

C:AVA

Cassava: Adding Value for Africa



MARKET OPPORTUNITIES FOR CASSAVA IN NIGERIA

Andrew Graffham
Diego Naziri
Andrew Sergeant
Lateef Sanni
Louise Abayomi
Bernard Siwoku

May 2013



Table of contents

Abbreviations/Acronyms/Exchange Rates.....	iv
Acknowledgements.....	v
Executive summary.....	vi
Introduction	1
High Quality Cassava Flour (HQCF)	3
Instant odourless fufu.....	6
Packaged garri/gari	7
Starch	8
Sugar-syrups / Sweeteners (Glucose syrup, high-fructose syrup & sorbitol)	9
Dried cassava chips for export.....	10
Dried chips for domestic consumption in livestock feed.....	12
Ethanol / biofuel	13
Beer	15
Cross cutting issues.....	16
Raw material supply.....	16
Lack of price data.....	21
End-user support	21
Conclusions & recommendations.....	21
Sub-sectors where BMGF could make interventions at several points in the value chain	22
Sub-sectors where BMGF could make interventions to support the development of smallholder inclusive raw material supplies for large-scale industries	23
Sectors with no potential in the short to medium-term	23
The way forward.....	25

Annex 1: Notes from the November 2012 and February 2013 missions covering the various sub-sectors for cassava-based products	26
1. High Quality Cassava Flour (HQCF)	26
2. Instant odour-less fufu	34
3. Packaged garri	36
4. Starch	40
5. Sugar Syrups & Sweeteners	45
6. Dried cassava chips	48
7. Ethanol/bio-fuel	64
8. Beer	68
9. Other issues.....	70
Annex 2: List of meetings	73

Abbreviations/Acronyms/Exchange Rates

AMPU	Autonomous Mobile Processing Unit
BGMF	The Bill and Melinda Gates Foundation
Capex	Capital Expenditure
C:AVA	Cassava Adding Value for Africa
CIDA	Canadian International Development Agency
CIF	Cost, Insurance and Freight
CTAP	Federal Government's Cassava Transformation Action Plan
DADTCO	Dutch Agricultural Development and Trading Company
EEG	Export Expansion Grant
FAO	Food and Agriculture Organisation of the United Nations
FCR	Fresh Cassava Roots
FUNAAB	Federal University of Agriculture Abeokuta
HFS	High Fructose Syrup
HQCF	High Quality Cassava Flour
IITA	International Institute of Tropical Agriculture
ITC	WTO/UN International Trade Centre
LPO	Local Purchase Order
NICAPMA	Nigerian Cassava Processors & Marketers Association
NRI	Natural Resources Institute
NSM	Nigeria Starch Mills
PIND	Foundation for Partnership Initiatives in the Niger Delta
SME	Small and Medium Sized Enterprise
TFI	Thai Farm International
UK	United Kingdom
USA	United States of America
USAID	United States Agency for International Development
WB	World Bank

N	Naira
USD	US dollar
£	Pound Sterling
ha	Hectare
kg	Kilogram
t	Tonne

EXCHANGE RATES

Phase 1 study: November 2012 = N150 to USD

Phase 2 study: February 2013 = N155 to USD

Acknowledgements

This study is an output from a research project funded by the Bill and Melinda Gates Foundation (BMGF) for the benefit of developing countries. The views expressed in this paper are those of the authors and do not necessarily reflect the views or policies of BMGF.

Executive summary

Nigeria is one of the largest producers of cassava in Africa with a long history of initiatives aimed at diversifying the market opportunities for this important crop. A favourable and supportive policy environment has encouraged the development of a range of cassava-based industries. However, cassava remains the second choice as a source of raw material for virtually all of the market opportunities seen in Nigeria. Much of the theoretical potential for cassava –based products has not been realised due to problems with accessing raw material supplies (in terms of volume, quality, price and reliability of supply), inefficient processing technologies and lack of appropriate technologies to enable potential end-users to adopt cassava-based alternatives to their existing sources of starch/flour.

During the studies in November 2012 and February 2013 the most promising sub-sectors were identified as high quality cassava flour (HQCF) for use in bread, biscuits, snacks and paperboard. Dried cassava for use in floating fish feed pellets for the aquaculture industry, starch for food and industrial applications and ethanol for industrial use and as a fuel for domestic stoves. There is also potential for cassava to be used as a partial substitute for barley in the production of clear beers. In theory these sub-sectors could consume ~10 million tons of fresh cassava root equivalents per annum and support the livelihoods of over 800,000 smallholders. However, based on current capacity and trends with the Nigerian cassava industry a more realistic assessment of achievable demand in medium term would be 755,000 tons of fresh cassava equivalents per annum supporting a maximum of 63,000 smallholders (see table 1 on page 2). Even these more conservative figures will not necessarily be achieved within the next 5 years as they depend on solutions to ongoing technical issues such as the avoidance of volume reduction in bread loaves. In addition raw material supply remains a major cross cutting issue that will influence success. Large-scale involvement of smallholders in these opportunities will depend on our ability to support companies to develop attractive smallholder inclusive procurement models.

For C:AVA2 the most promising sub-sectors could be further sub-divided into market opportunities (HQCF, aquaculture feed & ethanol for home cooking) where the BGMF could make useful interventions at several points in the value chain (farm, processor & end user) and market opportunities (starch, industrial alcohol & clear beer) where the BMGF would only focus on supporting the development of smallholder inclusive raw material supplies. The first group of market opportunities is characterised by including SME processors and involving small-scale end user operations that require technical support in order to adopt cassava-based products. The second group involves large commercial operations with well integrated value chains that do not require support in order to process or use a cassava-based product. However, there is a case for external intervention to support smallholder involvement in raw material supply which might otherwise be dominated by large commercial farms.

Our assessment of the market opportunities for cassava-based products also highlighted a range of sub-sectors that appear to have limited potential for realisation in the short to medium-term and would therefore not be recommended as suitable for BMGF support under C:AVA2. These included dry chips for export to China, dry chips for domestic poultry feed, cassava as a feedstock for sugar syrup production (especially high fructose syrup), ethanol for blending with petrol as part of the Governments E10 policy and packaged garri for high-value urban markets. Theoretically these sub-sectors could absorb ~13 million tons of cassava per annum and provide benefit for ~1 million smallholder farmers. However, the business and developmental cases are not good for any of these opportunities in the short to medium-term. Packaged garri for urban markets is a tiny market with little prospect of expansion. Ethanol E10 and sugar syrups would require very large capital investments and robust raw material

supply chains. There is little prospect of these investments taking place within the next 5 years. In the case of sugar syrups there are some prospects but all of the prospective investors are focused on procurement models that rely on large-scale commercial growers. Dry chips for export to China looks more attractive as the level of technology required to produce an unpeeled dry chip for industrial use is very low. However, a detailed assessment of the available data revealed that under current conditions Nigeria could not compete against rival sources of supply in South East Asia. Peeled chips for the domestic poultry industry is an apparently attractive opportunity with a strong developmental case. However, there are unresolved technical constraints and the business case is extremely weak with little prospect of change in the medium-term.

The next step for the C:AVA Nigeria team is to conduct investment studies to assemble the strongest possible business and developmental cases for inclusion of the most promising sub-sectors identified in the market studies as part of the BMGF investment in C:AVA2. These studies which are scheduled for early June 2013 should provide a firm basis for the development of C:AVA2 in Nigeria.

Introduction

The original work-plan for the Cassava Adding Value for Africa (C:AVA) project was designed around providing support for development of market opportunities for High Quality Cassava Flour (HQCF) in Nigeria. However, following the C:AVA strategy refresh exercise in late 2010, the lead organisations in the C:AVA Nigeria team (Federal University of Agriculture Abeokuta and Natural Resources Institute) decided that for possible future investments by the Bill and Melinda Gates Foundation (BGMF) it would be important to assess the full range of market opportunities for cassava-based products in Nigeria with a view to prioritising promising sub-sectors for future investment by the BGMF. We also recognised potential synergies with the Federal Governments Cassava Transformation Action Plan (CTAP) which has a much wider scope than the original C:AVA project.

Following preliminary studies in May 2011, the C:AVA Nigeria team developed a plan for a more detailed assessment of the potential of various markets for cassava-based products in the lead up to development of C:AVA2. We chose a three phased approach involving an initial scoping study of market opportunities for cassava-based products in Nigeria, followed by more detailed analysis of promising sub-sectors in in phases 1 & 2. In the third phase we plan to finalise the developmental and business cases for identified opportunities and make recommendations as to the most effective approach for further investments by BGMF under C:AVA2.

The current report deals with the outcomes of the scoping and detailed analyses of market opportunities which were developed and conducted jointly by a team from NRI and FUNAAB in November 2012 and February 2013. The team consisted of Dr Andy Graffham (Mission Leader & Food Technologist), Prof Lateef Sanni (Country Manager & Food Technologist) Dr Andrew Sergeant (business specialist/economist), Dr Diego Naziri (economist) Dr Louise Abayomi (Food Technologist), and Bernard Siwoku (Business Development Adviser / economist). The market subsectors included in the study were:

- High Quality Cassava Flour (HQCF)
- Instant odourless fufu
- Packaged garri (gari)
- Starch
- Sugar Syrups & Sweeteners
- Chips – for domestic livestock feed and for export to China
- Ethanol/bio-fuels
- Beer

The main report is divided into sections to cover each market subsector in detail, for each sub-sector we look at the current or potential market followed by our assessment of what might be achievable in the short to medium term (1-5 years from January 2014) for the purposes of C:AVA2. We also make a preliminary assessment of the potential for donor investment in the sub-sector with particular reference to the development of a strategy for C:AVA2. Table 1 provides a quick summary for all the market sub-sectors. Annex 1 provides detailed additional notes for each sector but it should not be necessary to read these in order to understand the business or developmental case for the various sub-sectors.

Table 1 Summary of potential demand for cassava-based products in Nigeria as of March 2013

Sub-sector	Competing ingredient	Current / potential annual demand for cassava-based products			Medium-term potential in FCR* equivalents t/yr	Potential for smallholder involvement	Comments
		Current market tons	Theoretical demand	Achievable demand			
HQCF in bread	Hard-Wheat Flour	2,500	400,000	40,000t	160,000	~13,300	Depends on solving root supply, processing & bakery inclusion issues
HQCF in biscuits	Soft-Wheat Flour	0	80,000	16,500t	66,000	~5,500	
HQCF in snacks	Hard-Wheat Flour	12,500	18,500	12,500t	50,000	~4,200	
HQCF in paperboard	Maize Starch	0	6,000	6,000t	24,000	~2,000	Depends on buy-in from paperboard factories
Instant Fufu	Wet Fufu	500	Niche market, with potential for development as a subsidiary market for HQCF SME's				
Packaged garri	Traditional Garri	50-100	100 t	100 t	430	V. small	Niche market no potential
Cassava Starch	Maize Starch	14,000	60,000 t	25,000 t	125,000 t	~10,416	Two established & one new factory opened in April 2013
Sugar Syrups	Maize-based syrups	0	200,000 t	0	0	0	Investment is unlikely in the medium-term
Chips for export to China	Cassava Chips from Thailand & Vietnam	0	2.2 million t	0	0	0	Nigeria is unable to compete, exports are not economic
Chips for poultry Chips for fish feed	Maize-based feed	0 Very small	450,000 t 23,000t	0 23,000t	0 74,000t	0 ~6,200	Depends on cost of maize, cassava & protein ingredients & access to pelletisation
Ethanol industrial	Imported ethanol	0	60 million litres	Industrial alcohol = 20 million litres E10 = 0 Home-cooking ~7.5 million litres	140,845 t	~11,737	The economics of E10 do not look favourable, cooking fuel is attractive but the business case requires clarification. Industrial alcohol offers a reasonable opportunity for smallholder inputs
Ethanol in petrol (E10)	Ordinary petrol without ethanol	0	700 million litres		0	0	
Ethanol for cooking	Kerosene & firewood (including charcoal)	0	1 billion litres		53,000 t	~4,416	
Cassava-based beer	Barley-based beer	0	30,800t ^a	15,400t	61,600t	~5,133	Dependant on firm commitment from breweries & tax incentives
Total					~755,000 t	~63,000	

* = Tons of fresh cassava roots (FCR) a = Cassava grits adjusted to 14% moisture or equivalent in wet-cake (~40% moisture)

High Quality Cassava Flour (HQCF)

Potential market – High Quality Cassava Flour (HQCF) is prepared from peeled and grated cassava, that has been de-watered, dried to 10-12% moisture content, milled and screened to give a fine flour capable of passing through a 0.25mm sieve. HQCF typically contains >90% starch but is not pure starch as it contains a certain percentage of fibre and traces of protein and fat. HQCF is so called to distinguish it from the many traditional cassava flours which are typically off white in colour, have a fermented smell and taste, and coarsely ground. The traditional products are not suited for use in bakery products or manufacture of paperboard adhesive.

