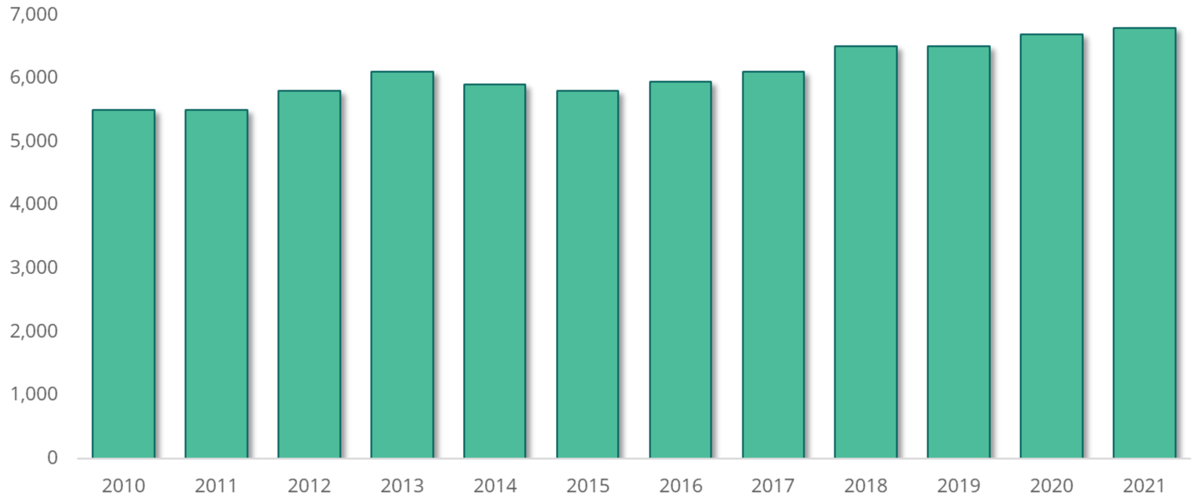
4.1. Rice Availability and Consumption in Nigeria

Generally, rice consumption is increasing rapidly in Nigeria due to the increasing population that is growing at about 3%. Nigerian population stands at above 210 million people (NBS, 2021). According to Federal Ministry of Agricultural Rural Development (FMARD) 2011 report, rice consumption in Nigeria is rising at 5.1 percent per annum, and projected to more than triple to over 30 million metric tons (MT) by 2050, with the urban areas of the country consuming more rice than the rural settlements. However, about 1.5% drop in rice consumption in Nigeria occurred in 2021 because of COVID 19 related distribution impairments. The devaluation of the country's currency, the Naira, and inflation that prevail in the country are leading to general increase in food prices. Despite the high price, per capita rice consumption increased and currently stands at 50 kg per year (USDA/GAIN, April 2022 report). Rice is becoming one of the primary staple foods among the Nigerian rapidly growing population.

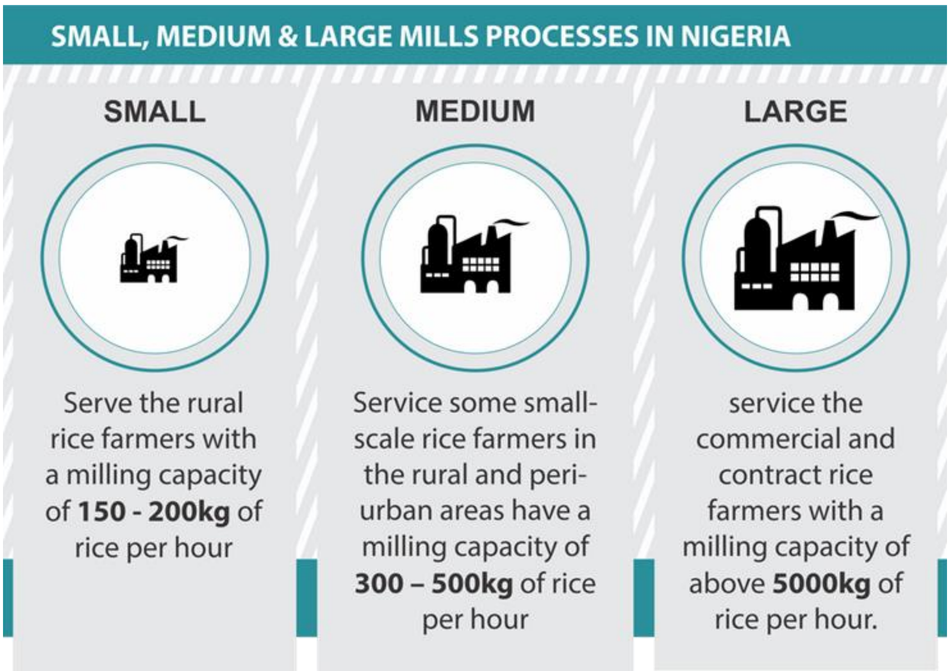
Presently, the country requires over 10 million metric tons of rice yearly. Also, out of about 7.357 million metric tons of rice consumed in 2021, only about 5 million tons were locally produced, (USDA, 2022). This implies that about 32.04% of the entire country's production deficit was sourced through importation to satisfy consumption demand. Before 2014, about 70% of the domestic rice consumption was produced by small size mills (IFPRI, 2016). With the introduction of Anchor Borrower Programme (ABP) and Growth Enhancement Scheme (GES), local domestic production and milling are increasing. There are three categories of rice milling outfits: large scale (integrated) rice mills, medium Rice Mills, and micro-small rice mills. While the large and medium rice mills are located within or in peri-urban areas, the small rice mills are located along various transit routes or in rural communities usually in semi-permanent structures. The bulk of the domestic rice consumption, however, comes from the integrated larger millers which are collectively producing about 3 million metric tons of milled rice annually (Table 1).

These figures show that the fortified rice, if adequately promoted by involving large, medium and small rice mils, can reach most of the country's population, especially the malnourished children and nursing mothers, school-age children, and women of reproductive age. Nigerian rice consumption trend is depicted in Figure 1.

Figure 1: Rice Consumption Pattern in Nigeria



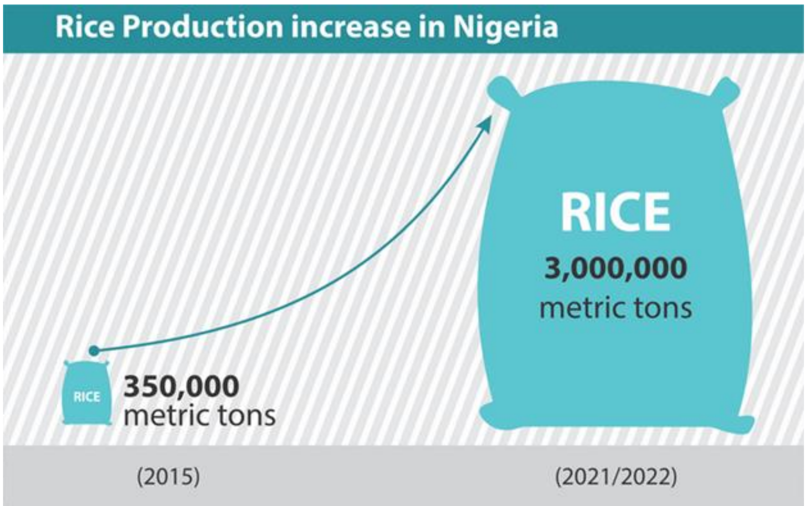
Source: USDA, 2022



Besides the estimated 1.5% drop in rice consumption in 2021, Figure 1 reveals a regular increment in the rice consumption from 2015 to 2021, although the increase is marginal. There is a steady increase in rice consumption even with households' low purchasing power and income, and high rice prices. At the same time, there were lots of fluctuations in rice consumption from 2010 to 2015. Fig 1 reveals that between 2016 and 2021, aggregate demand of 41.5 million metric tons of milled rice is through local supply and importation.

The consumption statistics underpin a huge economic potential for rice fortification in Nigeria. Also, from the information gathered from rice consumers interviewed during the work, the Nigerian rice consumers are willing to adopt fortified rice. About 75% of rice consumers indicate a solid willingness to consume fortified rice compared with 25% that opted for unfortified rice.

As recommended by World Health Organization (WHO), a country with 75 grams per capita per day (75/g/c/d) rice availability can start rice fortification. As of 2013, Nigeria had about 77g/c/d rice availability which is 13g/c/d short of the value for maize (FFI/GAIN, 2016), but the value increased to 138g/c/d in 2021 with the current per capita consumption per year of about 50kg. Therefore, Nigeria has a great potential for rice fortification.



4.2. Rice Production and Milling Structure in Nigeria

Rice milling in Nigeria is expanding exponentially with the increasing involvement of small and cottage-level processors. The emerging trend is in response to the policy incentive bolstered by a high interest of the current Nigeria Government towards achieving self-sufficiency in rice production. The Anchor Borrowers Program (ABP) raised production levels and discourages rice imports. Earlier, under the Agricultural Transformation Agenda (ATA), private investments in the rice sector focused on developing national capacity for rice production, processing, and marketing by leveraging subsidies of the Growth Enhancement Support (GES) Scheme. Significant fallout of the GES is the massive investment in rice milling by the private sector. Rice milling capacity in Nigeria increased from less than 350,000 metric tons per annum in 2015 to 3 million metric tons per annum in 2021/2022 by more than 68 integrated rice mills (CBN, 2022). The integrated rice mills in the country have the potential to compete with the rice imports but have operated far below their maximum capacity due to insufficient supply of rice paddy prevailing in the country (USDA/GAIN, April 2022 report). As a result, some rice millers purchase rice paddy and brown rice from other smaller millers or import from other countries to maintain appreciable levels of their installed capacity when they anticipate scarcity of rice paddy.

The research found that Nigeria has three categories of rice mills vis-à-vis small, medium, and large rice mills.

Table 1: Characteristics of the Rice Milling Structure in Nigeria

Mill sizes	Hourly capacity	Actual annual capacity	Actual capacity utilized	Percentage of utilization	Population served
Small	150-200kg	<3,000,000MT	1,380,000	46%	24%
Medium	300-500kg	<10,000,000MT	1,474,000	15%	25%
Large	5000kg	>10,000,000MT	3,000,000	30%	51%

Source: *IFPRI, 2016; CBN, 2022; WARDA/NISER, 2003, and KPMG, 2019.*

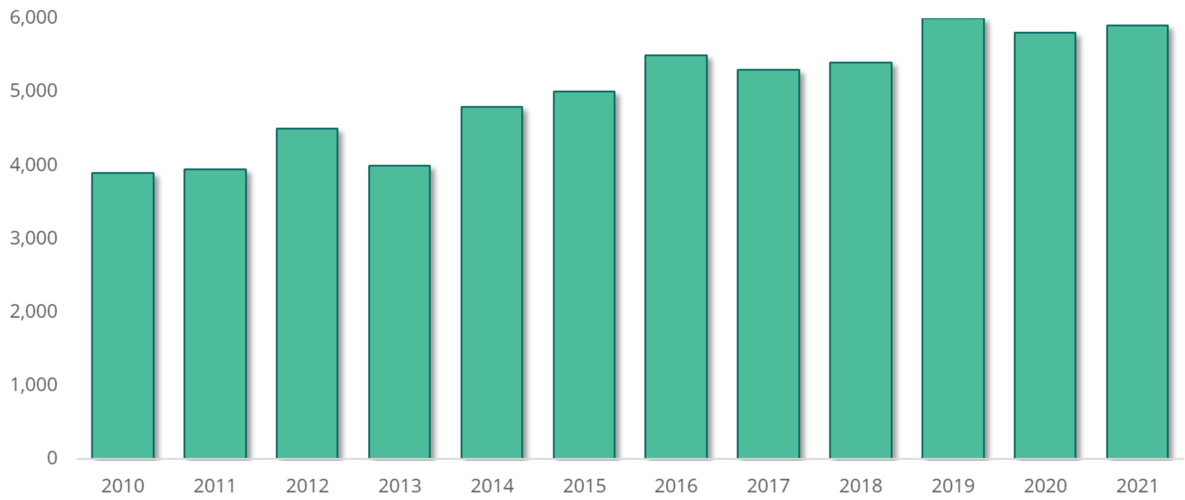
The small rice mills primarily serve the rural rice farmers with a milling capacity of 150-200kg of rice per hour. Sometimes, small-scale rice millers appear in clusters close to the rice farm and often serve as millers and traders. The medium-sized rice mills that service some small-scale rice farmers in the rural and peri-urban areas have a milling capacity of between 300–500kg of rice per hour. The integrated/ large rice mills service the commercial and contract rice farmers, and may have a milling capacity of above 5000kg of rice per hour. The general characteristics of Nigeria's rice milling industry are shown in Table 1. The data for the compilation are from different sources, which comprise of IFPRI, field findings, CBN, WARDA/NISER, and KPMG.