HQCF is ideal as a complete substitute for starch in starch-based paperboard adhesives (SBA). In Nigeria HQCF currently costs US\$530/ton whereas imported maize starch (normally used in SBA) sells for US\$933/ton thus offering an attractive margin. The majority of Nigerian paperboard mills use imported ready mixed glue powders at a cost of US\$973 per ton. A single batch of ready mix glue will cost US\$292/batch. HQCF mixed with soluble borax, caustic soda and water will produce an HQCF-based SBA costing US\$128 per batch a saving of ~44% (actual saving will be slightly lower as formulations need to be tailored to the requirements of individual factories). Factories interviewed in November 2012 & February 2013 were interested in the potential cost savings but were concerned that they lack the in-house expertise to prepare SBA from first principles and were unsure of whether or not supplies of HQCF would be reliable. Given our current understanding of the Nigerian paperboard industry we estimate potential for sale of 6,000 tons per annum of HQCF for use in paperboard (equivalent to 24,000 tons of fresh cassava roots). The market for HQCF in paperboard is quite small but should be relatively easy to capture as there is no difference in performance of HQCF when compared to maize starch. It might also be possible to charge a price premium for this market in the short to medium-term given the high price of the competing ingredient.

However, the largest potential market for HQCF is as a partial substitute for wheat flour in bakery products. This is the market targeted by the Government of Nigeria's Cassava Transformation Agenda Project (CTAP) which is attempting to persuade millers and bakers to adopt 20% HQCF in bread and other bakery products. Substitution of wheat flour is potentially a very large market, Nigeria lacks the climatic conditions for wheat and only produces ~8,000 tons of wheat per annum. As a result Nigeria imports ~4 million tons of wheat per annum (3% of the global supply of wheat) to be milled in country. There are 22 mills in Nigeria but 2 mills dominate with one of these mills having the monopoly for soft wheat flour (used in biscuits & cakes). Until the food crises of 2012, the mills were operating at ~60% of capacity and produced 2.5 million tons of hard wheat flour (for bread making) and 500,000 tons of soft wheat flour. The quality of flour has always been variable resulting in the need to use standard bakery improvers to stabilise quality characteristics. In July 2012, duty was increased by 15% and prices went up by 20% due to government policies designed to promote HQCF and upward trends in the global price of wheat). As a result of these increases demand for hard wheat flour for bread has fallen to ~2 million tons per annum. In addition there is a demand for ~30,000 tons of hard wheat flour per annum for use by the eight major sausage roll manufacturers (7 in Lagos & 1 in Ibadan). Demand for soft wheat flour for use by the 15 biscuit companies in Nigeria has fallen to ~400,000 tons per annum.

During 2012 the price for wheat flour in comparison to HQCF diverged. In February 2012, HQCF was selling at US\$0.51/kg whereas hard wheat flour was selling for US\$0.53/kg offering no financial incentive for millers or bakers to use HQCF. By November 2012, the price of HQCF had risen to US\$0.53/kg but the bulk price of hard wheat flour at the mill-gate was quoted as US\$0.92 (users quoted prices ranging

from US\$0.93-US\$1.00). The bulk price for soft-wheat flour had risen to US\$0.80/kg at the mill-gate but one of the major customers reported a negotiated price of US\$0.77/kg. Further away from the mills in Lagos prices are much higher, for example in Abeokuta (approximately 100km from the mills) the bulk price for hard wheat flour was quoted as US\$0.99 but for small-bakeries (who produce 80% of Nigeria's bread) the retail price in Abeokuta was quoted as US\$1.07/kg. The high price of wheat flour is forcing bakers to re-evaluate the case for using HQCF but as we will see later successful incorporation of HQCF presents many challenges that C:AVA-Nigeria are helping millers and bakers to address.

The key market for HQCF is as a partial substitute for wheat flour in bread. Using hard wheat flour containing conventional bakery improvers, HQCF can be incorporated at levels of ~7% without adverse effects on loaf quality. Above this level the volume of the loaf is visibly reduced and the texture of the bread has a heavy cake like texture due to the absence of gluten in HQCF. Furthermore shelf-life will reduce from 7-10 days to ~4 days due to the hygroscopic nature of HQCF that encourages mould growth. However, bakery improvers are available in Nigeria that allow 20% incorporation of HQCF with a 7-8 day shelf-life. One of the major bakeries has launched a 20% HQCF line of products including bread, sausage rolls, cakes and cookies. The 20% HQCF loaf is being retailed at US\$0.67 whereas conventional loaves are sold at US\$0.80 for a 400g loaf. The HQCF loaf is proving popular with estimated sales of 6,500 loafs per day. The bakery is currently buying 600-720 tons of HQCF per annum from the two major suppliers of HQCF and four of the HQCF producing SME's. Purchases from SME's have been constrained by problems with reliability of supply especially in terms of quality control. In theory a 20% substitution would create a demand for 400,000 tons of HQCF per annum (equivalent to 1.6 million tons of fresh cassava roots). However, the bakers and millers remain concerned about incorporation of HQCF in bread flour (either in mill or in the bakery), some technical issues need to be resolved and there is a desperate need for a sensible and coherent policy for inclusion. NRI and C:AVA-Nigeria are working with a manufacturer of flour improvers and industry representatives in Nigeria to evaluate an alternative flour improver that appears to have potential to allow incorporation at >20% HQCF.

The second market for HQCF in bakery products is for use in biscuit factories as a partial replacement for soft wheat flour. Prices for soft wheat flour are lower but there is still enough margin to attract interest if HQCF can be used at 20% or higher. Recent trials have shown that HQCF can be used at 10% in hard and soft-dough biscuits but at 20% problems were encountered with machinability and reductions in product volume. These problems are hindering uptake of HQCF by the 15 biscuit factories in Nigeria but several expressed interest in participating in trials with flour improvers to overcome the current problems. If 20% substitution of HQCF became possible demand from the biscuit factories would require 80,000 tons of HQCF which is equivalent to 320,000 tons of fresh cassava roots.

The third market for HQCF in bakery products is the packaged sausage roll market. Nigeria has 8 large sausage roll companies competing to supply a packaged sausage roll with a 10 day shelf-life under tropical ambient conditions. All of the sausage rolls sell on the street for US\$0.30 per item and the market is highly competitive. Recently one company increased their retail price to US\$0.47 per roll, they failed to sell any products for two weeks and were forced to reduce the price back to US\$0.30. The 8 companies are estimated to buy 60,000 tons of hard wheat flour per annum (but this could be as high as 100,000 tons/annum) for use in the outer casings which have a rubbery non crumbling texture obviously designed for rough handling by street-vendors. The companies were formerly buying wheat flour or maize starch as a binder for the meat filling. Rising raw material costs have encouraged interest in HQCF by the sausage roll companies. HQCF has been used to some extent in the outer casings but has also

proved to be highly effective as a binder for the meat filling and is believed to have virtually completely replaced wheat flour and maize starch for this purpose. Most HQCF is procured from the 2 main producers of HQCF and the market is reported to be ~12,480 tons of HQCF per annum (equivalent to 50,000 tons of fresh cassava roots) for use as a binder in the meat filling. If better flour improvers become available it should be possible to use at least 20% HQCF in the outer casings, this would create additional demand for 6,000 tons of HQCF per annum equivalent to 24,000 tons of fresh cassava roots. The total demand for HQCF in sausage rolls could be ~18,500 tons equivalent to 74,000 tons of fresh cassava roots.

In the medium-term the theoretical demand for HQCF for use in bakery products and paperboard industries could be ~500,000 tons of HQCF per annum (equivalent to 2 million tons of fresh cassava roots) if all of the current constraints to uptake could be resolved.

Achievable demand – Current HQCF production is centred around 2 large-scale commercial producers (maximum output 100 tons of HQCF per day for the 2 factories) using imported equipment benefiting from economies of scale and more efficient processing techniques and a number of small-medium scale enterprises using locally fabricated equipment with a capacity of 1-2 tons of HQCF per day. The largest factory has a capacity of 18,000-20,000 tons of HQCF per annum (equivalent to ~80,000 tons of fresh cassava roots) but in 2012 this factory operated at ~55% of capacity and produced ~11,000 tons of HQCF selling at US\$0.53/kg. The other large factory (capacity of ~15,000 tons/yr) is a hybrid operation relying on mobile processing units to obtain partially processed wet cassava-cake from rural locations for drying and milling at the main factory. Nigeria has ~153 SME HQCF factories that were mainly built during the Obasanjo government that left power in 2007. These factories were established using inefficient locally fabricated equipment with the intention of benefiting from President Obasanjo's policy for 10% inclusion of HQCF in bread flour. Most went out of business during 2008-2009 as they were not competitive and demand for HQCF had fallen. By 2010-2011 C:AVA Nigeria estimated only 23 SME's to be operational, by November 2012 this was nearer to 6-10 SME's, but 4-5 new operations were under construction in South Western Nigeria using more efficient equipment developed with support of C:AVA-Nigeria. The current output of HQCF from the operational SME factories in 2011-2012 was ~4,500 tons (based on figures supplied by NICAPMA).

If all SME the factories returned to operations they would have a capacity of ~67,000 tons but this is unrealistic. At a rough estimate no more than 50 of these factories are likely to be rehabilitated and return to operations even under the current favourable conditions. If 50 SME's resumed operations with upgraded equipment (as recommended by C:AVA) they would have a capacity of ~25,000 tons of HQCF per annum. The largest and most successful producer of HQCF believes they will reach full capacity for their current factory by end March 2012 due to increased demand and improved sourcing of cassava roots. They are also believed to be planning to establish a second HQCF factory of similar size to the first one in 2013 which would double the factories capacity to 40,000 of HQCF within the short to medium term. Overall in the medium term HQCF capacity seems set to increase from ~35,000 tons to 75,000 tons of HQCF per annum. This would only deliver 15% of the theoretical demand mentioned above, but investors remain cautious due to problems with obtaining reliable supplies of cassava roots at competitive prices, unresolved technical problems with using HQCF in bakery products and in the case of SME's operations ongoing issues over highly inefficient processing equipment that make profitable operation difficult or impossible at US\$0.53/kg. SME processors interviewed by the C:AVA Nigeria team estimate that HQCF would need to sell for US\$0.67/kg to be profitable under current conditions (in terms of current root prices & inefficient processing equipment). These figures seem reasonable in the

light of detailed financial analysis carried out by C:AVA. However, it is hoped that processing costs can be significantly reduced as a result of C:AVA interventions to develop low-cost energy efficient upgrades for existing drying technology to enable it to run on either kerosene or solid wastes such as palm kernels and cashew shells. In March 2013 a new type of heat exchanger was installed at an SME (with C:AVA support) to run on palm kernel shells. Using the new heat exchanger output was maintained but energy costs were reduced by 88% when compared to using black oil the next cheapest alternative fuel source which was proving to be too expensive.

Opportunities for donor investment – HQCF remains a promising sector for C:AVA in Nigeria, even under current conditions we estimate HQCF sales (excluding the hybrid wet-cake operation) to be approximately 15,000 tons per annum which is equivalent to 60,000 tons of fresh cassava roots. Delivery of this volume of roots will support the livelihoods of ~5,000 smallholder farmers. The market for HQCF is currently favourable and likely to remain so in the medium-term due in part to government policy but mainly due to the overall trend in global wheat prices which seem unlikely to undergo a dramatic fall. In fact the current conditions of rapid global economic growth with demand outstripping supply and inflated prices for virtually all commodities and especially oil coupled with increases in extreme climatic events linked to climate change make it high likely that current high prices for wheat will remain firm or even increase in the period to 2020. Constraints to using HQCF in bakery products and problems with inefficient processing technologies seem likely to be resolved. There are very real prospects of realising a market for 500,000 tons of HQCF in the medium-term in Nigeria with a requirement for 2 million tons of fresh cassava roots. Supply of this volume of roots could potentially support ~170,000 smallholders although in reality some of the root supply will come from commercial operations as larger-scale production of cassava becomes more common in Nigeria.

There are opportunities for donor investment particularly in the area of competitive production of cassava roots as a commercial crop by the smallholder farmer. This is perhaps the most important issue for development of the HQCF market and any other market in Nigeria that relies on cassava roots as its main source of raw material. Support is also required to maximise operational efficiency and marketing strategies of the SME operators and support should also be given to resolve the remaining technical constraints to use of HQCF in bakery products.

Instant odourless fufu

Potential market – Traditional Nigerian fufu is a wet fermented cassava dough (sometimes containing plantain or other root and tuber crops) that is steamed and eaten with meat or vegetable stews. This is a popular meal in Southern Nigeria and can be readily obtained from many small outlets in urban centres. The size of the traditional fufu market is difficult to quantify but thousands of producers are involved in Southern Nigeria with monthly sales reported to range from 0.5 – 29 tons of fufu per month. Over the last 15-20 years a dried odourless product has been developed as a convenience food known as instant fufu. Instant fufu is essentially a fermented and dried flour (more coarsely milled than HQCF) that can be mixed with hot water and steamed to form a stiff dough that resembles but is not identical to the traditional fufu product. It has the advantage of being shelf-stable and quick and easy to prepare when compared to the traditional product. The disadvantage of instant fufu are organoleptic differences from the traditional product. Currently instant fufu is a niche market with ~4 SME's involved in production, one SME dominates with a ~51% share of annual sales. According to data collected by the C:AVA Nigeria team 470 tons of instant fufu were sold in 2011/2012 (reports from NICAPMA) which

is equivalent to 1,880 tons of fresh cassava roots. Instant fufu costs ~US\$0.57/kg to produce but sells for US\$1.67-2.0/kg thus indicating a good margin for this product.

Achievable demand - Instant fufu is currently a small niche market that offers good margins to a small number of SME's. None of these businesses rely on instant fufu as their main source of income but produce a range of other food products with instant fufu as a profitable side-line. Instant fufu can be produced using much of the same equipment as that found in the Nigerian HQCF factories although some additional equipment is needed and the wet end of the two processes must be kept separate to avoid contaminating graters and presses and ending up with fermented HQCF. Instant fufu has proved profitable for a few of the HQCF companies, the question must be asked as to whether opportunities exist for this market to expand? Preliminary data from a large traditional wet-fufu market close to Abeokuta indicates that instant fufu powder may work out cheaper than purchasing cooked wet balls of traditional fufu. If this is confirmed it would appear that instant fufu powder could work out cheaper than purchasing cooked balls of wet fufu in retail markets. If this finding is confirmed there should be potential for growth of the instant fufu sector especially in smaller urban centres.

Opportunities for donor investment – Instant fufu is unlikely to be a large opportunity in its own right but would be worth supporting as an add on to any investment in the HQCF value chain. Donor support could help improve competitiveness of root supply, processing efficiency and improved marketing of the end product.

Packaged garri/gari

Potential market – Garri is a shelf-stable (10-12% moisture content) granular product made by roasting and drying small particles of fermented partially dewatered cassava mash. Garri is a highly versatile food that can be added to stews or simply mixed with water or milk (sugar may be added) and eaten on the street as a filling snack. Garri which is highly popular with all age groups is traditionally prepared by women in rural and urban communities on a small-scale using simple equipment with a very low level of capital investment (often garri makers operate in groups & share capital intensive items such as a motorised grater & screw presses). The Nigerian market for traditional garri is very large, in 2011 garri sales were estimated at ~6 million tons which is equivalent to ~26 million tons of fresh cassava roots or about 68% of Nigeria's annual production of cassava. Many attempts have been made to industrialise garri but these have been unsuccessful partly because of the high cost of the end product and also because industrially produced garri is very similar (or even inferior) organoleptically to the traditional product thus offering no positive point of differentiation. However, the rise of the urban middle class has created a niche market for nicely packaged garri for sale in supermarkets, petrol stations and corner-shops. The impression (from words on the packaging) is given that this garri has been produced under more hygienic conditions but investigations by the C:AVA Nigeria team indicate that this garri is mostly traditional product purchased in open markets and then re-packaged for re-sale at a higher price. Packaged garri is a high priced niche product with current sales ranging from 50-100 tons per annum (equivalent to 215-430 tons of fresh cassava roots). There are only a few companies involved with the largest company capturing ~75% of the market.

Achievable demand – Although packaged garri offers reasonable profits for a small number of players there appears to be very little opportunity for growth and it is clear that packaged garri is not adding to production but simply diverts a very small percentage of the traditional product into a higher value market.

Opportunities for donor investment – There appear to be no opportunities for donor investment in packaged garri and the sector is unlikely to have a real developmental impact. Traditional garri is a major business that appears to run very well although the method of production raises environmental and worker health and safety concerns. The C:AVA Nigeria team cannot envisage any realistic opportunity for useful donor investment in the garri sector and we do not recommend inclusion of garri either packaged or traditional in the strategy for C:AVA2. However, it will be important to take account of traditional garri production in any plans for investment in other sectors as traditional garri dominates utilisation of cassava roots in Nigeria and is often the key driver for price and availability of cassava roots.

Starch

Potential market – Starch has a wide range of food and industrial applications. In Nigeria 80-90% of starch is used in the food industries with examples including stock cubes, instant beverage powders and custard powders, the remainder is used by the pharmaceutical, paper, corrugated board and textile industries. All of these industries are believed to be reliant mainly on native starches (not chemically or physically modified) and could use starch from almost any source. In practice >90% of starch used is imported native maize starch (cassava starch is a prohibited import) sourced mainly from China (40%) and India (30%). The exact size of the Nigerian starch market is difficult to determine but we estimate it at ~60,000 tons / annum (equivalent to 300,000 tons of cassava roots). Nigeria has been attempting to develop a local starch industry since 1964 and although at least 8 factories have been built there has been limited success and only three factories remain operational with a capacity of ~50,000 tons per annum of cassava starch and probable production of no more than 14,000 tons in 2012.

The most established of the operational factories has a capacity of ~7,000 tons per annum, as recently as 2006 they operated at 86% of capacity but they currently run at 57% of capacity (4,000 tons of starch equivalent to 20,000 tons of fresh cassava roots) due to difficulties in obtaining roots supplies of the right quality at a competitive price. The companies' main customer says that would buy the factories entire output if root supplies were available. Until mid 2012 cassava starch was cheaper than imported maize at US\$900/ton for cassava starch as compared to US\$933 for maize. Since mid 2012 food shortages (due to floods and high food prices) have increased demand for garri pushing up cassava root prices and making sourcing close to the starch factory difficult (in February 2013 roots were being sourced from farms 350km from the factory) as well as locally. This has resulted in cassava starch prices increasing to US\$1,133/ton. Nestle accepts that this price is likely to be temporary and is continuing to buy local produced cassava starch as part of their buy local policy.

Achievable demand – The Nigerian starch market is quite small (although large by sub-Saharan African standards) and cannot sustain many factories or allow for investment in higher value products such as modified starches without access to export markets. However, Nigeria struggles to supply sufficient starch for domestic consumption and is non-competitive when compared to major starch producing nations. Although CIF prices vary according to the type of starch, quality and origin, average unit values for all starches from China and India in 2010 were US\$498 and US\$784 respectively. Thailand the worlds' largest producer of cassava starch can produce native cassava starch for US\$433-US\$467 per ton as compared to at least US\$900 per ton for Nigerian cassava starch. There are several reasons for this disparity in prices, Thailand has access to cheaper roots with much higher starch contents, starch extraction is more efficient, power and water supplies are cheaper and more reliable and the larger Thai

factories have advantages of economy of scale with outputs 7-10 times greater than the biggest starch factories in Nigeria.

The current prospects for Nigerian cassava starch are not very promising due to problems with access to competitive sources of raw material, cheap sources of power and energy and even access to water in some cases. However, there is still interest in investing in cassava starch, during the February 2013 visit a new factory was identified in Ogun State that was due to start operations in April 2013 with a capacity of 18,000t of cassava starch per year. In addition there is evidence that an 18,000 ton per annum starch factory will be built in Kwara State and probably become operational by late 2014. These are encouraging developments and although cassava starch is unlikely to be a very big opportunity in the medium term the existing factories could offer a potential market for ~10,500 smallholders.

Opportunities for donor investment – In the case of cassava starch the main opportunity would be to work with the large starch factories to improve access to a competitive raw material via a smallholder inclusive route. Support for development of relationship farming and improved farming practices should be encouraged.

Sugar-syrups / Sweeteners (Glucose syrup, high-fructose syrup & sorbitol)

Potential market – Starch from cassava roots or other carbohydrate sources such as maize can be hydrolysed using enzymes to form glucose syrup. Glucose syrup is actually a mixture of malto-dextrins of varying chain lengths. Glucose syrup is actually not particularly sweet when compared to sucrose but has applications in the food and beverage industries as a thickener used to give products body. Glucose syrup can be further refined to produce pure glucose for use as a sweetener. Alternatively the syrup can be treated with glucosyltransferase to form high fructose syrup (HFS). HFS has the advantage of intense sweetness at low concentrations and is favoured for carbonated drinks. The basic conversion yields a syrup containing 42% fructose, 55% glucose & 3% dextrin's which has many applications but is not of the right sweetness for use in beverages. HFS-42 can be further refined for industrial purposes to produce 90% fructose syrup which is then blended with HFS42 to produce HFS-55 (55% fructose, 41% glucose & 4% dextrin's) for sale to the beverage industries. HFS55 has the correct sweetness is stable, extremely soluble in water and thus has considerable advantages as a replacement for sucrose. It can also be used in bakery products, confectionary, soft ice-cream and other dairy products. HFS has received a bad press recently especially in the US. Allegations have been made of links between HFS in the diet and obesity, diabetes and related complaints, but the medical evidence is inconclusive. Sorbitol is a low-energy sugar alcohol produced by catalytic hydrogenation of glucose syrup. Sorbitol is commonly used in health (for dieting) foods and also by pharmaceutical industries.

Nigeria imports 50,000-70,000 tons per annum of glucose syrup at a cost of US\$933/ton mainly for use by the biscuit, snack and brewing industries (mainly for use in malt drinks and stouts such as Guinness). It is believed that much of the imported syrup comes from China. Very little is known about consumption of sorbitol but it is likely to be restricted to pharmaceutical industries and involve quite small volumes. HFS is an unfamiliar product in Nigeria but a major Nigerian beverage maker has confirmed that they are interested in HFS as a substitute for sugar in their beverages. The Nigerian beverage industries are estimated to be using 300,000 tons/annum of sugar which would equate to ~150,000 tons of HFS. If demand for glucose syrup and potential market for HFS were supplied by locally produced cassava-based products this would require 332,000 and 750,000 tons of fresh cassava roots respectively.

Achievable demand – There has been one attempt to produce glucose syrup from cassava roots in Nigeria. This company was operational from 2007-2011 but was not operational in 2012. Glucose syrup was produced from fresh cassava roots and sold to several of the major breweries and one of the major food companies at prices ranging from US\$700-US\$833 per ton. These prices compare favourably with glucose imported from China at US\$933/ton. However, the company has not been able to obtain sufficient volumes of roots of the right quality at a competitive price and the business has proved unsustainable. The company reported that costs of fresh roots accounts for 25% of the production cost, at current prices given a conversion ratio of 4.6:1, production of glucose syrup would cost US\$1,288 per ton which explains why production was not profitable. A major investor in Nigeria is reported to be considering an investment in a 50,000 ton/annum factory to produce HFS and starch. Given that refined sugar is selling at US\$1,067/ton (delivered) and with a roughly estimated cost for HFS production (given a conversion ratio of 5:1 and a cassava root price of US\$80/ton) of US\$600 per ton HFS might appear an attractive investment. However, production of HFS is a relatively complex process (compared to HQCF or even starch) and given the current problems with obtaining reliable supplies of roots of the right quality at competitive prices it could be difficult for a new entrant to become established as a supplier of HFS. Major customers will require large volumes of HFS and guarantees of consistent supplies to persuade them to convert their factories from crystalline sucrose to liquid HFS. Based on the discussion with the beverage maker it would seem likely that HFS would have to be priced at 75% of the sucrose price in order to prove attractive. Overall the C:AVA Nigeria team see little prospect for development of this sector in the medium-term and we therefore do not recommend inclusion of sugar syrups / sweeteners as part of C:AVA2.