Nigeria is ecologically endowed to attain self-sufficiency in rice production. The country has 4.9 million hectares of low land and upland areas that are suitable for rice cultivation. The climatic conditions are excellent, and water resources (rivers, dams and river basins) and seasonal precipitation offer considerable rice cultivation opportunities. Yet the country annually imported over a 2.2 million tons of milled rice in 2021 (USDA, 2022). An annual production growth rate of about 8.4% is required to nullify the overall domestic rice paddy supply-demand shortfall (FAOSTAT 2019 and NAERLS 2020).

The study noted discrepancies in the production data of the actual volume of milled rice in Nigeria among national agencies and international bodies. However, the data sets show that annual milled rice production increased dramatically within the last five years, although the yearly increases were insufficient to make importation unattractive. Similarly, the quality of locally milled rice also increased significantly because of the country's growing desire for quality rice products that encourage investments in color sorters and destoners in many rice mills. By the same token, when fortified rice becomes readily available, widespread acceptance and consumption should be envisaged.

Figure 2 depicts the production volume of milled rice in Nigeria. As shown above, milled Rice production increased from 2.8 million metric tons to 5.0 million metric tons (USDA), reflecting an annual growth rate of about 7.1%, slightly lower than the 8.4% annual production growth rate indicated by NAERLS. However, the data shows that the increase was not linear since there was a reduction in the quantity milled in 2013. The fluctuation likely followed the reduction in the production occasioned by the massive flooding of farms that occurred in 2012.

Figure 2: Milled Rice Production Pattern in Nigeria



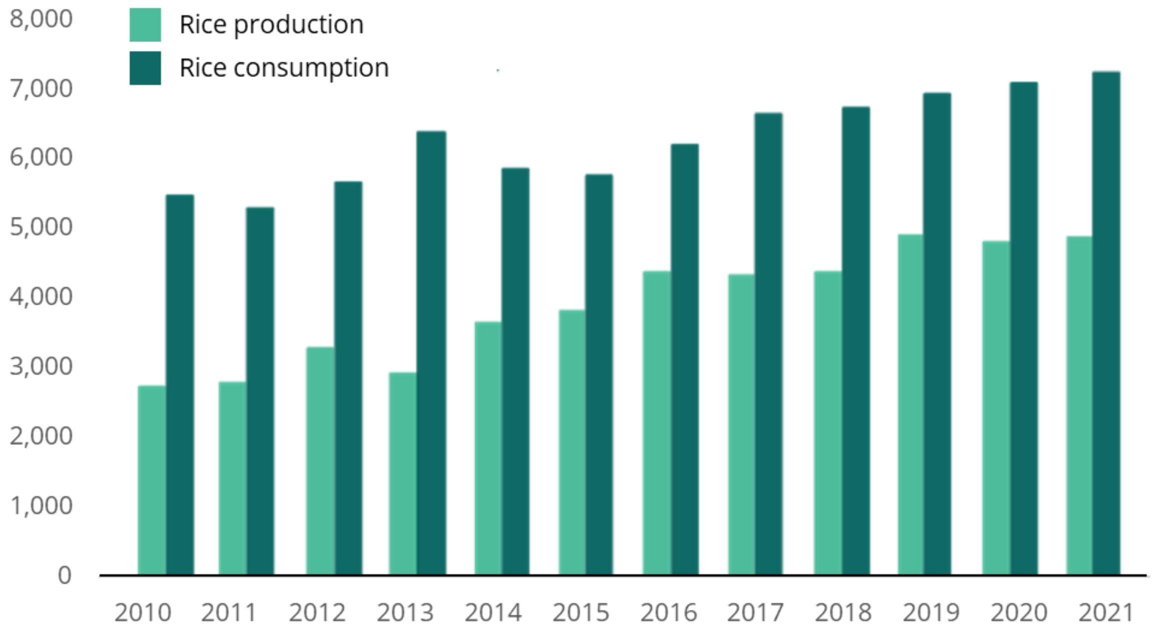
In 2013, the country embarked on a unique program to boost rice production and milling to mitigate the considerable supply deficit to stem dependence on imports under the Growth Enhancement Scheme (GES) program. The program paid off as the milled rice production experienced a sharp increase in the preceding years except for 2017, in which there was a decrease in milled rice output. Similarly, in 2020, local production and milling operations were constrained by the COVID-19 pandemic, leading to a reduction of milled rice.

4.3. The General Demand and Supply of Rice in Nigeria

There is a growing demand for rice in the country due to the rapidly growing population, and the forecast is a sustained demand growth in line with the country's population growth trend. Presently, the local production is inadequate to service demand and huge supply deficit. This is encouraging the government to explore options for boosting production. While the attention of the government tarry on rice, introducing rice fortification has potential for inclusion as part of the policy thrust for the country's rice sector.

Figure 3 reveals that rice consumption in Nigeria outweighed production, with a production deficit of about 2.2 million metric tons between 2010 and 2021. To meet the present demand, rice imports from neighboring countries remained attractive to offset the demand-supply deficit. Furthermore, the total demands between 2015 and 2021 increased by about 2.9%, while importation increased at the same rate during the same period. Therefore, although the rice consumption level is currently more than the local production level, the local production is increasing faster than the consumption implying that if rice production continues to increase, the local rice supply may equal to the demand.

Figure 3: Rice Demand and Supply Pattern in Nigeria



4.4. Rice Importers in Nigeria

Despite stringent measures taken by the government of Nigeria to stop the importation of rice, the country continues to rely on imports to meet local demands. As a result, the country is among the world's top four rice importing nations and the largest in Africa, importing about 1.8 million metric tons between 2020 and 2021. This import figure represents 18.2% of the 2.2 million metric tons of the 2017-2018 imports (Statista, 2021). Some of the rice importers operating in Nigeria are shown in table 2. More than 6 of the importers are in Lagos. In addition, some importers are involved in rice trading, and a few have rice mills.

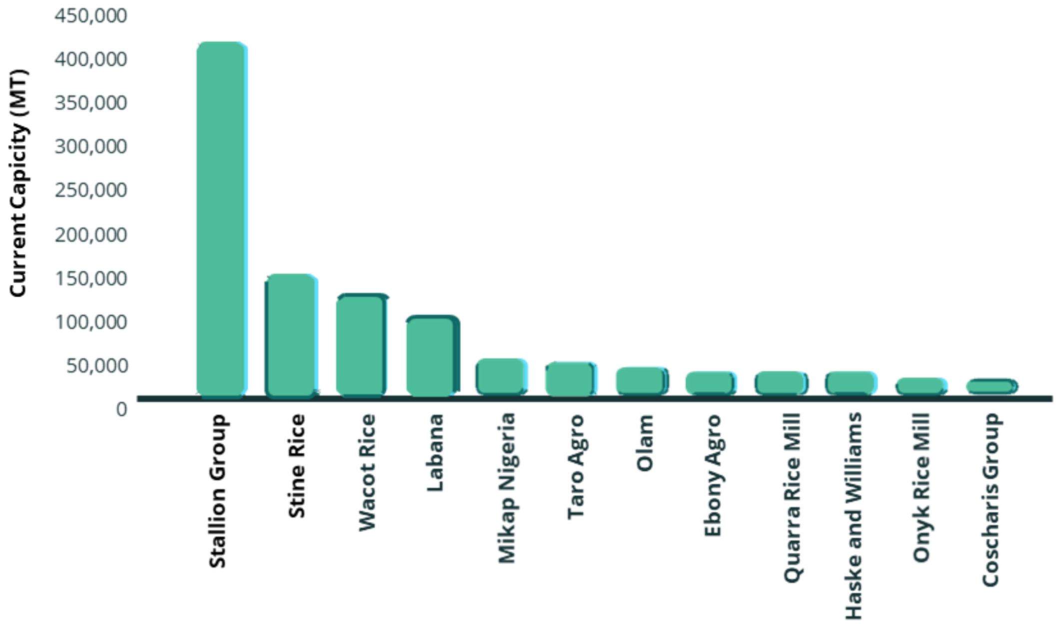
Table 2: Some Rice Importing Companies in Nigeria

Rice Importing Company	Location (State)
Ejima Store	Abia
Jariben Rice	Cross Rivers
Kambel Rice Limited	Lagos
Mjimoh Nigeria Enterprise	Osun
Rice.com.Ng	Lagos
Rice Innovation Platform Co-operative Society	Jigawa
Olaoba Farm	Lagos
Great Farmers	Benue
Daily Godgets Enterprise	Oyo
Compet Enterprise	Lagos
Bofit Nigeria Limited	Lagos
Rice Authority	Delta
Elichuks Rice Venture	Ebonyi
Olam Plc	Lagos
Stallion Group	Lagos

4.5. Technological Capabilities – Current Status

Generally, food fortification is one of the major strategies to decrease the incidence of nutrient deficiencies at the global level. Based on the field survey analysis, Nigeria is likely to employ one major technique for rice grain fortification: hot extrusion. Large scale rice mills in Nigeria were randomly selected and visited to ascertain their production capacity and their willingness to commence rice fortification production. The collected data revealed that the Stallion Group has a milling capacity of 430,000 MT/year, followed by Stine rice mill, Wacot rice, and Labana with a milling capacity of 141, 000, 120,000, and 100,000 MT per year respectively.

Figure 4: Twelve (12) Top Most Rice Processing Companies in Nigeria



4.6. Rice Fortification in Nigeria

Meeting the nutrient requirements of Nigerians requires ensuring the availability and affordability of nutrient-rich food products. Often, most of the nutrients from plant sources are lost during processing. Since most of these nutrients are lost during processing, fortification becomes a vital tool to introduce these nutrients back into the food. Also, provisions are made for nutrient losses that often occur during processing and food preparations. Therefore, food fortification introduces one or more nutrients into the food after processing, focusing on the proportion that may be available to the target consumers (International Finance Corporation, 2018).

Food fortification started 100 years back due to inadequate intake of specific micronutrients from the population's food base, a public health concern (International Finance Corporation, 2018). Food fortification helps restore nutrients lost during food processing to a level that equates and may exceed the natural nutrient content. It involves standardizing the nutrient content in the food and restoring / adding new vital nutrients that are not present or present in a tiny amount in the food's natural content.

In Nigeria, fortification is making tremendous progress. The interest to introduce rice fortification in Nigeria started recently in 2021 anchored by WFP, supported by GAIN based on the need to prevent micronutrient deficiency, and contribute to the reduction of the country's high mortality rate of under-5 and maternal persons. The production of fortified maize flour, wheat flour, cooking oil, sugar, and salt as part of the country's comprehensive nutrition strategy has made tremendous impact on the citizens. However, fortifying rice requires a different process than fortifying flour. Rice is consumed in its milled grain form rather than flour, and rice fortification requires creating a fortified kernel.

As the country experiences a rise in economic growth and emerging common markets, the Federal government is harmonizing fortification standards. Rice fortification is the new conversation for expanding fortified food vehicles in Nigeria. It is the enrichment of rice with essential vitamins and minerals after harvesting to increase its nutritional value and the potential for using rice as a vehicle to further increase the intake of missing essential vitamins and minerals in diets. Lessons from other countries where rice fortification has become widely accepted are of very remarkable importance. The final product (fortified rice) must look the same in appearance and taste the same as unfortified rice. This requirement has imposed special considerations for the type and form of the micronutrients that are incorporated into the fortified rice kernels.

Currently, affordable technology exists to produce fortified rice kernels that look and taste like non-fortified rice. The latest technology offers the benefits of rice fortification without requiring consumers to change any of their buying, cooking, or eating habits. The potential for individuals to benefit from rice fortification varies across a lifetime depending on the micronutrient requirement, dietary intake, the amount of rice consumed, and the existing capacity to fortify the rice.

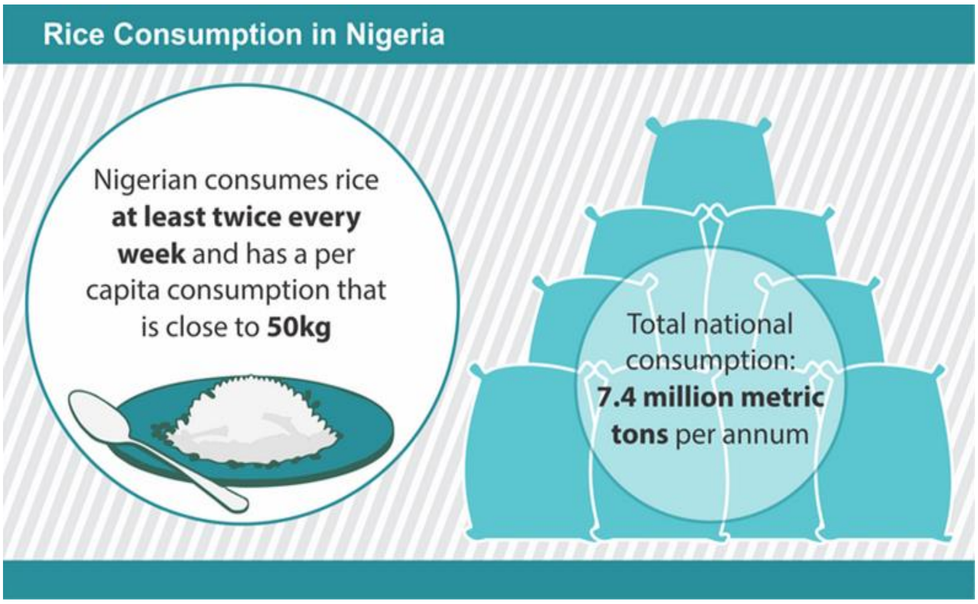
A. Rational and Public Health Need for Rice Fortification in Nigeria

The deficiencies of vitamins and minerals often go unnoticed and are referred to as a pang of hidden hunger. Pregnant women, nursing mothers, and children under 5 years of age are vulnerable to the risk of micronutrient deficiencies in Nigeria. About 55.1% of Nigerian women of reproductive age are anaemic, while 31.5% of children under 5 years of age are or likely to be stunted. The prevalence of micronutrient-induced stunting in Nigeria is higher than the average (30.7%) for Africa. Anaemia is a condition where the number of red blood cells and their oxygen-carrying capacity are insufficient to meet the physiologic needs.

UNICEF (2021) reported that an estimated 2 million children in Nigeria suffer from severe acute malnutrition and that one child in every eight in Nigeria cannot survive to their fifth birthday (NPC and ICF International 2019), and one of the causal factors is malnutrition (USAID, 2021).

To address the micronutrient problem, the Government of Nigeria has a robust nutrition improvement strategy, including mandatory fortification through diversified products such as salt, cooking oil, maize flour, wheat flour, and cassava flour. However, despite elaborate programs, including implementing regulations, micronutrient deficiencies remain prevalent. Increasing population, poor awareness, and adoption of good dietary regimes contribute to the high incidence of malnutrition in the country. To remarkably impact the health of a large segment of the population, it is critical to promote access to safe and nutritious foods leveraging important staples. Rice has become a preferred food for children and women. Rice has also become a popular food for a considerable proportion of adults.

It is important to note that the food consumption pattern is largely replacement and rarely additive. The consumption of any fortified food vehicle may not negate the fortification of other food vehicles because of the habit of replacing one food type with another. Economic hardship is compelling families to shift to less costly foods which may not contain the necessary nutrients. It is not uncommon for families to remove bread or other wheat products made with fortified wheat flour or fortified maize flour from their diets because of rising prices.



On average, a Nigerian consumes rice at least twice every week and has a per capita consumption that is close to 50kg that contributes to the total national consumption of 7.4 million metric tons a year. Moreover, rice has become a prominent part of family diets that is popular in almost every home, during ceremonies, and festivals. These factors make rice an excellent vehicle that can contribute to the remediation of the micronutrient deficiency problem of the country should it become economically and socially viable to promote its fortification.

The unfortified rice is a poor source of micronutrients (WFP, 2019). However, through advances in technologies, the enrichment of the rice with micronutrients, minerals, and vitamins far beyond amounts that are inherently present in the rice is made possible. In this study, we examine if the technology for fortification of rice is available, the cost implications, and the feasibility of rice fortification in Nigeria to support the larger goal of more embedded nutrition security in the nation.

B. Potential Obstacles/Barriers to Rice Fortification in Nigeria

Although fortified rice is a potential nutrition improvement opportunity for Nigeria, addressing critical implementation barriers can accelerate realizing the health impact of rice fortification. There are barriers to resolving the malnutrition problems using rice fortification.

The respondents interviewed believe that rice fortification is feasible and economically viable in Nigeria. Rice fortification barriers in Nigeria enumerated during the study are:

- Lack of FRK making machines along with the complementary units for rice fortification.
- Limited know-how and underutilization of installed capacities.
- A strong contrasting pattern of rural-urban consumption (the rural consumers rely on local rice mill while the urban consumers are largely supplied by large rice (integrated rice mills).
- Insufficient policy support or sustained political will from the government.

Presently, many companies in Nigeria have difficulties sourcing foreign exchange to procure spare parts and/or replace some of their machines from abroad. Because the key component, the extruder, would need to be imported until local capacity to fabricate it is confirmed. The forex may impact on the decision of the local mills to expand or shift to the production of FRK and/or fortified rice.

Also, if rice fortification becomes mandatory in Nigeria, the cost of monitoring and supervising the compliance, and minimizing unscrupulous practices add to the cost of the final product to the consumer. Furthermore, Nigerian consumers are sensitive to price and may shift to cheaper foods if fortified rice price is significantly higher than unfortified rice. Malnutrition is rampant among the economically less endowed. Hence, delivering micronutrients leveraging rice fortification is of great potential if the fortified rice is economically accessible to people at the bottom of the income pyramid[12]. Although the trade-off would be improved consumers' health, a slightly higher cost to consumers should be anticipated, which may require additional efforts to enhance the patronage of the target (malnourished) population.

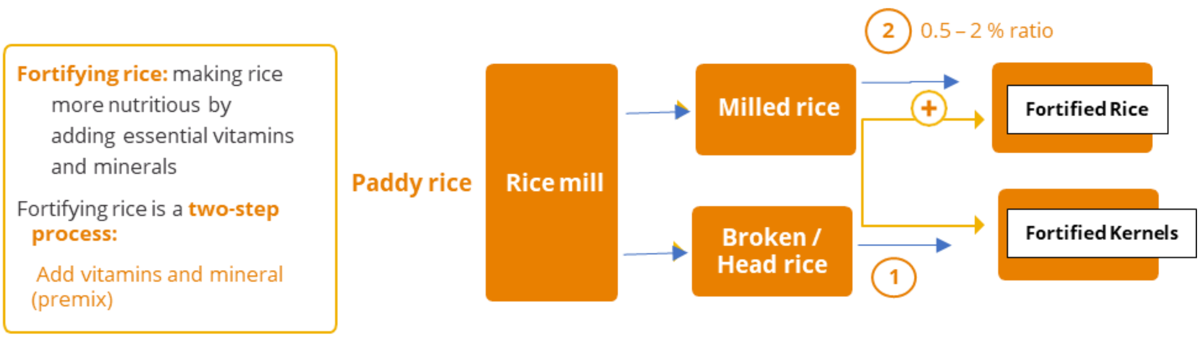
There is also the social dimension of promoting fortified rice. Hence, its promotion needs to take cognizance of the suspicion among the population regarding food technological innovations and plan to manage information asymmetry that may follow the wide scale introduction of nutrient-rich fortified rice in the country.

The other significant barrier to widespread rice fortification is the massive number of small rice processors in the value chain that essentially serve rural communities, unlike in the urban areas that large scale Rice Millers predominantly service.

Consequently, a substantial proportion of the small rice millers hope to continue producing unfortified rice unless compelled by regulation enforcement when enacted. Without such a mandatory regulation, the present outlook captured during the study favors the production of unfortified rice by both the large scale and small-scale millers. But strategic interventions bearing incentives that promote inclusive participation of both the large and small rice mills in the rice fortification agenda has enormous potential to quicken the realization of the health impact of rice fortification in Nigeria.

4.7. Rice Fortification Technologies and Methods

Several reports highlight the components and processes in use for the fortification of rice, and a universally accepted flow chat has been described (FFI and GAIN, 2016; WFP, 2019; Alavi, et al. 2008). A two-step process is involved, the preparation of the fortificants and the blending of the fortificants into unfortified rice. Thus, micronutrients are added after rice harvest, a concept that has been in used for over 90 years.



[12]George Steiger, Nadina Muller-Fischer, Hector Cori and Beatrice Conde-Petit (2014). Fortification of Rice: Technologies and Nutrients. Technical Considerations for Rice Fortification in Public Health. Ann. N.Y Sci. ISSN 007-8923.