Dried cassava chips for export

Potential market – Dried cassava chips are a shelf-stable product that can be used as a carbohydrate energy source or an industrial feedstock for production of alcohol and various sweeteners. Internationally China has created a large demand for cassava chips for industrial purposes since the Chinese Government decided in 2007 to discourage production of alcohol from cereal crops as part of a drive to avoid undermining food security through diversion of food crops into biofuel production. China has 5 major ethanol producers but not all of these were using cassava as of mid 2012. The second largest of these is Henan Tianguan Group Ltd. According to Tenan Tianguan Group they produced 500,000 tons of biofuel ethanol and 180,000 tons of potable ethanol in 2011. This level of production required ~1.36 million tons of dry chips (equivalent to 4.08 million tons of fresh cassava roots) According to figures sourced from the Chinese Cassava Agro Technology Research System (CCARS) and UNCTAD, China produced 8 million tons of cassava roots in 2011, some 52% (4,680,000 tons of FCR equivalent to 1.56 million tons of dry chips) of this was used for ethanol production and the rest was used for production of starch & sugar syrups. In addition Thailand and Vietnam are currently the major suppliers of dried cassava to China supplying 4 million and 0.7 million tons respectively in 2011-2012. It is reported that 85% of the global supply of dry cassava is being used by China for ethanol production. The current Chinese market for chips for ethanol production can be estimated at ~6.3 million tons per annum. According to the USDA (GAIN) China produced 2.4 billion litres (equivalent to 1.92 million tons) of ethanol in 2012. Production increased by 8% from 2011 and overall production is predicted to grow by 6-8% over the next 5 years. Thailand and Vietnam are the major drivers in setting prices for dried cassava in the far eastern market. Current prices for dried cassava to China are US\$139 / ton and US\$178 / ton FOB for Thai and Vietnamese chips respectively. The largest importer of dried cassava into China is said to be Asia Cassava Holdings Limited (ACR) with head offices in Hong Kong and operational

bases in the major ports of mainland China. According to ACR they are investing in production of dried cassava in Cambodia and Laos to boost supplies.

Another interesting development in the Chips to China story is the Government of Thailand's alternative energy plans to reduce reliance on fossil fuels. In 2008 the Department of Alternative Energy Development and Efficiency (DEDE) of the Government of Thailand launched their 15 year alternative energy plan. The DEDE plan calls for an increase in domestic biofuel production from 2008 levels of 328 million litres per annum to a projected 3.3 billion litres of ethanol by 2022. The projections in the plan envisage increases in cassava production both in terms of planted area, yield and starch content. However, exports of dry chips are projected to decline by 75% from ~4 million tons/annum (98% of which went to China) to 1 million tons per annum by 2018 and then remain stable at this level but with a marked increase in price. This development has serious implications for China as the major customer for Thailand's dry cassava chip exports. Most of China's agricultural land is outside the cassava growing belt (extending from 20° south to 20° north of the equator) leaving little opportunity for dramatic increases in domestic production of cassava. This means that China will have to invest in alternative sources of supply if they wish to continue to use cassava (NB China is experimenting with sweet sorghum as a potential feedstock but this is not yet available in commercial quantities). Vietnam, Cambodia and Laos are obvious targets but in the longer-term opportunities may well arise for sourcing from countries in sub-Saharan Africa such as Nigeria.

According the Federal Government of Nigeria, Chinese demand for dried cassava is outstripping supply creating an opportunity for Nigeria to export at least 2.2 million tons of chips per annum (~3 million tons of fresh cassava) at a price of US\$272 million (which equates with US\$124/ton). However, one of the former exporters said that China is willing to pay US\$210 /ton CIF for Nigerian cassava exported to China. In theory this a highly attractive opportunity based on the assumption that "surpluses" of cassava exists in Western and Central states of Nigeria. Conditions in these states are favourable for sun-drying of chips (reducing production costs) and production of cassava chips can be as simple as peeling and slicing with a knife (manual and mechanised chipping machines can be used) and drying on a mat or simple wooden rack. The reality has been different, previous (early 2012) interviews conducted by members of the C:AVA Nigeria team had identified two main exporters of cassava chips from Nigeria, one of whom claimed to have exported 10,000 tons of chips to China in 2010. Follow-up calls to these exporters in November 2012 found that both have withdrawn from the business as they have not been able to make any money. In fact one exporter said that they had made a loss trying to export chips to China. According to the Federal Government, trial shipments of 150 and 200 tons of chips had been made over a 2 month period in 2012 but there has been no feedback from China and no further shipments as of November 2012.

Achievable demand – The problem for Nigeria is how to produce at a competitive price, for dry chips this starts with the cost of fresh cassava roots. Root prices vary according to season and location but based on current information it seems unlikely that a chip producer could buy roots for less than US\$53 per ton (further investigations of root prices in North Central Nigeria will be made in February 2013) with a conversion factor of 3:1 three tons of cassava roots would be required at US\$159 to produce 1 ton of chips. Setting aside processing costs for a moment, the would be chip exporter faces costs of US\$32 per ton for transportation to the port, US\$40 / ton for port administration costs and US\$80/ton for container freight to China. Given a price of US\$210/ton and total costs so far of US\$310/ton without allowing for processing and transportation from the farm to the collection point, it appears that chips for export cannot be produced competitively under current conditions. Failed attempts by businesses in

Ghana back in the 1990's to export dry chips highlighted some of the many pitfalls of this business. Processing of chips on farm is more expensive than imagined due to high labour costs and poor reliability of processing equipment. Further costs and difficulties are incurred in transporting dry chips from the farm to the nearest road for collection by lorry. Road transportation and handling at the port is typically more expensive and far less efficient than Thailand or Vietnam. For example in 1996, freight costs in Ghana were US\$5/ton for dry chips as compared to US\$1.6 per ton in Thailand. Overall there appears to be no potential for export of dry chips from Nigeria in the short to medium-term (although this may change in the longer-term) and no obvious opportunity for donor investment. The C:AVA Nigeria team does not recommend inclusion of cassava chips for export under C:AVA2.

Dried chips for domestic consumption in livestock feed

Potential market - Cassava chips offer a readily digestible source of carbohydrate energy (85-93% that of maize grain) as an alternative to maize in animal feed formulations. However, unlike maize cassava contains very little protein so any formulation containing cassava must contain a suitable protein supplement. For cassava to compete with maize, the cost of the cassava plus the protein supplement (such as soy or fish meal) must be significantly cheaper than the existing maize based formulation. There can also be technical problems, cassava chips are best suited for use in cattle and pig rations. For use in poultry and aquaculture feeds the cassava must be pelletised. In the case of poultry palletisation avoids palatability issues, increased water intake and problems with dust that may lead to chronic respiratory syndrome.

Nigeria has relatively low demand for cattle and pig feeds but the poultry sector is a large and expanding sector that currently consumes 2 million tons of maize based (mainly non-pelletised) poultry rations per annum. If 25% dried cassava was incorporated into the feed ration in place of maize (and supplemented with soymeal) this would require 450,000 tons of dry chips per annum equivalent to 1,400,000 tons of fresh roots. Supplying this market could support the livelihoods of ~100,000 smallholder farmers. Our analysis indicates some potential for use of cassava in broiler rations especially at times when maize is scarce and costly. However, these advantages would be seasonal at best and it must be noted that the costs of protein supplements (soybean meal & groundnut cake) have doubled in the last two years making cassava unattractive as an alternative to maize in poultry rations.

Several feed millers reported that they had used dried cassava in the last 5 years but had stopped due to palatability issues. Dried cassava chips generate dust which is not liked by poultry and also increases the likelihood of chronic respiratory disease in poultry. Pelletisation was recognised as a possible solution but only 1 mill in Nigeria is reported to have facilities for producing pelletised rations and this was not visited in November 2012 as it lies in a high-risk area in Northern Nigeria. Several feed millers expressed some interest in cassava but would be unwilling to invest in a pelletised product unless a robust business case for inclusion can be demonstrated. This seems unlikely to be achieved given the high-cost of available protein supplements.

Aquaculture in Nigeria is still a fledgling industry although it appears to have good prospects for expansion, currently 22,000 tons of floating pellets are imported from the Netherlands and 4,000 tons of sinking pellets are produced locally. These markets are small, but aquaculture is expanding rapidly with a tenfold increase in production over the last 10 years. Nigeria is now the largest aquaculture producer in sub-Saharan Africa and second in the whole of Africa after Egypt. Currently aquaculture accounts for 25% of Nigeria's fish production with annual yields of >200,000 tons of catfish and tilapia but this is

continuing to expand to meet increasing demand for fish as a source of animal protein especially in urban and peri-urban areas.

Achievable demand – Information gathered in November 2012 & February 2013 indicate that cassava chips for use in pelletised poultry feed could be an interesting opportunity but available figures do not look promising. According to our estimates a cassava-based ration (containing 20% dried cassava & 45% soybean meal) would break even at US\$117 per ton but this would require cassava roots to be available at US\$40-47 per ton which is very low for Nigeria. Cassava could only compete with maize on a reasonable basis for use in broiler rations and the high cost of protein supplements weaken the business case for cassava in poultry rations in Nigeria. In addition locally sourced cassava would simply switch the market away from locally sourced maize offering few real advantages. Overall it seems unlikely that this will be a realistic opportunity in the medium-term. In contrast cassava in aquaculture feed looks much more promising due to its technical advantages in floating fish pellets and reduced level of protein ingredients when compared to poultry feeds. At least one of the ten aquaculture feed companies in Nigeria is already using cassava and several other companies have expressed interest in adoption of cassava as an alternative to maize. Aquaculture feed manufacturers appear willing to pay a much better price for cassava than the poultry feed millers.

Opportunities for donor investment – There is still work to be done on the detailed business case for cassava in aquaculture feed but it looks as though C:AVA2 could work with farmers, feed millers and fish farmers to increase adoption of cassava in locally produced floating pellets. This would be an advantage over poultry feed in that locally produced cassava-based floating pellets would act as an import substitute replacing existing pellets from the Netherlands.

Ethanol / biofuel

Potential market – Nigeria imports ~60 million litres per annum of refined ethanol mainly from Brazil, the price for ethanol is US\$2 (300N)/litre. Some 27 million litres of this is used by the 4 major distillers to produce alcoholic beverages. The rest is used by the pharmaceutical and chemical industries. Virtually all ethanol is imported although one of the distillers confirmed that they buy and refine small volumes of local gin, but this supply is limited in terms of volume and reliability of supply due to shortages of fermentable sugars.

There are also two potential markets for industrial alcohol in Nigeria the first is as a partial substitute for petrol in motor car fuel and the other is as a replacement for kerosene in cooking. Nigeria imports approximately 7 billion litres of petrol and 1 billion litres of kerosene per annum. Nigeria has a policy to incorporate 10% ethanol in petrol (E10) and the National Power & Technology Agency (NPTA) has imported 1000 cooking stoves and a quantity of 5 litre bottles of ethanol-based (ethanol gel) cooking fuel for a trial replacement of kerosene in domestic cooking. CTAP is supporting a company in Kogi State to establish a small-scale ethanol plant (1000 litres/day) using Brazilian equipment. However, import of the plant has been delayed by more than 1 year. Another company is selling stoves and cooking alcohol imported from South Korea. The company has no local production facility. In addition there is a project based around Benin City that has imported 3 million stoves single and double burner stoves from Sweden with support from a US NGO. 500,000 of the Swedish stoves are designed to use Ethanol the balance are intended to use sawdust briquettes. Ethanol compatible stoves are being sold for US\$25 for a single burner and US\$61 for a double burner. The ultimate aim is to encourage establishment of 5,000 litre/day (using cassava as a feedstock) plants in small towns. A 5,000 litre/day

plant has the potential to provide cooking fuel for 10,000 families (based on estimated consumption of 0.5 litre/day). Given a 10% replacement the E10 market could consume 700 million litres of ethanol per year, the kerosene would be virtually a direct replacement and thus require 1 billion litres of ethanol per annum.

The classic feedstock for ethanol production is a source of fermentable sugar such as molasses. Cassava roots contain starch which can be used but the starch must first be hydrolysed into fermentable sugars. This extra step makes cassava the number 2 choice in terms of feedstock, but in Nigeria there are very limited supplies of fermentable sugars and even if more sugar-cane is planted it is more likely to be refined and used for other purposes. Cassava conversion ratios vary according to the starch content of the cassava roots and efficiency of conversion, but industry sources from Thailand and Latin America indicate that a ratio of 6:1 would be reasonable for calculation purposes. Given this ratio complete replacement of imported industrial alcohol with a cassava-based product would require 360,000 tons of fresh cassava roots. Ethanol for the E10 fuel would require 4.2 million tons of fresh cassava roots and for complete replacement of kerosene in cooking 6 million tons of fresh cassava roots.