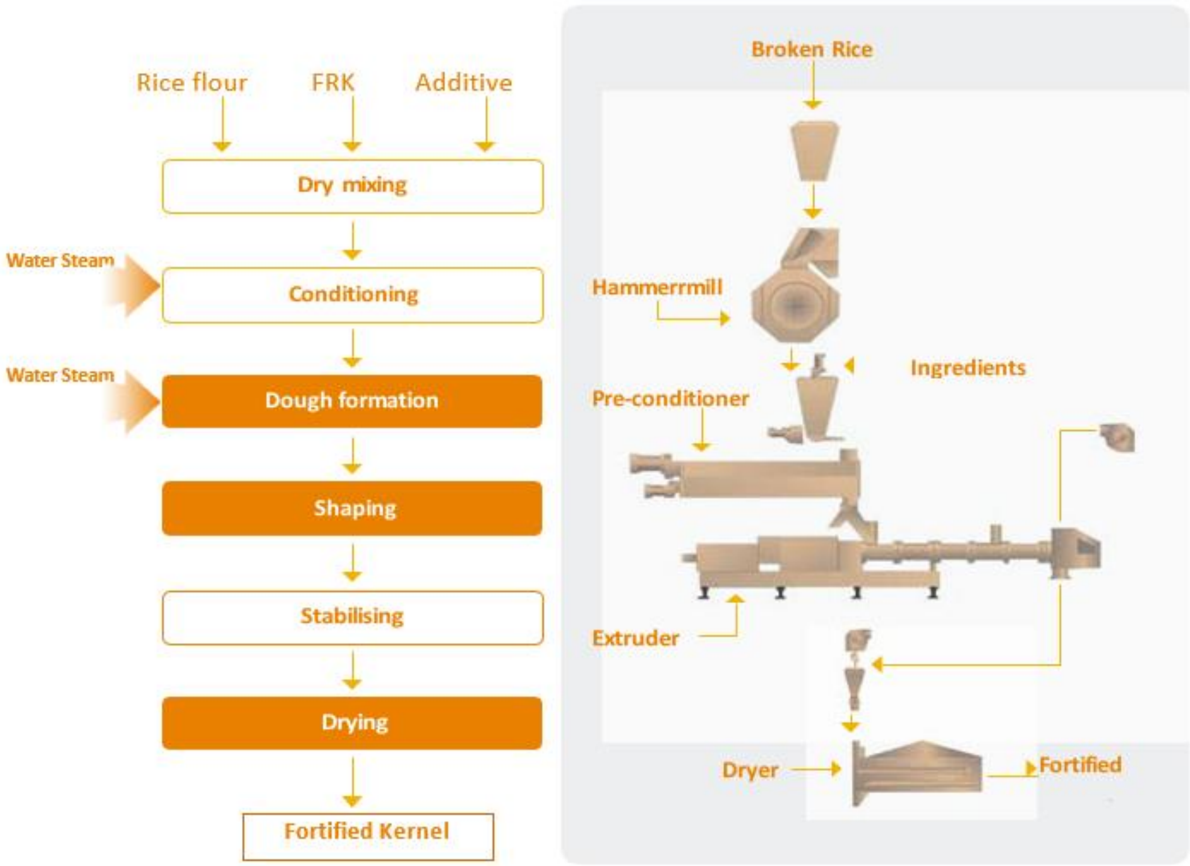
There are three primary methods of rice fortification namely: coating, dusting, and extrusion. There are two forms of extrusion: hot extrusion method and cold extrusion. Rice fortification is safe because the type and level of micronutrient added are calculated based on the following:

- The recommended daily intake of specific micronutrients,
- The highest level of intake that poses no health risks,
- The level of specific micronutrients typically consumed by the target population and
- The daily quantity of rice consumed by the target population.

In every country, a national consultative group on nutrition alliance is responsible for the determination of the components and levels of micronutrients and blending ratios into the fortified rice. The technical committee on nutrition alliance would need to be activated to drive the rice fortification program in Nigeria.

The following section describes the four rice fortification methods. However, it is essential to state that elaborate use of these methods is not yet the norm in Nigeria.

Figure 5: Hot Extrusion Schematics



A. Hot Extrusion Method (HEM)

Hot extrusion passes dough made of rice flour, a fortificant premix, and water through a single or twin-screw extruder and cuts it into a grain like structure that resembles rice kernels. This process involves relatively high temperatures (70-110^{0}C) obtained through steam-heated barrel jackets and preconditioning and heat transfer (Figure 5). It results in fully or partially pre-cooled simulated rice kernels with a similar appearance (luster and transparency) as regular rice kernels. Wuxi NutriRice Co. (DSM/Buhler), COFCO in China, and

Superlative Snacks Inc. in the Philippines use this extrusion method. Commonly used equipment in the extrusion process includes a hammer mill for rice flour production, mixers, single or twin-screw extruders, and dryers.

DSM/Buhler NutriRice Co. and COFCO equipment is a twin-screw extruder fitted with a steam and water preconditioning system manufactured by Buhler. The rice flour (which may be obtained from broken rice kernels or poor quality rice) is mixed with the fortificant premix, water, binding agents, and emulsifiers before passing through the extruder. The dough moves through the extruder via one or more screws, experiencing increased pressure, shear, and heat. Attachments at the extruder's end shape cut the paste into grain-like structures resembling rice kernels.

The capacity of both COFCO and Wuxi NutriRice Co. is approximately 5 MT/day of fortified rice kernel, i.e. 1,500 MT per year. Superlative snacks in the Philippines uses smaller equipment with an annual production of 300 MT per year. The FRK is formulated for blending at either 1:100 (i.e., 10 kilograms per metric ton of fortified rice) in China or 1:200 (i.e., 5 kilograms per metric ton of fortified rice) in the Philippines.

The 1:200 blending may be applied when the production and consumption of rice are large. The fortification ratio of 1:50, or 1: 100, or 1: 200 are the global blending standards, and we have adopted the lower concentrations in the cost analysis section of this document as in India and many other countries.

B. Cold Extrusion

Cold extrusion is a process used for manufacturing pasta. It also produces rice-shaped simulated kernels by passing dough made of rice flour, a fortificant premix, and water through a simple pasta press. This technology does not utilize any additional thermal energy input. It uses the heat generated by itself, and is primarily a low temperature (below 70^{0}C), forming process resulting in uncooked grains, opaque and easier to differentiate from regular rice kernels. PATH (an International non-profit organization domiciled in China) uses a similar method, while Bon Dente International produces UltraRiceTM premix. Antioxidants are added as part of the ingredients of the synthetic rice kernels to improve the stability of the vitamins.

The cold extrusion process involves combining a fortificant premix with rice flour dough, extruding, cutting into rice-shaped grains, and drying. The resultant product resembles natural milled rice grains in size and shape but usually slightly softer in consistency and is more opaque than natural rice kernels. Given the prevailing food habits, the kernel characteristics archived by cold extrusion are not likely to attract widespread acceptance in Nigeria.

C. Coating

The coating technology combines the fortificants mixed with ingredients such as waxes and gums. The mixture is sprayed on the rice on the surface of grain kernels in several layers to form the fortified rice kernel before blending with polished rice. This method is being applied in the U.S. and by NQT Group in Costa Rica. The NQT Group in Costa Rica employs a unique mixture developed for the coating process called Kuruwax, made of palm oil-based wax, gums, and an emulsifier.

First, two solutions are prepared; one containing only Kuruwax and the other containing Kuruwax and a micronutrient premix in a 1:1 ratio, by dissolving in water at 85^{0}C. A unique batch coating drum, modified from drying and cleaning drums used in the milling industry, is then used to apply these solutions onto the surface of rice grains in a five-step (or five-layer) process, with each step involving a coating of the Kuruwax solution followed by a coating of the Kuruwax–premix solution. Finally, the coated rice is simultaneously dried in the drum using hot air. The final moisture content of the coated rice must not exceed 10 percent (wet basis), and levels of fortificant premix and Kuruwax in the fortified rice are 2.4 percent and 0.2 percent respectively. A batch process takes about an hour to complete.

D. Dusting

This method involves dusting the polished rice grains with the powder form of the micronutrient premix, so that the fortificants sticks to the grain surface because of electrostatic forces.

Dusting uses a micronutrient premix, a blend of the fortificants with cornstarch and other ingredients to improve micronutrient stability, premix flowability, dryness, and prevent the formation of aggregates.

Dusting process is in uses in the fortification of flours. Segregation of the micronutrient premix might occur from the rice grains, but it would be difficult to perceive because of the significant blending factor. However, it is essential to know that rice fortified with powdered premixes should not be rinsed before or after cooking, nor should the rice be cooked in excessive amounts of water and then drained. Washing with water before or during cooking causes the loss of the fortificants.

For this reason, the dusting technique is not appropriate in Nigeria, where rice is washed and rinsed before cooking.

4.8. Cost of Rice Fortification in Nigeria

Cost is one of the most important considerations before embarking on any project or programme. Cost gives insight into the proposed project's total financial involvement and wedges investment decisions. Usually, the cost of fortifying rice is much higher than that of wheat and maize flours because of the requirement of special machines and procedures.

Whole wheat flour and maize flour are fortified directly with fortificants. Fortification of rice, especially by the extrusion method, requires the production of fortified rice kernels, and the blending of unfortified rice with the fortified rice kernels. Therefore, the cost items in rice fortification significantly contrast with wheat or maize flour and include special machines to produce fortified rice kernels (FRK) and calibrated machine for blending the FRKs into unfortified rice. Other cost items are personnel, energy, water, and promotion.

Thus, rice fortification requires adequate infrastructure for making the FRK either through extrusion, coating, or dusting method. The report examines the cost structure of rice fortification based on the hot extrusion method. Because the pattern of rice meal preparation in Nigeria requires washing multiple times before or during cooking, hot extrusion method is considered appropriate.

A. Estimated Cost of Fortified Kernel Production and Rice Volume

One of the critical aspects of rice fortification is the production of fortified rice kernels. The fortified rice kernel is blended with the unfortified rice to produce fortified rice. Information gathered from the field reveals that the rice millers in Nigeria show a solid willingness for fortified rice. Therefore, there are prospects that the production of FRKs within the country would attract investors, although the capacity of the existing rice mills are yet to be tested, and would need to be strategically developed.

In the analysis, three different production steps of extruded fortified rice kernels are assessed. The initial step in the production of fortified rice is the acquisition of FRKs. There are three investment options for sustainable supply of FRKs (Figure 6):

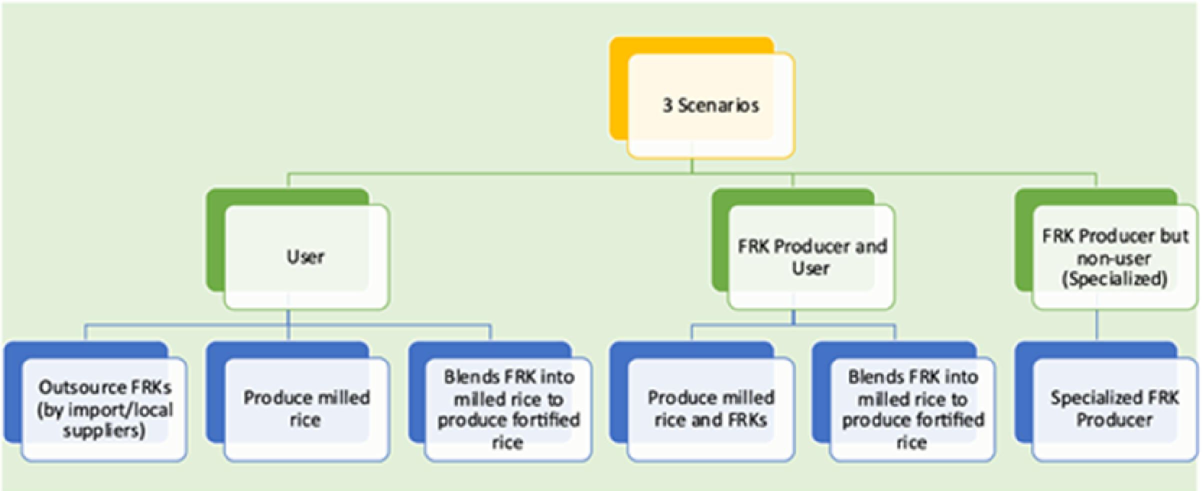
a. Sourcing FRK from local producers or from importation,

b. Producer and user, in which case the rice mill expands its existing production line to include FRK production and blending, and

c. Specialized FRK producer that is dedicated to the production and supply of FRKs to various rice mills.

The entry point that can accelerate the transition to comprehensive coverage with fortified rice is to begin with the importation of FRK while developing local capacity for FRK production. At an advanced stage, some rice mills may wish to specialize on the production of FRK, which would enable smaller rice mills to participate in rice fortification programmes as in India.

Figure 6: Investment options for FRK supply and use



The first scenario is currently being evaluated by Oya Foods Nigeria. We found limited quantities (samples) of FRKs during the study in the company's warehouse in Lekki, Lagos, which indicates that outsourcing FRK by importation and/or local suppliers or producers of FRKs are possibilities.

The analysis in Table 3 shows significant variations in the volume output of FRK at different production lines. It was discovered that at a high output level of 1MT per hr, significantly higher volume of FRK is produced compared with lower outputs of 0.5MT/hr or 0.25MT/hr. Therefore, depending on the volume of FRK or preferred blending ratio or the volume of milled rice to be fortified, the capacity of the extruder may be selected. The enormous volume of rice that may need to be fortified may warrant adopting high output extruders except several lower output extruder is installed. The promotion of medium power extruders may enable spatial placement of the extruders in different regions to service the proliferating and existing rice mills across the country. Many medium power extruders may also be economic in term of breakdown and maintenance cost. The long-term strategy however, would be to develop local capacity for the fabrication and maintenance of the extruder. In this regard, the manufacturing experience of Federal Industrial Research Organization (FIRO) and the National Center for Agricultural Mechanization (NCAM) at Ilorin may be useful.

Table 3: Potential Fortified Kernel Production and Rice Volume using extrusion

Extruded kernel		
Production lines	3 Lines 0.25MT/hr 0.5MT/hr 1MT/hr	
Hours/year	**Blending ratio**	**Fortified rice Kernels (MT)**
3900	1:49 0.25MT/hr 0.50MT/hr 1MT/hr	 48,750 97,500 195,00
3900	1:99 0.25MT/hr 0.50MT/hr 1MT/hr	 97,000 195,000 390,000
3900	1:199 0.25MT/hr 0.50MT/hr 1MT/hr	 195,000 390,000 780,000

Assumption: A Processing plant operating at optimal efficiency is operating for 13 hours for 300 days in a year. Base on the information gathered from the field, most rice milling factories operate at an average of 13 hours per day and 300 days per year.

Going by the calculation above, one extruded kernel line with capacity of above 0.25MT/hr could produce enough fortified rice kernels to fortify the entire milled rice (which is slightly above 5,000,000 MT) in Nigeria.

B. Cost Associated with FRK Production

Key highlight/assumptions made in this cost analysis that govern the scenarios illustrated:

- The cost of the micronutrients used in the analysis are from Olivria Foods & Beverages Private Ltd, and JVS Foods Pvt, India Mart, and Sigma Aldrich. The average of the prices from these sources for each item were used in the analysis;
- The cost of some of the equipment used are from the rice milling industries in Nigeria including Oya Food Nigeria, Alibaba.com (China) and India;
- The equipment cost is inclusive of tariff, CIF, and VAT;
- The cost of the FRK used in the analysis are from Olivria Foods & Beverages Private Ltd, and JVS Foods Pvt, India Mart, and Gujarat. The average of the prices from these sources were used in the analysis;
- 3900 MT is assumed volume of rice milled as generated from the survey (assuming there is no downtime) ;
- Local prices in the local currency were converted at the rate of N418/ $1;
- The cost of broken rice grains marked at 20% discount of whole rice grain;
- The cost of the imported FRK is inclusive of tariff (1% of administrative charges, ETLS levy of 0.5% 0f CIF and 6.475% charges at the landing port and transportation) and 5% of CIF and 7.5% of VAT;

- A 10-year lifespan/straight-line depreciation, and credit cost rate/annum of 4.5 - 12%, and amortized salvage value are assumed;
- We used constant cost obtained from the rice mills in Nigeria for energy, labour, equipment, and blending for the scenarios;
- Quality control cost is subsumed in the existing practice for each mill.
- A processing plant operates for 13 hours for 300 days in a year as elicited from our survey.
- We based our analysis on India standard as studies showed that Nigeria has similar micronutrient deficiency burden as India.
- The price of unfortified rice used in this analysis came from the retailers and consumers interviewed, we used the average of the given price for the lowest and highest grade of local unfortified rice.

The availability of FRK and access to a blending machine are critical cost elements in the rice fortification flow line. There are two strategic options for securing FRKs namely: importation from other countries and local production. These options are discussed separately.

Scenario A:

Local Production of Fortified Rice Kernels in Nigeria using fortification Standard of India

Producing fortified kernels by Hot Extrusion Method (HEM) requires making the dough from unfortified rice flour mixed with prescribed vitamins, minerals, and water. The dough, once made, is further processed through an extruder, and shaped to resemble rice kernels, and finally dried. The process implies machine, energy, micronutrient, and carrier costs. The fortified kernels are produced based on established micronutrient premix and concentrations standards of the country. Because Nigeria is yet to establish the standard for rice fortification, we have adopted standards of India. Once produced, the FRK is blended with milled rice at a set ratio to produce fortified rice.

Adopting the hot extrusion method requires setting the extruder at a very high temperature of above 100°C, while cold extrusion utilizes a simple extruder or pasta press which does not involve the use of thermal energy. The cost of producing a ton of FRK is based on various cost items at 2021 prices the source listed earlier.

Nigeria local Production of FRK Based on fortification Standard of India using Seven (7) MN fortificants at Blending level of 1:100

The upper and lower concentration limit of the micronutrients as well as their cost is shown in Table 4.

Table 4: Seven (7) Micronutrients Base on India Standard

Micronutrients	Forms	Micronutrient Levels Mg/kg	Target Level in the Rice 30% Average	Target Range Ex-Factory	Fortificants Cost (US$)
Folic acid µg/g	Folic acid	75-125	97.5 -162.5	87.5-172.5	1.89 – 3.14
Vitamin B12 µg/g	Hydroxycobalamine	0.75-1.25	0.98-1.63	0.91-1.05	413.25 – 688.75
Iron	Micronized ferric pyrophosphate	28-42.5	36.4-55.25	35.4-56.25	0.01 – 0.03
Vitamin B3	Nicotinamide	1.25-1.75	1.63-2.28	1.53-2.38	0.05 – 0.07
Zinc	Zinc oxide	10-15	13-19,5		0.12 – 0.174
Vitamin B1	Thiamine mononitrate	1-1.5	1.3-1.95	1.15- 2.10	291.6 – 437.33
Vitamin B6	Pyridoxine hydrochloride	1.5-2.5	1.95-3.25	1.85-3.35	0.06 - 0.11

The calculated cost of local FRK production in Nigeria based on expanded MN premix (India) consisting of seven (7) micronutrients is on Table 5 below.

Table 5: Cost Implication to Produce 1,000kg Per Hour of Fortified Rice Kernels in Nigeria by Extrusion with India Standard of Seven (7) Fortificants

Cost of FRK/ton (USD)		**1,310.3 -**	**1,732.9**			
Hour of production/year			**3,900**			
Extruder capacity tons/hour			**1**			
Production of tons/yr.			**3,900**			
Cost of Raw Materials	**t/h**	**USD/t**	**Amt/yr (USD)**		**Amt/hr (USD)**	**% Share**
Broken rice	0.95	550	2,037,750		522.5	
Emulsifier	0.01	3,000	117,000		30	
Micronutrient	0.04	17,675 – 282,440	2,757,300 – 4,405,440		707 -1129.6	
Sum per year			**4,912,050 – 6,560,190**		**1,259.5 -1,682.1**	**96.1 -97.1**
Cost of capital investment		**Unit**		**Dep./yr.(USD)**		
Equipment Hammer mill, Mixer, Extruder and Dryer		USD	580,000 – 596,620	28,950 – 30662		
Equipment shelf life		Years	10			
Salvage value		USD	290,000			
Building		USD	20,000 -40,000	1,050 – 2,100		
Building lifespan		Years	10			
Salvage value		USD	9500			
Interest		%	4.5 -12	27,000 -76,394.4		
Sum per year				**57,000 - 109,156.4**	**14.6 - 28.0**	**1.62- 2.14**
Energy cost						
Electricity		USD	8500			
Fuel		USD	12000			
Steam		USD	16000			
Sum per year				**36,500**	**9.4**	**0.5 - 0.72**
Utilities/ maintenance cost						
Equipment parts		USD	10,000			
Works (repair)		USD	18,900			
Water		USD	1000			
Sum per year				**29,900**	**7.7**	**0.44-0.59**
Personnel cost						
Labour		USD	12,900			
Supervision		USD	8500			
Sales/transportation		USD	800			
Sum per year				**22,200**	**5.7**	**0.32-0.44**
Total cost per ton					**1,310.3 – 1,732.9**	**100**

Assumption: The Extruder Plant is Operating for 13 Hours for 300 days in a Year with a Capacity of 1000kg per Hour

Note: The amount per year divide by 3,900 (that is 300 X 13 X 1) gives the amount per hour. Summation of the total amount per hour divided by the total cost contribution of cost items per ton multiply by 100 gives the percentage contribution per share in 1 ton of FRK. The price of micronutrients/ton were multiple with 3900 to get its price per year (3,900 tons in a year).

The analysis in Table 5 shows that the total estimated cost of producing FRK in Nigeria using 7 MN fortificants based on India standard India is between USD$1.31-1.73/kg, of which the cost of raw materials is 96-97% of the total cost while utilities and maintenance, energy and personnel costs are negligible - each being less than 1% of the Total Cost (TC). The estimated cost of rice fortification under this scenario ranges between US$22.64/MT, and US$26.84/MT (lower and upper concentration limit) at the dilution rate of 1:100 as shown in Table 6. Although the cost of emulsifier, and micronutrient in the fortificant premix could vary depending on how they are purchased, there are currently no local producers of FRK in Nigeria. The calculation assumes 13 working hours per day and 300 working days per year that currently prevails in many rice mills across Nigeria operating under adequate supply of paddy. Although many rice mills run two or more production shifts, this was not factored in the computation. The higher the working hours, the higher the possibility of cost reduction because of machine/warehouse usage intensity.

It is also assumed that the extruder is available, and that 10-year depreciation makes the aggregate cost a bit accommodative. At a higher depreciation rate and higher energy cost the aggregate cost of producing the FRK may change correspondingly.