Achievable demand – There is considerable interest in cassava-based alcohol in Nigeria, but little real progress has been made with establishment of facilities to produce ethanol for use as a cooking fuel. The Cassava Transformation Agenda (CTAP) is reportedly supporting the establishment of a 1000 litre per day pilot plant but this has been delayed for more than 12 months and is still not operational, the NPTA are also talking of the possibility of supporting the establishment of a 1000 litre per day pilot plant as part of their ethanol-based cooking stoves programme but this had not been realised in February 2013.

One distillery evaluated cassava as a possible feedstock to produce ethanol locally in place of imported alcohol. They decided against this plan for several reasons, the first was the level of capital investment required (estimated at a minimum of US\$60 million) to build a suitable plant. They also commented on the high cost of cassava roots and potential problems with obtaining reliable volumes of roots of the right quality with high starch content. They expressed concern at the high cost of power for generating steam for the distillation column, as Nigeria lacks a reliable supply of power from the national grid the distillery would have to rely on expensive power from diesel generators (they experience this with their current operations when they refine local gin and cheaper partially refined imported alcohol). Overall they estimated that it would be difficult to produce ethanol from cassava at a cost low enough to compete with imported Brazilian ethanol or even to achieve parity with price of the imported product.

In contrast, another distillery has invested ~US\$30 million establishing a 20 million litre/year ethanol plant close to Lagos that uses cassava roots as a feedstock. The company spent 5 years building up a reliable raw material supply base (using a mix of small and large-scale farms) before building the distillery. The input capacity of the distillery is 250 tons of cassava roots per day but in February 2013 they were achieving 100 tons/day. The company have reduced their power costs by linking into a main LPG gas line. The company estimate that they produce cassava-based ethanol for 140-150 Naira per litre (given a cassava root price of 12 Naira/kg). In February 2013 production costs were estimated at 160 Naira/litre due to the unusually high root price of 16Naira/kg. However, even with the more expensive cassava roots the distilleries production costs compare favourably with 300 Naira/litre for imported ethanol.

Opportunities for donor investment – The story of using ethanol stoves to replace fire-wood and kerosene in domestic households is appealing due to the potential health benefits derived from burning a much cleaner fuel and safer fuel. However, it is important to take account of the food security implications of the establishment of a large-scale ethanol industry using millions of tons of cassava roots per annum. China has placed restrictions on the use of cereals for production of biofuel as cereals are the main food staples in China. In Nigeria, cassava is one of the major staple crops). In 2012, Nigeria experienced food shortages and high prices for staple foods, many consumers were forced to switch to cheaper readily available foods leading to a boom in garri sales and dramatic increases in prices for cassava roots driven by demand from the garri sector. This impacted adversely on the HQCF and starch factories who were forced to source roots from more distant locations, pay higher prices and often accept poorer quality roots with knock on effects on their product quality. There is a high level of interest in developing small-scale distilleries to produce ethanol for home cooking. This is certainly technically possible and the raw material requirement would be similar to a typical Nigerian HQCF SME operation. However, some aspects of the economics of the business opportunity remain unclear. The C:AVA Nigeria team will investigate this in more detail as part of fieldwork scheduled for May 2013.

The large-scale cassava-based ethanol distillery close to Lagos is an encouraging development that is already supporting the livelihoods of ~4,000 smallholders in Ogun and Oyo States. The number of smallholders involved is likely to double over the next 12 months as supplies are gradually built up. The companies approach for development of relationship farming systems is commendable and deserves support. There is an opportunity for C:AVA2 to work with this distillery and other major users of cassava roots to improve the links between smallholders and commercial operations, to encourage relationship farming and to improve the competitiveness of smallholder production of cassava in Nigeria.

Beer

Potential market - With a population of ~160 million and a per capita consumption of 10 litres of clear beer per annum Nigeria is the second largest market for beer in Africa. In 2011 demand for beer was estimated at 22 million hectolitres, with a volume growth of 13% over the previous year. Production is dominated by three brewers, most of the current brands are clear lager beers produced using malted barley. Under current government policies there is a strong push to source more ingredients locally. One brewer has announced that they intend to focus on using locally sourced maize and sorghum. Cassava has potential as a replacement for 70% of imported barley in beer. SAB-Miller have launched cassava-based beers in Mozambique (Impala Beer) and Ghana (Eagle beer) and looking at launching a similar product in South Sudan. Guinness Ghana have launched a cassava-based beer (Ruut Extra) in neighbouring Ghana but SAB-Miller has the most experience of cassava-based brewing starting with their operations in Mozambique.

In October 2011, SAB-Miller introduced Impala in Northern Mozambique. Impala is a lager containing 70% (140g/litre) cassava and 30% (60g/litre) malted barley. The price for Impala is 30% lower than other brands and this has proved popular with consumers. The lower price is attributable to a government tax incentive (Specific Excise Duty) that reduces tax on cassava-based beers to 10% of taxable net income as compared to 40% for conventional barley-based beers. In the first 12 months of production, Impala sales were 9 million bottles (50,000 hectolitres) which equates with 2.7% of the market for beer in Mozambique. In the first year of production 500 small-scale growers produced 2,700 tons of fresh cassava roots for use in Impala beer. Cassava was processed into wet-cake (~40% moisture) in the village using mobile processing units known as AMPU (developed by DADTCO in

Nigeria) and transported to the brewery. According to SAB-Miller Impala has been so successful that they plan to expand production in 2013 to involve 1,500 farmers and consume 10,000 tons of fresh cassava roots per annum.

Given the success of Impala in Mozambique and Ruut Extra in Ghana it is not unreasonable to suggest that 5-10% (by volume) of Nigerian beer sales could be taken over by a cassava-based brand in the short to medium-term. 5-10% of beer sales by volume would require 15,400-30,800 tons of dried cassava grits (adjusted to 14% moisture) or equivalent in cassava wet-cake (~40% moisture) this would equate to 61,600-123,200 tons of fresh cassava per annum and could support at least 11,000 smallholder farmers.

Achievable demand – Realisation of the potential market for cassava in clear beers will depend largely on the level of commitment of the major brewers to cassava-based products, availability of a tax incentive to encourage investment and consumer acceptability. It is too early to determine if this market will take-off but based on experience from other countries cassava-based beer seems a strong possibility for Nigeria.

Opportunities for donor investment – If one of the major breweries invests in cassava-based beer, there would be an opportunity for donor investment in smallholder farmers wishing to supply the brewery to improve yields of cassava and starch content of cassava roots through training and support to adopt good agricultural practices. The concept of supporting stronger links between smallholder farmers and major industries is discussed further in the section on cross-cutting issues under raw material supply.

Cross cutting issues

Raw material supply

The biggest issue that has hampered the development of new industries based on the processing of cassava has been the availability and cost of fresh cassava roots. All factory owners interviewed claimed that it was both the high cost and erratic supply of roots that stopped or prevented their factories achieving their capacities; in fact, almost without exception, all the cassava processing factories were operating at well below their installed capacity. It is therefore vital that before any support is given to expansion of cassava processing, the issue of the cost of fresh cassava roots is understood and methods of ensuring the availability of roots throughout the year is discussed.

One of the important lessons that has emerged from the study of raw material supply in Nigeria and other C:AVA countries is that farmers do not plant surplus cassava in the hope that there will be a market when it is ready to be harvested. As has been reported here, even though factory owners are often told that there is a plentiful supply of cassava roots, they invariably have root supply issues. This is partly due to the price that farmers want, but it is also simply that there is not a surplus of roots. Any new factory established that needs a significant supply of cassava needs to have a procurement strategy in place. A good example is a large processing company, which started developing its relations with farmers five years before the factory started taking in cassava roots. Farmers need to be assured that there is a market available for their produce if they are to plan specifically for that market.

Fresh cassava roots are the largest cost associated with all the potential cassava based industries (Table 2). With the exception of garri, all processed products listed in Table 2 have to be sold at a constant

price irrespective of the cost of the fresh cassava roots. The price of garri tends to move in line with changes in fresh root prices; the processor simply passes on any cost changes. All the other products tend to be sold at constant prices, so a rise in root prices has a major impact on the margins.

Table 2 Contribution of cassava root price to production cost for a range of cassava-based products

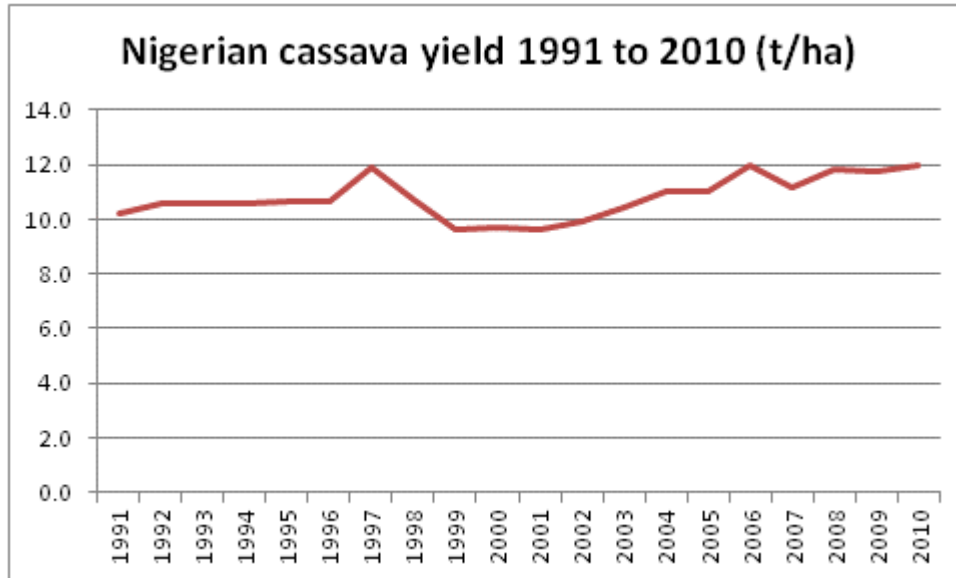
Product	Ratio* FCR to end- product	Product selling price (N/kg)	Cost of FCR (at N7/kg)	% FCR of sales price	Cost of FCR (at N10/kg)	% FCR of sales price	Cost of FCR (at N15/kg)	% FCR of sales price
HQCF	4.0:1	100	28	28%	40	40%	60	60%
Dry chips (unpeeled)	2.5:1		17.5		25		37.5	
Dry chips (peeled)	3.0:1		21		30		45	
Native starch	5.0:1		35		50		75	
Garri	4.3:1		30.1		43		64.5	
Instant fufu	4.0:1	250	28	28%	40	40%	60	60%
Glucose syrup	4.6:1		32.2		46		69	
Glucose powder	6.5:1		45.5		65		97.5	
High Fructose syrup	5.0:1		35		50		75	
Sorbitol	6.0:1		42		60		90	
Ethanol- industrial	6.0:1	200	42	21%	60	30%	90	45%
Ethanol- cooking	6.0:1	110	42	38%	60	55%	90	82%

* NB: Conversion ratios do vary, due to differences in root quality, processing efficiency and differences in starch content between the wet and dry seasons.

If large and sustainable cassava-based industries are to be established, then competitively priced roots are needed on a regular basis; without this the opportunities for establishing sustainable industries will be severely compromised. However, this does present a dilemma; processors want cheap roots to secure their return on investment whilst farmers want to sell roots for as much money as possible to achieve profits or an acceptable living standard. Obviously there needs to be a compromise over pricing so that both farmers and processors both make acceptable returns. It is often suggested that if farmers achieve higher yields, then they will accept lower prices. To a degree, this is true – but there have many efforts by extension workers and other projects to try and improve agronomic techniques to farmers, but average cassava yields have only increased slowly, from just over 10t/ha to just under 12t/ha (Fig 1). It must be accepted that the main reason why cassava yields are low is because of the low levels of on-farm management associated with the fact that most farmers do not

take a commercial approach and are handicapped by the small-farm sizes. The small farm size also makes it exceedingly difficult (and costly) for processors to coordinate purchases from farmers; they find it easier to buy from larger producers. This section on raw material supply considers whether securing roots from larger-farms is a sensible plan and reviews options of how smaller-farms could be incorporated into the supply chain for processed cassava.