Rice Fortification Cost Using Locally Produced FRK with Seven (7) Fortificants at the Blending Level at 1:100

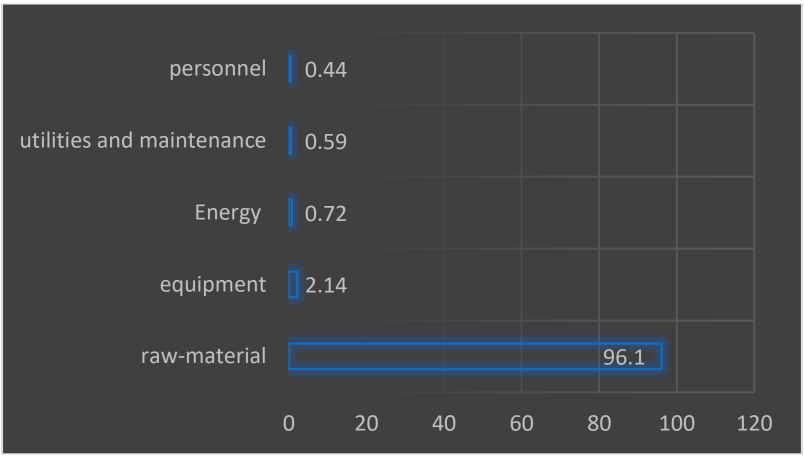
Table 6: Cost of Fortification Based on 1:100 dilution with 7 Fortificants FRK (Using Locally Produced FRK)

Variables	Costs (US$)	(US$)
Capital Cost		
Feeder/blender (1 feeder x 1mill)	55,421	
Annual Costs		
Capital	5542	
Interest (Loan)	2494	8036
Variable Inputs Cost (annual costs)		
Labour (3 x $4.3@300 days)	3870	
Supervision	7500	
Electricity	3500	
Fuel	12000	
****Transportation of fortified kernels (within)**	100	
Blending	2200	
FRK 39,000kg x $1.31/1.73	51,090 -67470	**80260 -96640**
Total annual cost		**88296 - 104676**
Total cost of fortification per ton		**22.64 - 26.84**
NB: the cost figures in this Table are for a generic extrusion operation, not for any specific company		

Assumption: The blending point is less than 500**m away from the FRK producing point.**

The disaggregated component cost for local production of FRK in Nigeria is shown in Figure 7. The estimated cost proportion shared by each cost item reveals that the cost of raw material accounts for the bulk (96.1%) of the total cost. Nigeria do not yet have reliable producers of FRK, which implies that should the country decide to make its FRKs, dependable suppliers of most of premix would need to be identified.

Figure 7: Proportional Share of the Cost Items



Scenario B:

Assuming Nigeria were to import the same composition of FRKs as in scenario A from India (JVS Foods Pvt; India Mart; Olivria Foods & Beverages Private Ltd; Gujarat) and to Fortify Rice with them.

Production of the fortified kernels have not started in the country, but we noted from the study that some rice dealers/millers had samples of FRK which they imported from other countries for their specialty clients. According to the information gathered as part of this study, the landing cost of the fortified rice kernels (FRKs) with the 7 micronutrients composition (scenario A Table 4 upper concentration limit) at 1:100 ratio of India standard is currently at USD1.70 per kg while the lower limit is about USD1.20. The cost of the upper concentration limit of seven micro nutrients composition of FRK in India is about USD1.5 per kg and that of lower limit is USD 1 per kg, factoring the cost of importation, CIF and Tariffs translates to about USD1.70 and USD 1.20 per kg of fortified rice kernels respectively. The cost of the imports comparatively lower than our calculated cost estimates if Nigeria were to produce the FRKs. However, the marginal differentials in the comparative cost between calculated production cost and import cost of FRK may be indicating that investing in local production may be cost- effective.

The breakdown of the cost of importing 1kg of FRK into Nigeria.

- The cost of India standard FRK (lower concentration limit in India -Table 4) is US$1.00 (note that this cost is the average cost of JVS Foods Pvt; India Mart; Olivria Foods & Beverages Private Ltd; and Gujarat)
- 7.5% VAT = US$0.075
- 5% CIF or C&F (Cost of Insurance & Freight or Cost of Freight) = US$0.05
- ETLS (ECOWAS Trade Liberalization Scheme) Levy 0.5% of CIF or C&F value = US$0.0025
- 1% Administrative charges = US$0.01
- 6.475% charges at the landing port and transportation = US$0.06475

The total cost of importing lower concentration limit of FRK India standard is US$1.00 + US$0.075 + US$0.05 + US$0.0025 + US$0.01 + US$0.06475 = US$1.20 while that of upper concentration limit is US$1.70.

Table 7 reveals that the estimated cost of fortification (using imported FRK) at blending ratio of 1:100 ranges between USD21.51 and USD26.51 per ton (lower and upper concentration limit respectively). The calculated values are comparable although it is marginal lower than USD 22.64 -26.84/ton of using locally produced FRK to fortify rice.

The cost implication of rice fortification with a dilution rate of 1:100 using imported fortified kernels is shown in Table 7.

Table 7: Cost of Rice Fortification based on 1:100 dilution (Imported FRK)

Variables	Costs (US$)	(US$)
Capital Cost		
Feeder/blender (1 feeder x 1mill)	55,421	
Annual Costs		
Capital	5542	
Interest (Loan)	2494	8036
Variable Inputs Cost (annual costs)		
Labour (3 x $4.3@300 days)	3870	
Supervision	7500	
Electricity	3500	
Fuel	12000	
Blending	2200	
FRK 39,000kg x $ 1.20 - 1.70	46,800 – 66,300	**75,870 - 95370**
Total annual cost		**83906 - 103406**
Total cost of fortification per ton		**21.51 – 26.51**
NB: the cost figures in this Table are for a generic extrusion operation, not for any specific company		

Theoretical Cost Comparison of the Cost of Rice Fortification using locally produced FRK and Imported FRK in Nigeria

Table 8 below compares rice fortification cost using both locally produced FRK and imported FRK in Nigeria**.** The increase in the retail rice price after fortification is between 2.14% and 2.53% using locally produced FRK to fortify rice, while it is between 2.03% and 2.50% using imported FRK to fortify rice. This reveals a marginal cost differential between the two scenarios. The retail price increment in both scenarios is less than the global range of 3-6%. The comparison is based on 7 micronutrients premix (lower and upper concentration limit) at 1:100 blending ratio.

Likewise, the estimated cost of locally produced FRK is marginally higher than the cost of imported FRK. However, different factors (cost of extruder, labour, energy etc. difference in the countries) may have influenced the cost. Therefore, encouraging local investments on the fabrication of the extruder and using cheaper energy sources can further reduce the cost of producing the FRK and followed with its blending into milled rice. Once rice fortification gains widespread acceptance, scaling production would likely orchestrate a reduction of the unit cost of FRK such that local production could become more competitive. Also, Table 8 reveals that the estimated cost of rice fortification with locally produced FRK is higher than using the imported FRK. However, t-test statistics was used to ascertain if there is any significant difference in the cost of rice fortification and retail rice price increment between using imported FRK and locally produced FRK to fortify rice in Nigeria, the result reveals that there is no significant difference in cost of fortification and increase in retail rice price between using imported and locally produced FRK to fortify rice. Thus, the marginal incremental cost of retail rice price and cost of fortification in both scenarios shows that it is cost effective to use either of locally produced FRK or imported FRK in rice fortification in Nigeria.

Table 8: Cost of Rice Fortification using locally produced FRK and Imported FRK in Nigeria

FRK Status	Retail rice price (US$/kg)-unfortified rice	Estimated FRK cost (US$/kg)	Dilution Factor	Estimated cost of rice fortification (US$/MT)	Retail price increase (%)	Fortification cost per consumer (US$/year)
Locally produced	1.06 – 1.45	1.31-1.73	1:100	22.64 -26.84	2.14-2.53	1.13-1.34
Imported	1.06 -1.45	1.20 – 1.70	1:100	21.51 - 26.51	2.03-2.50	1.08 – 1.33

Note: per capita rice consumption of 50kg/person/year was used in the calculation of both scenarios

Theoretical Cost Comparison of the Cost of Rice Fortification between Nigeria and India

Table 9 below compares rice fortification costs of two developing countries- Nigeria and India. The Nigeria and India calculation was done using the estimated cost of local production based on India seven micronutrients premix of FRK (upper concentration limit).

Table 9: Characteristics of Rice Fortification Cost Profiles of Countries

Country	Retail rice price (US$/kg)	Estimated FRK cost (US$/kg)	Dilution Factor	Estimated cost of rice fortification (US$/MT)	Retail price increase (%)	Fortification cost per consumer (US$/year)
Nigeria	1.06 – 1.45	1.73	1:100	26.84	2.53	1.34
India	0.8	1.50	1:100	14.7	1.84	1.20

Table 9 reveals that the retail price increment after the fortification is about 1.84% in India, while in Nigeria it would be around 2.53% which is less than the global range of 3-6%. The comparison is based on 7 micronutrients premix (upper concentration limit) and at 1:100 dilutions ratio. An inconsequential increase of less than 3% in the retail price following fortification was calculated for both Nigeria and India. This marginal estimated cost increase may encourage the desired transition towards rice fortification. When the costs of promotion of fortified rice are added, the adjusted cost of the fortification would potentially rest within the global cost range of 3-6%.

The calculated price of FRK in Nigeria can be compared with that of India with the same micronutrient premixes and concentrations for the two countries. The estimated, calculated price of FRK is about USD 1.73 per kg in Nigeria while it is USD 1.5 per kg in India. Should Nigeria decide to import FRKs, it would be critical to review the MN premix and concentration in the identification of potential suppliers to meet national need and standard.

At per capita rice consumption of 50kg/person/year, the estimated fortification cost per person is less than USD 2 (1.34)/year (Table 16) for Nigeria, which is substantially higher than USD 1.2/kg in India, where the per capita consumption is 81.6kg/year. Overall, the analysis shows that rice fortification in Nigeria is feasible and economically viable should the country decide to adopt a similar rice fortification standard as in India.

Given the widespread dichotomy in the micronutrient deficiencies and malnutrition across the country, adopting variable levels of fortificants and levels in the FRK for rice fortification seem a strategic decision for Nigeria. In which case, the fortification standards of India may be a relevant benchmark.

4.9. Strengths and Weaknesses of the Existing Large Scale Rice Mills Poised Towards Fortification

Nigeria has a comparative advantage over most developing countries to push forward with rice fortification because it has both the institutions, a large and growing rice consuming population and a regulatory backbone to drive the process. Demand for rice in Nigeria is projected to grow in line with the growth of the national population. The country is encouraging the increasing integration of rice into the traditional food culture, which underpins the prospects for a massive health impact with unimpaired access to fortified rice. The key strength of the current rice fortification initiative in Nigeria is the increasing consciousness among the citizens to consume more nutritious diets that are certain to pull and push demand.

The government of Nigeria has demonstrated a solid disposition to support its citizen's aspirations for healthy diets and is committed to creating an enabling environment for nutrition enhancement investments and regulations. For example, the Federal Government of Nigeria through its agencies such as the National Agency for Food and Drug Administration and Control (NAFDAC) and Standard Organization of Nigeria (SON) has the mandates (policy instruments) to support rice sector operations and investments.

The Federal Ministry of Health (FMOH) is fostering a more embedded consciousness for nutrition security in Nigeria through engagements with highly diversified stakeholders in the nutrition space such as Federal Ministry of Agriculture and Rural Development (FMARD), United States Agency for International Development (USAID), Global Alliance for Improved Nutrition (GAIN), World Food Programme (WFP), and The Nigeria Agribusiness Register, and Rice Processor Association.

The country has developed its Nutrition Policy with the technical support of a mix of development agencies. Therefore, the strength of the large scale rice mills in Nigeria rests on backstopping from the myriad of stakeholders, including development partners like WFP, GAIN/ others, consumers, and potential consumers of fortified rice participating in the rice sector value chain.

Rice fortification is relatively a new potential investment decision for most Large-Scale Rice Mills (LSRM) in Nigeria. Because the concept is new and there are no mandatory regulations to force compliance, most LSRMs are ill-prepared to commence the production of fortified rice immediately. Most rice mills lack the technical know-how/facilities and personnel requirements and the finance to invest in their capacity development.

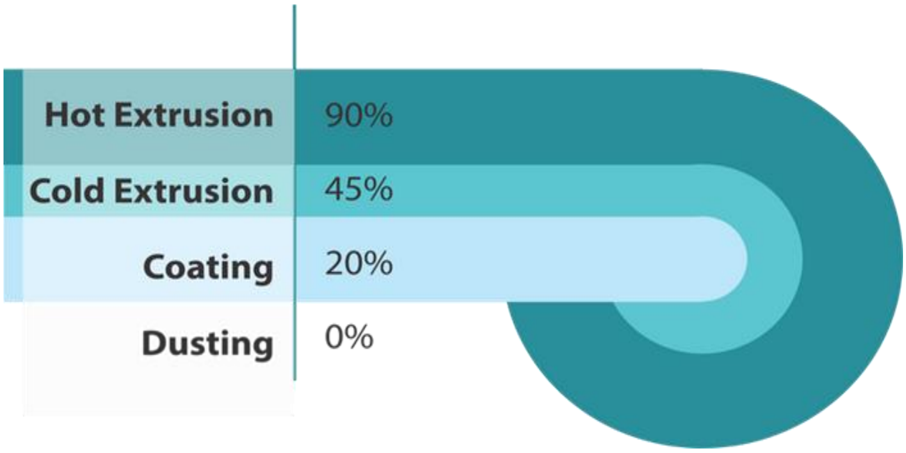
Unfortunately, the motivation to accelerate internal capacity development would remain low unless a rice fortification policy governs their operations, or the government incentivizes the large mills to start voluntary rice fortification. There are currently no monitoring or regulatory measures that support the production and distribution or consumption of fortified rice in Nigeria. Should rice fortification become mandatory, enforcement of compliance would be necessary to elaborate additional investments to promote rice fortification.

Numerous small rice mills are springing up across the country that may not have the capacity to shift to the production of fortified Rice. Small rice mills are predominant in the rural areas supplying local population. Because most of the small rice mills do not have fortification capacity, it may be critical to adopt innovative outreach programmes that enable their access to FRK to enhance the health impact of their operations.

4.10 What Type of Rice Fortification Technology should the Country Adopt?

Nigerians have strong food habits. Rice is washed with water several times, including pre- and during cooking washing, making the dusting method of fortification unsuitable for fortified rice targeting consumers in Nigeria because most of the micronutrients applied through dusting may be lost. For this reason, most rice millers interviewed opined that Hot Extrusion Method presents the most viable option for rice fortification targeting Nigerian consumers. The lower visual appeal for fortified rice produced using non-uniformed Premix from the coating or Cold Extrusion Method may affect its' demand relative to those of the Hot Extrusion Method. Nigerians prefer rice with homogeneous grains in form, size, consistency, flavor, and color produced using the Hot Extrusion Method. The cost analysis of the study shows that the cost of making FRK and fortification in Nigeria based on the Hot Extrusion Method is comparable with those of the other countries.

Figure 8: Responses of Large Scale Millers on Preferred Fortification Technology



Although the production of fortified rice is in its infancy in Nigeria, it is necessary to capture the views of the rice mill industries on the adaptability of the different premix production methods that could be adopted for Nigeria. Data analysis, as shown in Fig. 6, revealed that over 90% of the fifteen Rice Millers interviewed opted for Hot Extrusion Method to produce FRK, while Coating and Dusting do not seem to attract consensus for now.

4.11 Which Micronutrients should be added to the Fortified Rice Kernel?

Findings reveal that micronutrients recommended for rice fortification are determined by the following variables or factors:

1. Micronutrients that are depleted during processing or fortification technology deployed.
2. Micronutrients that address a target population's nutrient gaps.
3. Another consideration for the selection of micronutrients for the Premix is the nature of the

fortificants - their bioavailability (i.e., the micronutrients that the body can effectively absorb and utilize), stability, and sensory acceptability (in this context, it must not affect the color or taste of the fortified rice) to engender acceptability by the general populace.

4. Country's regulatory act for food fortification.

Within Nigeria, Vitamin A Deficiency (VAD) is the leading cause of under-5 and maternal mortality (Data World bank, 2019), which has compelled its inclusion in the fortification of a range of food vehicles that are entrenched in food culture of the population. Because Vitamin A is already covered, its inclusion in rice fortificants may be unnecessary.

with regards to iron, the use of micronized Ferric pyrophosphate (FePP) is recommended because it can produce acceptable color in fortified kernels. Other micronutrients for the premix (fortificants) include Vitamin E (dry forms), vitamin B1, niacin, folic acid, vitamin B12, zinc (zinc oxide), and selenium. The incorporation of β-carotene, vitamin B2, and iron as ferrous sulfate change the color of the fortified kernels and therefore these nutrients could be included if the plan is to produce fortified rice kernels that the consumer can distinguish as fortified. NAFDAC Act 2021 stipulates the range of micronutrients and their benchmarks adoptable in food fortification, although rice fortification was not explicitly covered.

In general, the type and level of micronutrient added in FRK for rice fortification is usually determined by a national technical consultative group on nutrition alliance based on several considerations including drawing from the World Health Organization (WHO) and Food and Agriculture Organization (FAO) guidelines on food fortification with micronutrients[13], which also covers the following:

- The Recommended daily intake of specific micronutrients,
- The highest level of intake poses no health risks.
- The level of specific micronutrients typically consumed by the target population, and
- The daily quantity of rice consumed by the target population.

[13]Allen, L.H., B. de Benoist, O. Dary & R. Hurrell, Eds. 2006. *Guidelines on Food Fortification with Micronutrients*. Geneva: World Health Organization/Food and Agriculture Organization

4.12 Perception of the Rice Millers (Field study)

Aside the recommendation from the nutritionists on the possible vital micronutrients/levels to be incorporated into rice, we examined the perception of rice millers regarding the possible content of FRKs, which are captured in figure 7. Their perception is in line with the perception of the nutritionist interviewed in the Federal Ministry of Health.

Figure 9: Responses of Respondents on the Micronutrients to be added as Fortificants

The micronutrients that were perceived to be vital in rice fortification in order of importance include: vitamin A, zinc, folic acid, iron, Vitamin B12, riboflavin, thiamine and niacin while other micronutrients such as manganese, Iodine, Selenium, etc. were considered less important. Most of the large rice millers are knowledgeable about food fortification as discovered from the field.

4.13 How can the Financial Sustainability of Rice Fortification be Ensured?

Primary investment decisions are required to trigger and to sustain rice fortification in Nigeria. Principal among which are creating awareness for the health improvement implications of consuming fortified rice to stimulate demand, and building local capacity among rice millers to enable them transition to rice fortification. Local capacity development would need to focus on installation of extruders and blending machines, and personnel development in the existing mills to enable local production of FRKs. Assurance of demand for fortified rice can enhance the prospect of profitability that would further encourage the rice millers to massively promote consumption and in the process push demand. In practical terms, nutrition conscious development institutions would need to demonstrate the value proposition of enriched rice nutrition to every segment of the Nigerian population as well as policy makers. Hence the entry point for sustainability of rice fortification is to stimulate demand using advocacy, regulation, and product stewardship.

The result of this study revealed that, the industry requires modest investments to commence the production of fortified rice. Structured financing would be required to encourage the sector to initiate and to sustain the fortification process at scale.

To ensure broad participation of actors in the rice processing sector, it is pertinent to have a rice fortification policy that can smooth access to FRK, ensure stable quality of the fortified rice that are made available to the population. Presently, such a policy is not in place but would need to be urgently developed.

Given the growing demand and consumption of rice in Nigeria noted in this study, the prospects are high for financial sustainability of the fortified rice project. One of the most significant enablers of sustainability envision for rice fortification in Nigeria is the pervasive micronutrient deficiencies that is worsening. If the micronutrient deficiencies remain critical in Nigeria, every avenue for reducing the problem is important. Hence, fortified rice offers massive health improvement impact because of the huge proportion of the population consuming rice.

It is also important to state that because of significant start-up and promotion costs, donor or public support are critical to kick-start the transition to rice fortification in the country.

CHAPTER FIVE

RECOMMENDATIONS

The study makes the following recommendations:

1) The established rice-based food preparation practice exposes rice to rigorous washing, and rinsing before and during cooking, which makes FRK production using the hot extrusion method appropriate for Nigeria;

2) There is high diversity in the micronutrient premix and concentrations in countries where rice fortification is implemented at large-scale such as India, China or Costa Rica from which Nigeria could learn from in developing its rice fortification standard. However, the country needs to activate its nutrition alliance consultative technical committee to develop appropriate guide/outreach programs to fast-track the nation's transition to rice fortification in conjunction with the ongoing fortification efforts of other key staple foods;

3) The estimated cost of FRK production in Nigeria and its importation shows that it is economical for the rice sector to explore both avenues of securing adequate quantities of FRK to support the rice fortification program of the country. At the early stages of the transition, its reliance on FRK imports may be critical until local capacities for FRK production are developed;

4) Base on the cost analysis, it is technically and economically feasible to proceed with rice fortification in Nigeria. The estimated average additional cost of fortifying rice in Nigeria is estimated between 2% to 3% over unfortified rice;

5) Drawing lessons from other countries such as India, Costa Rica and China, the following micronutrients could be considered to be included in fortified rice in Nigeria: vitamin B1, niacin, vitamin B12, folic acid, zinc (zinc oxide), and iron (as micronized ferric pyrophosphate);

6) The country would need also, to update the Food Fortification Regulations. The NAFDAC Act 2021 on food fortification regulations is silent on rice fortification.

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ANNEXES

Annexure 1: Checklist for key informants' interview

1. Do you know about rice fortification?
2. Has Nigeria started rice fortification?
3. Do you think there is a need for rice fortification in Nigeria and why?
4. What do you think could be a barrier to rice fortification in Nigeria?
5. Which segment of the population do you think will benefit more from rice fortification and why?
6. What type of fortification method do you think Nigeria can adopt and why?
7. What micronutrients do you consider as vital to be included in rice during fortification and why?
8. Do you have any knowledge on where the micronutrients can be sourced?
9. How much does it cost to purchase 1g of the following micronutrient?
   a. vitamin A b. Vitamin B12 c. Folic acid d. Iron E. zinc
   f. Niacin g. Thiamine h. Riboflavin i. Iodine j. Calcium k. Selenium
10. What percentage of the aforementioned micronutrient do you think is recommended for the following?
    a. Nursing mothers b. Women within reproductive age c. Children 5 years and below
    d. Children above 5 years e. Adults
11. Are you aware of fortified rice kernels (FRK)?
12. Where do you think FRK could be sourced?
13. How much does 1kg of FRK cost from the aforementioned source/s?
14. What is the landing cost of 1kg of FRK?
15. What is the cost of blending FRK with unfortified rice?
16. Are you aware of any regulations in place for food fortification?
17. What do you think is the cost for food regulation?
18. Please proffer us any other information you think is necessary to be considered before rice fortification commencement in Nigeria?

Annexure 2: Questionnaires used – LARGE MILLERS AND PROCESSORS

Instruction: kindly tick (√) or fills in the blank spaces as appropriate, you can choose as many options as possible.