Fig 1 Average yields of fresh cassava roots in Nigeria, 1991 to 2010 (t/ha)



Source:- based on FAOSTAT data

Many people look to South East Asia for solutions to the low yields and erratic supply for processors. They note that much of the crop in Thailand is grown by small-farmers, but their yields are higher. However, the big difference is that virtually all the Thai crop is sold through a large-scale marketing chain for animal feed or processing (starch or bio-fuels). By comparison, the vast majority of the Nigerian crop is grown for human consumption and growers do their own processing or it is traded to a myriad of small-scale traders. This difference between growing the crop for truly commercial reasons in Thailand, whilst much of the crop is grown for own-consumption in Nigeria probably explains the differences in the attitude to on-farm management between the two countries.

Production costs of fresh cassava roots.

One of the difficulties of working in Nigeria is obtaining accurate and timely data on production costs and root selling prices. A model has been developed to try and understand the production costs and yields of high and low cassava production¹. Most of the current cassava crop is grown using very few inputs; perhaps in the belief that cassava is able to scavenge for nutrients; but this simply drains the resources from the soil resulting in low yields from subsequent crops. This low input scenario is typical of most of the production, ie no fertiliser, using planting material from their own-crops and hand labour for weeding and harvesting. Yields can be significantly increased if fertiliser and better management are applied to the crop. The high input model will be more along the lines of the commercial production in

¹ Based on discussions with Landell Mills Commodity Studies

Kwara State and it assumed that 400kg/ha of fertiliser (NPK) is used, some new (improved and disease-free) planting material, some herbicides and mechanisation coupled with hand labour is used for harvesting and weeding. An amortised cost is used for clearing and preparing the land. Average yields for the low input scenario is 10t/ha whilst 25t/ha is used for the high input. What is interesting about this model is that the cost of production per kg of cassava is reasonably close for both high and low input. The high input is slightly cheaper at N4.0/kg whilst with the low input system it works out at about 4.3/kg between the two different systems. If a sensible margin is added to the direct costs, perhaps equivalent to the profit growing maize, then the minimum prices for fresh cassava roots that would make the crop attractive to farmers, assuming that the planting decision was based on economic logic, could be theoretically calculated. This works out at about N6.5/kg for low input system and N5.4/kg for the high input system. Perhaps in reality, the high input system would require slightly higher prices to compensate for the extra costs of management. These prices are actually comparable to historical price data – farm-gate prices during both missions were much higher because there was a shortfall in cassava production.

The quick analysis above shows that the farm-gate production costs per unit weight of both low and high input costs are actually reasonably similar, with the high input system perhaps being slightly cheaper. However, it is likely that the cost of getting roots to the factory will be more expensive for the small-farmer as larger transport and transaction costs will have to be included. The transaction and transport costs will vary enormously depending on size of vehicle, whether it is a backload or not and transaction costs will depend on the number of actors and the competition that they have. Transport and transaction costs could be in the order of N1 to 3/kg; the higher price would be for the low input farmer with only a small amount of roots to sell. This would mean that a sensible **minimum** price for purchasing roots delivered to a processing site would be in the order of N7 to 9/kg. These calculations are similar to the price points that farmers claim should be the minimum delivered price, ie about in the order of N10 to 12/kg. If the mid-point price of N11/kg is taken, this would give the larger high input growers a margin of about N4,100/t² or N102,500/ha (US\$680/ha) – which should be very attractive return, providing the farmer had the management capability to convert inputs into a crop yielding 25t/ha. The margin for the smaller farmer is obviously less, about N2,000/t³ or N20,000/ha (US\$125/ha). The combination of the higher yields and smaller marketing charges makes growing cassava much more attractive for the larger commercial farmer.

There are perhaps three important reasons why cassava processors would like to secure fresh cassava roots from large commercial farmers;

- They are probably a more reliable source of roots because they are less likely to side-sell the crop.
- It is much easier and cheaper to coordinate supplies from a larger farmer compared with a plethora of smaller ones.
- As larger commercial farmers make a much bigger margin, there is a greater opportunity to negotiate cheaper prices for roots.

² Assumes N1,500/t for transport and marketing

³ Assumes N2,500/t for transport and marketing

Contract farming

Contract farming is often mentioned as a way of securing cassava roots from farmers. However, if the produce has other potential markets – and in the case of cassava, farmers normally have the option of selling to garri manufacturers – farmers are often tempted to side-sell to obtain higher prices or to avoid the repayment of debts incurred during the growing of the crop. Even if a farmer signs a contract, there is actually very little the processor can do if the cassava roots are not supplied. Perhaps instead of trying to develop contract farming, processors should develop a “relationship” with farmers.

Even though the evidence points very strongly towards larger farmers being the most reliable source of cassava roots for large-scale processors, the efforts by one of the major processors have shown that there might be another way and perhaps “relationship” farming might be the answer. They have developed a system of contract farming to obtain raw materials for their factory. The contract farming operation was started almost 5 years before the factory was completed, but they still purchased the cassava roots off their farmers and sold them to other processors; so by the time their factory was ready to produce, they had identified reliable farmers and had started to build up good relations. They insist that farmers grow improved varieties, which are suitable for their process, but in fact are probably less suited for human consumption; which does reduce the opportunity for side-selling. However, they do insist that the farmers grow sufficient cassava of the varieties of their own-choice for their own consumption. Farmers are expected to use fertiliser and herbicides; spray operators have been trained to undertake this work by the company. They receive consistent agronomic advice which, coupled with fertiliser and herbicide applications, result in higher than average yields – in the order of 14 to 20t/ha. The processing company hopes to invest in tractors and provide a land-preparation, planting and possibly harvesting services to farmers (at a cost) and help them obtain bank loans.

The company collects roots from the farmers and pay the market price for the roots. The great advantage that this processor has compared with, say HQCF processors is that that they have a much greater margin and are less vulnerable to increases in root prices. Currently, they have 790 farmers contracted to grow 2,226 ha of cassava, ie an average amount of 2.82ha per farmer. Therefore, given that the farmers will also be growing cassava for themselves, the target farmers are therefore small-commercial farmers. It is the targeting of larger farmers that has contributed towards the success of their contract farming operation. In time, they will need to double the area of cassava contracted to about 5,000ha to keep the factory working at full capacity; which probably means working with almost 2,000 farmers. It would be possible for a large commercial farm to supply virtually all of the processors cassava requirements, they have taken the corporate decision to try and source from small-farmers, even though it might be more costly.

In order to manage the “contract” farming operation, the company needs a team of about 25 people to cover extension, procurement, transport and research. It is important that their efforts are recognised and supported by donors. **Serious consideration needs to be given to supporting companies that are establishing contract farming operations; this could be in the form of paying for some of their extension staff or capital equipment.** Additionally, it would be sensible to try and get some of the contract farming operations **to cooperate with their research and development; perhaps by financing some of the research programs needed to improve yields and profits of the crops for processing.**

Buying centres

As noted above, the transaction and transport costs associated with small-farmers supplying factories with fresh cassava roots are a serious impediment to the inclusion of smaller-producers into the value

chain. In some countries, rural based buying centres have been established to facilitate the inclusion of small-farmers supplying processors. In Nigeria PIND (Partnership Initiatives in the Niger Delta) is trying to establish some buying centres for farmers to sell their roots to the largest HQCF processor. The plan is for the processor to send a 30t lorry each day to the buying centre and collect roots, which have been purchased by PIND acting as an agent for the private company. It is hoped that if the first buying centre is successful, then others will be established. This model should be reviewed when it is operational and see if it can be replicated in other states. Other countries have tried to establish rural collection points; the big starch factories in Thailand establish their own buying centres, which they operate themselves. They have a buyer who pays the farmer for the roots, which are then off-loaded and transferred into a large lorry for transport to the factory. A variant of a buying centre are the rural collection markets established in India for horticultural produce. These markets have been established using public finance and tend to operate seasonally, but are a place where farmers can bring their produce and where buyers come to purchase the produce. The interesting thing about this system is that the operational costs are carried by the State Government and that there is competition between the buyers for the farmer's produce. Besides providing an environment to attract buyers who will compete with each other, the other advantage for the farmer is that they do not have to transport their produce very far; which is obviously cheaper.

The concept of establishing buying centres needs to be further reviewed and evaluated to establish whether they would prove attractive for encouraging farmers to sell cassava to processors. The costs and returns need to be reviewed with the aim of determining whether they represent an opportunity for donor support.

Lack of price data

One of the common difficulties of preparing any agricultural market report in Nigeria is the problem of statistical accuracy. This is exaggerated in the collection of cassava price data; Nigeria's market data collection suffers from a lack of coordination; it should be noted that obtaining **accurate** market price data for perishable produce is difficult in many countries, but obtaining nationwide up-to-date statistics proved impossible on both missions.

End-user support

The second area of importance is provision of support for potential end-users to adopt cassava-based products as alternatives to existing materials. As with root supply it will be very important to work closely with industrial partners to develop solutions and also to help government and the private sector to develop clear and sensible strategies for adoption of cassava-based products. For example in Nigeria the Government is trying to promote cassava in bakery products but there is still a lack of clarity with regard to approach in terms of whether they should focus efforts in the big mills or support SME's to work with local bakeries. The areas of most interest at the present time are cassava improvers for bakery products, pelletised formulations of cassava-based feed for aquaculture and use of HQCF in paperboard adhesives.

Conclusions & recommendations

The November 2012 & February 2013 missions were conducted to provide greater information on the current status of the various market opportunities for cassava-based products in Nigeria. This data will help us recommend to the Bill & Melinda Gates Foundation (BMGF) which sub-sectors offer the most

potential for BMGF to add value to existing investments and maximise positive impacts on the wellbeing of as many smallholder farmers & small-scale entrepreneurs as possible. C:AVA and C:AVA2 are intended to support development of sustainable smallholder inclusive value chains. We recognise that cassava is the second choice for nearly all of the sub-sectors. This raises the question as in which sub-sectors can cassava-based products offer an attractive alternative to existing materials?

For Nigeria we can divide the various sub-sectors into 3 sub-groups, namely:

- Opportunities where BMGF could make interventions at several points in the value chain (farm, processing & end-user);
- Opportunities where BMGF could make interventions to support the development of smallholder inclusive raw material supplies for large-scale industries;
- Sub-sectors that have no obvious potential for development in the short to medium term and hence of no interest to C:AVA2.

Sub-sectors where BMGF could make interventions at several points in the value chain

These sub-sectors are characterised by involving SME type processing operations and also by having potential end-users who require support to enable cassava-based products to be adopted. In every case raw material supplies are likely to come from either smallholder farmers or combinations of small-scale and larger commercial farms. The sub-sectors that fall into this group are:

- HQCF for bakery & paperboard industries
- Instant fufu as an additional line for HQCF SME's
- Dried cassava chips for in aquaculture feed
- Cassava fresh/dried for SME production of ethanol for home cooking

At this stage HQCF as a partial substitute for wheat flour in bread and other bakery products, and as a complete substitute for maize starch in paperboard adhesives is the most promising sub-sector with a theoretical demand of ~500,000 tons of HQCF per annum, and attractive margins when compared to wheat flour or maize starch. However, even if short-term proposals for expansion of the industry are carried through the Nigerian HQCF will only be able to meet 15% of this theoretical demand (table 1). Realisation of the potential demand will depend greatly on solving issues of competitive raw material supply, resolution of constraints to use of HQCF in bakery products and in the case of SME factories much improved energy efficiency, management and quality control and better marketing focused on small-scale bakeries rather than large flour mills.

Instant odourless fufu is a very small niche market that is unlikely to have much potential for growth in terms of volume. However, the margins for instant fufu are very high, and we believe that this sub-sector could offer an additional and quite important source of income for some of the SME HQCF producers.

Nigeria is the second largest producer of aquacultural products in Africa and the industry is rapidly expanding. Fish farming (mainly catfish and tilapia) offer an excellent business opportunity for small-scale farmers and a valuable source of locally sourced protein. Cassava is technically feasible in fish feed and more attractive economically than cassava in poultry feed. In addition 80% of fish feed is currently imported offering an opportunity for import substitution. A few fish feed manufacturers are already trying to use cassava but lack the knowledge and expertise for a successful product. The current market

would only absorb ~74,000 tons of fresh cassava root equivalents per annum. However, this market could be an opportunity for sun-dried chips (an easier and less expensive product to produce in rural areas) and prospects for expansion appear strong.

Nigeria imports ~1 billion litres of kerosene per annum for use in home cooking, in addition many poorer households are unable to afford kerosene and rely on non-sustainably sourced firewood and charcoal for cooking. The Federal Government and several private sector initiatives are attempting to promote locally produced bio-ethanol as a cheaper cleaner and more sustainable source of cooking fuel. All of these initiatives are using (or intend to use) cassava (fresh/dry) as a feedstock for SME type rurally based biofuel operations. The C:AVA team is working with one of these initiatives to finalise details of the business case and initial findings look promising and the developmental case is very strong.

Sub-sectors where BMGF could make interventions to support the development of smallholder inclusive raw material supplies for large-scale industries

Nigeria has a number of large-scale commercial investments in production of cassava-based products. These include HQCF, starch and industrial alcohol. In addition, it seems likely that one or more of Nigeria's major breweries will push forwards with investments on cassava-based clear beers following the positive results seen by SAB-Miller Mozambique and Ghana and the Diagio Group (Guinness Ghana) in Ghana. For these sub-sectors there is no case for BMGF investment in processing or end-user support (with the exception of HQCF which would benefit from end-user trials aimed at supporting HQCF SME's access to wider market opportunities).

However, as these industries use quite large volumes of cassava there is a strong developmental case for BMGF to invest in supporting the development of smallholder inclusive supply chains. Currently only one of the large industries has succeeded in sourcing mainly from smallholders. The others have all had supply problems and have tried to move towards procurement models centred around smaller numbers of larger commercial growers. However, these models have proved costly (mainly due to the long distances between farms and factories) and supplies are still insufficient in most cases. The approach taken by the one factory using Asian inspired models offers valuable lessons and indicates that with the right support smallholders could have a bigger role in supplying the large-scale cassava-based industries.

Sectors with no potential in the short to medium-term

The sectors that we do not recommend BMGF investing in are packaged garri, cassava chips for export to China, production of sugar syrups, cassava in poultry feed and cassava-based ethanol in petrol (E10).

Packaged garri is a tiny niche market involving re-packaging of small-volumes of traditionally prepared garri to add-value. We see no potential for growth of this sub-sector.

Dried chips for export to China is a large market but Nigeria is unable to compete with suppliers in Thailand and Vietnam. The Nigerian value chain is not profitable and it very unlikely to become profitable in the medium-term (However, we do recognise that this sector is very dynamic and prospects in the slightly longer term beyond 2020 look more promising).

Production of cassava-based sugar-syrups is not currently profitable in Nigeria and entry to market requires substantial investments and major technical hurdles especially in the area of raw material supply. It is possible that in the medium-term major beverage industries such as Coca-Cola may switch to high fructose syrup (HFS) in place of sugar, this could create an opportunity for investment by a major operator. However, would be investors will have a much steeper learning curve to establish a reputation for reliable supplies of large volumes of HFS especially when compared to HQCF which is technically a much easier product to produce reliably.

Dried cassava chips can provide a source of carbohydrate energy in a range of livestock feeds including poultry rations. Many of the Nigerian feed mills have used cassava as an alternative in the past and there have been many projects and initiatives in this area but with very little success. To use cassava in livestock feed rations it is necessary to add additional protein supplements. For this reason the cost of cassava plus protein supplements must be competitive against the price of maize during most months of the year which is unlikely to occur in real life. In addition millers who have used cassava had problems obtaining reliable supplies of cassava of the right quality. Low quality chips were often found to contain unacceptable levels of mycotoxins and some millers were also concerned about cyanide and palatability issues due to problems with high dust levels in cassava-based feeds. Finally if cassava did enter this market it would simply shift income from maize to cassava farmers as most maize for animal feed is locally produced. On balance it seems unlikely that this opportunity will be realised in the medium term in Nigeria.

Nigeria has an E10 policy to incorporate 10% ethanol in petrol. Cassava could be used as a feedstock for ethanol production. However, the E10 policy shows little sign of realisation on the ground. Vast volumes of ethanol would be required needing a major investment in cassava-based distilleries. This level of investment seems unlikely in the short to medium-term but may change in future especially if current investments prove successful.

The way forward

The next step for Nigeria is to conduct an investment study to assemble the strongest possible business and developmental cases for inclusion of the most promising sub-sectors identified in the market studies as part of the BMGF investment in C:AVA2. For the next mission scheduled for early June 2013 we intend to:

- Investigate the smallholder inclusive raw material supply model adopted by Allied & Atlantic Distillers;
- Refine our information on SME production of biofuels for home cooking via closer interaction with Project GAIA;
- Convene a cassava users forum for a wide range of private sector players to discuss the best way forward for development of private sector driven, sustainable value chains for cassava-based products that encourage smallholder inclusive procurement models;
- Our preliminary thinking on smallholder inclusive procurement models. In particular to recognise the likely ratios of smallholders to commercial growers that will be acceptable to different private sector players and how this fits with BMGF developmental objectives;
- Prepare the business and developmental cases for the most promising sub-sectors, paying especial attention to the need to achieve a balance between commercial and developmental objectives;
- Our theory of change with logic and justification;
- A preliminary risk assessment to cover factors (risks & constraints) that might realistically impact upon success, with our recommendations for mitigation measures;
- Prepare an outline of the recommended approach for C:AVA2 in Nigeria including details of managerial and logistical requirements, the types of interventions that will be required (to build sustainable smallholder inclusive value chains), the geographical focus, and partners (private & public sector) who will be required to achieve the objectives of C:AVA2 in Nigeria;
- Our initial thoughts on setting realistic targets for C:AVA2 based on what C:AVA2 might contribute towards realisation of the estimated achievable demand for the various sub-sectors;
- Some initial thoughts on how C:AVA2 can achieve synergies with other BMGF investments such as the Catholic Relief Services (CRS) sustainable cassava seed systems project;
- An outline of our intentions with regard to environmental impacts both positive and negative associated with the most promising sub-sectors for cassava-based products (this will form the lead in for a separate study later in 2013).

Annex 1: Notes from the November 2012 and February 2013 missions covering the various sub-sectors for cassava-based products

The following sections provide more details for each sub-sector collected during the November 2012 and February 2013 missions by the C:AVA Nigeria team. This material is designed to supplement the material provided in the main report, but it should not be necessary to read these sections in order to understand the potential of a given sector.

1. High Quality Cassava Flour (HQCF)

a) Background

- HQCF has been produced in Nigeria for almost 50 years with varying degrees of success; technically, it has been proven that HQCF can be produced which can partially substitute wheat flour in many baking processes, but the substitution has not always been cost effective. Nigeria pioneered the innovation of technologies to allow small and medium-businesses to produce HQCF; in particular, the use of flash dryers that are capable of drying de-watered grated cassava using a range of fuels. The initial equipment was capable of producing about 1 ton of HQCF per eight-hour shift. More recently, machinery with about twice the output and which are much more energy (and cost) efficient have been developed.
- Since 2008, the C:AVA project supported the development and expansion of HQCF.
- The main market for HQCF was as a partial substitute for wheat flour; however, as HQCF does not contain gluten, it has limitations as a direct substitute without additional ingredients.
- In addition, the costs of producing HQCF tended to be about the same as wheat flour therefore, there was little enthusiasm amongst the millers and bakeries to use it. It is only recently (mid-2012) that Government has increased the duty on imported wheat from 5 to 25% that HQCF has the potential to become seriously competitive with wheat flour.
- In mid-2011, it was estimated that between 6,000 and 12,000t/year of HQCF was being produced⁴. About half of this HQCF came from two large-scale processors and about 23 operational SMEs. The major processors use imported drying equipment whilst the SMEs, use technology developed in Nigeria⁵. The imported equipment has a much larger capacity, but is also much more expensive.
- Wheat imports were estimated at about 4 million tons/year; which is the equivalent of about 3 million tons/year of wheat flour⁶. Despite the very large market opportunity and the efforts made to promote its substitution, there has been, at the very most, about 0.5% substitution. It is likely that given the increase in wheat flour prices, wheat imports have decreased slightly.

⁴ Market Opportunities for HQCF in Nigeria (May 2011), Andrew Sergeant for C:AVA.

⁵ The technology developed in Nigeria for use by the SMEs is often referred to as “Flash Dryers”.

⁶ Market Opportunities for HQCF in Nigeria (May 2011), Andrew Sergeant for C:AVA

- The concept of incorporating cassava flour into wheat flour is sensible as it saves foreign exchange and provides another market for small-farmers to sell their cassava; and now, it enables bakers to reduce their input costs.

b) Recent developments

- Since May 2011, the Cassava Transformation Agenda Programme (CTAP) within the Ministry of Agriculture has been actively promoting the inclusion of HQCF in bread production. During the November 2012 and February 2013 trips, very few SMEs were operational; it was claimed that the cost of roots made it impossible to manufacture and make a margin. In fact, this confirms the observation that has been made previously that most of the SME flash driers that are supposedly in existence have not operated for many years⁷. However, it is hoped that the high root prices will not last beyond May/June 2013 and will fall to a price, which will allow HQCF to become competitive with wheat flour. It is hoped that this expected fall in root prices coupled with C:AVA's efforts to promote local marketing and upgrade existing dryers to become more efficient will allow the SMEs to produce and sell HQCF profitably.
- At the time of the November mission, CTAP planned to allocate US\$66,667 (N10 million) for flash dryer owners; US\$26,667 (N4 million) will be a subsidised loan for capital expenditure and US\$40,000 (N6 million) as a grant for working capital in order to stimulate production. The objective of the capex loan is to improve the efficiency of the flash driers⁸ and the working capital is to allow the owners to purchase roots. However, it seems that the majority of factory owners want to use the money to purchase a truck so that they can buy fresh roots cheaper; often by going to States a few 100km from their factories. At the time of the February 2013 visit, there had been little progress with the allocation of the N10 million facility.
- The other solution to the lack of HQCF that the cassava transformation agenda (CTAP) team plans to implement is to order 18 factories from China with a capacity of 240t HQCF/day. If it is assumed that these factories operate 333 days per year, each will produce 80,000t/year HQCF. Therefore, 18 factories would produce 1.4 million tons HQCF/year, which equates to almost a 50% substitution of the country's wheat flour.
- It is reported that 6 factories have been ordered and are "in-transit" and will be installed in different parts of the country. It is reported that the CTAP team hopes that the private sector will operate these factories, Government will assist with the provision of US\$8 million working capital in return for the private sector investing US\$3 million of their own funds and the promise of paying back the capital when the factories come into profit. It is highly unlikely that these factories will be in full operation before at least 2015 or 2016.
- To supply each factory, it requires the roots from 45ha/day – assuming yields of 20t/ha. The plan assumes that the factories will be able to buy roots from about 14,000ha of cassava located within 30km of the factories. It is assumed that the State Governments will be active in training and organising this supply of cassava to each factory.

⁷ In fact two of the four flash driers that were visited, had not operated for 5 or 6 years! In fact, the majority stopped operating in 2008/9 in the Obasanjo era.

⁸ Installing more efficient heat exchangers; though there seems to be an effort by the cassava transformation team to purchase a heat exchanger on behalf of the owners – and not let the owners determine how best they could improve their factory's efficiency.