1. What is the Installed capacity of your rice mill?
2. What is the capacity utilization of your rice mill?
3. Do you produce fortified rice kernels in your mill?
   a. Yes b. No
4. Do you import fortified rice kernel?
   a. Yes b. No
5. What is the landing cost of 1kg fortified rice kernels from your source?
6. What are the potential sources of FRK for your company?
7. Which of the following methods have your company adopted or would like to adopt to fortified rice?
   a. Hot extrusion b. Cold extrusion c. Coating
   d. Dusting e. None of the above f. All of the above
8. What is the motivation behind your choice of rice fortification method?
9. Are you participating in any government food and nutrition security intervention to improve rice quality by fortification?
   a. Yes b. No
10. Has your company ever participated in fortification (nutrient enrichment) of any product?
    a. Yes b. No
11. Which consumer segments are your targets?
    a. Adults b. Teenagers c. Children d. Malnourished individuals
    e. Vulnerable persons f. Others……………………………………………………………..
12. What are the reasons to your answer in question 11?
13. Do you think rice fortification is feasible in Nigeria?

    a. Yes b. No

    c. If yes, please state the reasons for your answer to question 13…………………………………..
14. Do you know any company that is producing fortified rice in Nigeria?
    a. Yes b. No
15. Please list three companies either producing or selling fortified rice in Nigeria?
    a.
    b.
    c.
16. What is the prevalence of fortified rice in Nigeria?
    a. High b. Medium c. Low
17. Why is this prevalence so in Nigeria?
    a. What are the possible barriers to the prevalence of fortified rice in Nigeria?
    b. Lack of technological knowhow
    c. High cost of producing fortified rice

d. Fortified rice is not generally accepted (Low demand)
e. Cooking methods prevent people from buying them
f. Fortified rice is quite expensive
g. Others- Please specify------------------

18. Why is this prevalence so in Nigeria?
19. What are the possible barriers to the prevalence of fortified rice in Nigeria?
    a. Lack of technological knowhow
    b. High cost of producing fortified rice
    c. Fortified rice is not generally accepted (Low demand)
    d. Cooking methods prevent people from buying them
    e. Fortified rice is quite expensive
    f. Others- Please specify...
20. What are the possible ways to increase the prevalence of fortified rice in Nigeria?
    a. The price of fortified rice should be reduced
    b. General awareness on the benefit of consuming fortified should be done
    c. Access to Fortified Rice Kernels
    d. Others..
21. Is the current rice processing in Nigeria moving or likely to move towards rice fortification?
    a. Yes b. No
22. What is the reason to your answer in question 19?
23. List the items that your company would need to start rice fortification?
24. What are prices of the items listed in question 22?
25. How willing are you to start rice fortification?
    a. Strongly wish to start
    b. Considering starting
    c. Not likely to start soon
26. List the factors that could hinder the involvement of rice fortification
27. If we have a law-making rice fortification mandatory, what could be your preferred source of fortified rice kernels (FRK)?
    a. Import b. Production
28. What are the reasons for your preferred choice of source of FRK?
29. What is the install capacity of your rice mill?
30. At what capacity is your company operating?
    a. 100 % Capacity
    b. b.75% capacity
    c. c.50% capacity
    d. 25-30 % capacity
31. What are the factors responsible for the level of capacity utilization?

a. Inadequate supply of paddy

b. High cost of electricity

c. Frequent breakdown of machine

d. Lack of spare parts

e. Low demand of your milled rice

f. Other- Specify

32. In your opinion, how prepared are the rice sector in Nigeria for rice fortification?
    a. Well prepared   b. Not prepared

33. Based on value chain approach, what is the comprehensive comparative cost analysis for dusting fortification technology?

34. In your opinion, do you think that dusting fortification technology has the capability and suitability of FRK production?
    a. Yes   b. No

35. What are the implications of introducing rice fortification in Nigeria?
    a. Food insecurity will reduce
    b. Malnutrition will be reduced
    c. More income to producers and the country
    d. It will lead to zero hunger in the country
    e. Others

Annex 3: Questionnaire for Research Institutions and Nutrition Related Institution

1. Which micronutrients should be added to the rice-premix?
   a. Zinc b. Iron c. Vitamin A d. Vitamin B12
   e. Vitamin B6 f. Others………………………………………………………
2. Why did you consider the micronutrient(s) necessary?
3. Which nutrients are lost during milling of rice that should be considered during fortification?
   a. Zinc b. Iron c. Fat and oil d. Vitamins
   e. Folic acid f. Others
4. Which nutrients are lost during cooking of rice that should be considered during fortification?
   a. Zinc b. Iron c. Fat and oil d. Vitamins
   e. Folic acid f. Others………………………
5. What fortification technology can better transmit the nutrient to consumers?
   a. Hot extrusion b. Cold extrusion c. Coating d. Dusting
   e. Others…………………………………
6. In your opinion, does rice fortification improve people's health?
   a. Yes b. No
7. Please explain your answer to question 6?
8. Has Nigeria started local production of fortified rice?
   a. Yes b. No
9. Do you think rice fortification is feasible in Nigeria?
   a. Yes b. No
10. What should be done to introduce and sustain rice fortification?
11. What is the prevalence of fortified rice in Nigeria?
    a. High b. Medium c. Low
12. Why is this prevalence so in Nigeria?
13. What are the possible barriers to the prevalence of fortified rice in Nigeria?
    a. Lack of technological knowhow
    b. High cost of producing fortified rice
    c. Fortified rice is not generally accepted
    d. Cooking methods prevent people from buying them
    e. Fortified rice is quite expensive
    f. Others………………………………………………………………………………………
14. What are the possible ways to increase the prevalence of fortified rice in Nigeria?
    a. The price of fortified rice should be reduced
    b. General awareness on the benefit of consuming fortified should be done
    c. Provide access to FRK
15. Is the current rice processing in Nigeria moving towards fortification?
    a. Yes b. No
16. What can drive the process of rice fortification?

17. What are the strengths of the current rice fortification?
18. What are the weaknesses of the current rice fortification?
19. What are the opportunities available for rice fortification?
20. What are the threats to rice fortification?
21. Within Nigeria, which rice fortification technology is economically viable and sustainable?
    a. Hot extrusion   b. Cold extrusion   c. Dusting   d. Coating
    e. Others
22. What is the reason to your answer in question 21?

Annex 4: Questionnaire for Regulatory Bodies and Donor Funded Projects

1. Do you think rice fortification is feasible in Nigeria?
   a. Yes b. No
2. State the reason to your answer in question 1
3. Has Nigeria started local production of fortified rice?
   a. Yes b. No
4. What is the prevalence of fortified rice in Nigeria?
   a. High b. Medium c. Low d. Non-existent
5. Why is this prevalence so in Nigeria?
6. In your opinion, is fortified rice healthy to the body?
   a. Yes b. No
7. What are the possible barriers to the prevalence of fortified rice in Nigeria?
   a. Lack of technological knowhow
   b. Lack of rice fortification regulation/Policy
   c. Fortified rice is not generally accepted
   d. Cooking methods prevent people from buying them
   e. Lack of support from the government
   f. Others
8. What are the possible ways to increase the prevalence of fortified rice in Nigeria?
   a. Enforcement of quality assurance
   b. Creating awareness on the benefit of consuming fortified should be done
   c. Monitoring of regulatory compliance
   d. Strong collaboration between regulators, rice millers and development partners
   e. Others
9. In your opinion, do you think Nigeria is viable for fortification?
   a. Yes b. No
10. What are the critical factors to consider before setting up a rice fortification project within Nigeria?
    a. Consumer preference
    b. Creating benchmarks for rice fortification
    c. Creating demand for fortified rice (market)
    d. Public education
    e. Others
11. What are the implications of introduction of rice fortification in Nigeria?
    a. It will help to tackle malnutrition in the country
    b. More work for regulators
    c. More revenue will be generated for the country
    d. More opportunity to collaborate with other stakeholders
    e. Others
12. In your opinion, do you think that the rice fortification companies should be regulated?
    a. Yes b. No
13. Which component(s) should be regulated?

a. Rice milling through to packaging b. Importers c. Exporters
d. Distributors e. Advertisers f. Retailers

14. How often should the rice fortification companies be inspected to ensure total compliance?
    a. Quarterly b. Twice a year c. Annually

15. In your opinion, should forticants be regulated?
    a. Yes b. No

16. Does your organization have the capacity to monitor the quality of FRK?
    a. No b. Yes

Annex 5: Questionnaire for Rice Fortification Input Suppliers/Importers

1. Do you supply fortified rice equipment?
   a. Yes b. No
2. Where do you obtain the rice equipment from?
3. Which of this rice fortification equipment do you sell?
   a. Hammer mill b. Mixer c. Extruder d. Dryer e. None
   f. All of the above
4. What is the cost of hammer mill in the market?
5. What is the cost of mixer in the market?
6. What is the cost of extruder in the market?
7. What is the cost of dryer in the market?
8. Do you sell fortified rice kernels?
   a. Yes b. No
9. Where does your fortified rice kernel come from?
10. What is the price of fortified rice kernel?
11. Do you know the important micronutrients used in fortified rice?
    a. Yes b. No

Annex 6: Questionnaire for Rice Retailers

1. What is the wholesale price of fortified rice per 25kg?
   a. ₦14,000 b. ₦16,000 c. ₦18,000 d. ₦20,000 e. Others (₦......................)
   f. Not available
2. What is the retail price of fortified rice per 25kg?
   a. ₦14,000 b. ₦16,000 c. ₦18,000 d. ₦20,000 e. Others (₦......................)
   f. Not available
3. What is the wholesale price of non-fortified rice per 25kg?
   a. ₦10,000 b. ₦12,000 c. ₦14,000 d. ₦16,000 e. ₦18,000
   f. Others (₦......................)
4. What is the retail price of non-fortified rice per kg?
   a. ₦10,000 b. ₦12,000 c. ₦14,000 d. ₦16,000 e. ₦18,000
   f. ₦20,000 g. Others (₦......................)
5. In your opinion, can Nigerians afford to buy fortified rice
   a. Yes b. No
6. Why did you answer so to question 5
7. What recommendations do you have to make rice affordable and researchable to many Nigerians?
8. What is the shelf life of fortified rice?
   a. 1-2 years b. 3-4 years c. 5-6 years d. 7-8 years e. Above 8 years
9. What is the shelf life of non-fortified rice?
   a. 1-2 years b. 3-4 years c. 5-6 years d. 7-8 years e. Above 8 years
10. How does this impact sales and consumption of non-fortified rice?
11. What is the shelf life of fortified rice kernel?
    a. 1-2 years b. 3-4 years c. 5-6 years d. 7-8 years e. Above 8 years
12. What is the shelf life of blended fortified rice?
    a. 1-2 years b. 3-4 years c. 5-6 years d. 7-8 years e. Above 8 years

Annex 7: Questionnaire for Consumers

1. Do you know about fortified rice?
   a. Yes b. No
2. Are you willing to eat fortified rice?
   a. Yes b. No
3. Are you willing to pay for fortified rice?
   a. Yes b. No
4. Do you think fortified rice has benefits for the body?
   a. Yes b. No
5. How much do you pay for 25kg non-fortified rice?
   a. ₦10,000 b. ₦12,000 c. ₦14,000 d. ₦16,000 e. Others (₦......................)

6. How much are you willing to pay for 25kg fortified rice?
   a. ₦10,500 b. ₦12,500 c. ₦14,500 d. ₦16,500 e. Others (₦......................)

7. Which of these micronutrients should be added to rice fortification?
   a. Vitamin A
   b. Folic acid
   c. Iron
   d. Zinc
   e. All of the above

END

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