- The purchase of the CTAP's factories will be financed by the Federal Government (15%) and the Chinese EXIM bank at 2% interest (with a guaranteed supplied by the Federal Government).
- In addition to these initiatives, there has also been an effort to encourage a 40% substitution of wheat flour in bread as a result of IITA efforts.
- In late 2011, the Hotel Catering & Travel Services Manager at IITA produced bread made with 40% HQCF which was shown to the President and Minister of Agriculture. There was "confusion" as to whether the catering manager also added other ingredients. A report by Accenture and others state that eggs and milk powder were added to the recipe⁹. If the Accenture recipe is correct, and all the bread produced in Nigeria followed the IITA recipe, there would be a demand for 2 to 3 billion eggs and 134,000t of milk powder per year from the bakers! Also, the concept of adding eggs to the bread recipe could have hygiene implications for some of the smaller traditional bakeries.
- By February 2013, the CTAP target was now a more sensible 20% inclusion and training to bakers was being provided to try and achieve this. However, the short to medium-term constraint to achieving the federal 20% target will be the lack of appropriate quality HQCF.
- However, it must be noted that the efforts to promote HQCF has led to the private sector taking the concept of HQCF inclusion more seriously. In addition, the recent increase in import duty on wheat (from 5 to 20%) and the rise in the world prices of wheat have resulted in the ex-factory price of wheat flour rising from N118/kg (in Feb 2012) to N140/kg at the time of the mission.
- The manager a major baker in Lagos has developed breads made with 20% cassava flour – and they are advertising the fact. In fact they produce a loaf targeted specifically for children. This bread is made using an "improver" and is sold cheaper than bread made from 100% wheat flour.
- Whilst still the majority of bread they produce is 100% wheat flour, the efforts to use HQCF and advertise the fact is extremely encouraging and should be supported.
- The large flour mills recognise that they are under pressure from Govt to include HQCF in their flours – they also recognise that there is not enough HQCF available to make a meaningful inclusion. However, at least one mill has included the machinery to incorporate HQCF and, if they are convinced of the market, they could produce a bread-making flour with significant quantities of HQCF and an "improver". Again, what is interesting about this approach is that the HQCF would be advertised and not "hidden".
- It has often been said HQCF can be used in biscuits and laboratory trials have been reasonably successful. In 2011, one of the biscuit makers undertook factory-scale trials using 20% HQCF, but the dough created "machinability" issues on the line – it sticks to the equipment and hinders the process. They concluded that only way to correct it is to add extra butter/margarine and other additives. However, they were making hard biscuits and recognise that if they were making biscuits from soft dough, a higher inclusion rate should be possible.
- One of the key issues that has been raised by end-users of HQCF is its variable quality. C:AVA has started some analysis of HQCF samples and training to try and improve standards. Large-scale producers tend to maintain a consistent standard of product quality,

⁹The ingredients for this recipe include 7.2kg wheat flour, 4.8kg HQCF, 12 eggs, 200g milk powder, 800g butter plus yeast, salt, sugar and water. This should make about 24 loaves of bread:

but most of the SME operations experience variable quality especially in terms of pH, moisture content, fibre, quality of starch and organoleptic properties. Many of these quality problems relate to the variable quality of cassava roots processed in HQCF. However, some of the problems indicate technical and managerial problems within the SME's. Many of the SMEs have failed to grasp the link between quality assurance and repeat sales of products.

- The efforts at “pressuring” users of wheat flour have been successful in encouraging the development of HQCF incorporation. The use of “improvers” has allowed for 20% inclusion in bread without too dramatic reduction in quality.
- **There are opportunities for the inclusion of HQCF in bread and other products; the key is to establish technically sensible targets that match HQCF production can be achieved over a sensible time frame. Recently, the cost of wheat flour has increased and this, and the pressure from Government, has certainly helped focus the private sector on trying to use it. The targets should not risk causing hygiene/health issues and should not lead to a significant rise in the cost of bread and other baked products.**

c) The market

- The market for HQCF can be segmented into either use as a partial substitute for wheat flour or maize starch.
- The market for partial substitution of wheat flour is large; Nigeria imports 4 million t/year of wheat and the milling industry converts it into 3 million t wheat flour. This represents a market opportunity of at least 300,000t/year (at 10% HQCF inclusion).
- The main market segments as a partial substitute for wheat flour are
 - In bread
 - In biscuits
 - Other confectionary products
 - Local markets
- The most widely talked about market opportunity is the **bread segment**. In May 2011, the market demand for wheat flour size was estimated to be about 2.2 million tonnes. However, with the increase in price of flour, and subsequent reduction in sales of bread will have a led to a reduction in flour consumption, probably to about 1.5 to 2.0 million tonnes. If the lower figure is assumed, then 10%, and 20% substitution would amount to 150,000 to 300,000t of HQCF; which is way in excess of the current production capacity of the industry.
- Perhaps the key issue for this segment is how best to target it. The CTAP has decided to train master bakers without having a strategy for how they should access the HQCF. The bakers want the millers to include HQCF in the flour whilst the millers would rather prefer that bakers mix the flours. Encouraging the bakers to incorporate HQCF and increasing the amount of HQCF at affordable prices could make an important contribution to the development of processed cassava.
- The structure of Nigeria's bread making industries is interesting. There are a few large bakeries in the main cities, but the vast majority of bread is made by a myriad of smaller bakeries that use less than a tonne of flour per week. Therefore, if HQCF inclusion is to be achieved through the bakers, there is need to target (and train) a vast number of small bakers. Nigeria is reported to have 480,000 small-scale bakers spread across the rural areas and smaller urban centres – and the vast majority buy less than 5 by 50kg bags of wheat flour per week.

- There is considerable interest by the **biscuit** manufacturers to incorporate HQCF as a means of reducing their costs. Retail price is an important factor affecting market share in Nigeria and if the production cost can be reduced, it could have a major impact on biscuit sales. It is reported that most companies that produce biscuits from soft dough are seriously looking trying to use HQCF and many are in dialogue with HQCF producers to secure adequate supplies. It is believed that 30% replacement may be achievable for soft dough biscuits, but 20% will be difficult for hard dough ones, although the use of improvers may make it easier.
- In May 2011, the wheat flour usage by the biscuit industry was about 500,000t/annum¹⁰. With the increase in flour prices, this has declined by about 20%; ie is estimated to be 400,000t/annum. If 20% replacement could be achieved, this represents about 80,000t of HQCF – which is significantly more than the capacity of the large processors and currently operational SMEs.
- The price differential between wheat flour for biscuits and HQCF is smaller than with bread; because biscuit flour is cheaper; about N120/kg. Therefore, the margins for selling HQCF to the biscuit manufacturers will be less than selling for bread production.
- The **snack product industry** is interesting. It is a much smaller market opportunity than bread or biscuits, but for products that are very sensitive to selling price, it could be an interesting opportunity, especially for the SMEs. One of the biggest opportunities could be in sausage rolls; the industry could be using as 60,000 to 100,00t/year of wheat flour, and if significant HQCF could be substituted, it could be interesting for SMEs and larger-scale processors. It is believed that HQCF is already being used in the fillings for some snacks, eg sausage rolls as well as in some of the outer pastry layer. In addition, it can be successfully used in some cakes or muffins. It is important that more effort is made to explore the size and opportunity of this market segment, because it should pay higher prices than the millers.
- The **paperboard industry** is another small but potentially interesting opportunity. Currently, the factories import ready mixed glues that have maize starch as an ingredient. Factories could make their own glues using HQCF and other chemicals that are obtained locally. In fact one factory has already done this when it ran out of imported ready mixed glue. However, the factories currently use imported ready mixed glues because it is much easier, rather than use locally procured materials. Additionally, if they prepared their own glue mixes regularly, they would probably have to make a small capital investment in some cooling and other equipment.
- It is estimated that there is a significant cost saving if the factories made their own glues from HQCF and other chemicals. Based on a formula successfully tried in Malawi, it was estimated that factories could save US\$164 (N24,625) per batch of glue in terms of reduced costs for adhesive, a very significant saving of 50% when compared to using imported ready mixed glue. In practice the actual saving would be slightly lower as it would be necessary to take account of additional costs for power associated with mixing glue in the factory and the final figure would have to reflect the specifications of the Nigerian factories which are likely to be different to factory in Malawi.
- In May 2011, it was estimated that the size of this market opportunity could be at least 3,000 to 6,000t/year, but in reality, it could be much more. In February 2013, the estimate of the market opportunity was re-evaluated and a similar figure was obtained. Only a

¹⁰ Market Opportunities for HQCF in Nigeria (May 2011), Andrew Sergeant for C:AVA

limited number of companies have been interviewed, but it is apparent that there is a gradual realisation that sourcing local materials would be a sensible approach – especially, if it helped reduce costs. If the paperboard companies were subjected to pressure by Government to use locally produced inputs in their glue manufacture in the same way the millers and bakers have pressured, it would increase the chances of HQCF being used in their industry.

- Another important advantage of targeting the paperboard industry is that higher prices might be achievable, because it is competing with maize starch rather than wheat flour – and maize starch is more expensive than wheat flour. In addition, all of the maize starch can be substituted, not partial substitution.
- In Malawi, two distinct and successful marketing strategies have been developed for the two different sized industries. The smaller sun-drying groups have been encouraged to sell their HQCF in the immediate vicinity of their factories, mainly to rural small-scale manufacturers of “mandazis” (the name given to a type of doughnuts) and small-scale bakers. In contrast, the imported flash drier from Nigeria will target the larger buyers in the main cities. The advantage of selling in the immediate vicinity of production is that the competitive product, i.e. wheat flour, is more expensive than in the main cities due to the extra marketing and transport costs. In addition, as there are no transport costs for moving the end product to the major towns, production costs are cheaper. Finally, in the case Nigeria, if the SMEs sell in the vicinity of production, they will not be competing for the product with the larger factories with their cheaper production costs.
- Whether there is a sufficient market size within say a 20km radius of flash dryers has still to be determined. However, the flash dryer owners interviewed believed it was an interesting strategy and agreed to help estimate its size.
- Since the November 2012 mission, the BDA has discussed the concept of local marketing of HQCF with a number of SMEs and the response has been extremely favourable.

d) Economics of producing and using HQCF

- The costs of producing HQCF are dominated by the price of fresh costs roots and then the ratio of fresh roots needed to produce a ton of HQCF. At the time of the field trip, the cost of roots in Ogun State was exceptionally high at N15 to 20/kg. However, manufacturers claimed that a more normal average price would be N10/kg delivered to the factory. They also noted that if they had transport, they could purchase roots from other states much cheaper. Therefore, if they had access to transport, they could secure roots regularly for N10/kg.
- Recently, C:AVA has made a number of efforts to calculate the production costs of HQCF. There is still a lack of understanding of the economics of HQCF inclusion in wheat flour and the impact on the price of bread and biscuits.
- In 2011, Hanneke Lam’s comprehensive analysis estimates the cost of producing HQCF from the current generation of flash driers be N116,000/t. With the C:AVA led efforts to increase the efficiency of the current flash driers it is hoped that the costs will be driven down to N92,000/t; but this has still to be proven. In addition, since Lam’s analysis, there will have been some costs increase due to inflation. These costs do **not** include a profit element for the owners, but do make an allowance for depreciation and for some rejections and unexpected down time.

- Siwoku (2011) calculated HQCF costs of production to be between N62 to 73/kg depending on whether fresh roots of wet mash are used. It assumes root prices of N10/kg, a root to HQCF ratio of 4:1 and assumes that the source of energy for drying is black oil. Again, if an allowance is made for inflation and the costs being based on a comprehensive plan; the real costs of production at the time of the field work might be a bit higher.
- The current price being offered by millers for HQCF is N80/kg – which the SMEs state is not attractive enough. They claim that they need a price of N100/kg and the price of roots to be less than N11/kg. The claim by the SMEs that they need a price of N100/kg gives credence to the accuracy of the analysis by Lam and Siwoku.
- Currently, the bulk ex-factory prices of wheat flour are N140/kg for hard wheat flour and N120/kg for soft wheat. Therefore, the addition of HQCF will reduce the cost of composite flour. It should be noted that part of the saving associated with the use of HQCF will be negated by the cost of “improvers” and other ingredients that might be needed in the recipe. However, it has been reported that in the case of bread production, the out-turn is improved using HQCF – by an increase of about 4% more loaves.
- The further away from the main mills, the more expensive wheat flour becomes. For instance, in Ifo town, Ogun State, wheat flour wholesaled at N144 to 146/kg and retailed as high as N160/kg. This confirms that HQCF producers would get better prices if they sell to the rural bakers (and other end-users) than to the millers based in Lagos. In addition, their marketing costs will also be reduced if they target nearby customers rather than the millers who are based further away in the main towns.
- The cost structure for the larger HQCF factories is different to the SME-owned flash driers. In addition to having efficiencies of scale, they achieve much better conversion rates of fresh roots to HQCF (3.6 to 1 compared to 4.5 to 1) because they do not hand peel the fresh roots. These two differences mean that the larger factories are significantly cheaper producers than the flash driers. Currently, one large processor sells HQCF at N80,000/t; which it claims gives them an adequate margin. Interestingly, the N80/kg is has been assumed in the feasibility studies for the large factories the Government wants to import from China.
- **In summary, it would appear that a selling price of N100/kg is required by the flash dryers and N80/kg for the larger factories to achieve sufficiently positive margins to stimulate production. These projections do assume a fresh cassava root price of about N10/kg delivered to the factory. However, it is important that the financial analysis is revisited to confirm that flash dryer owners do make sufficient money at N100/kg to cover their costs and make sufficient to repay any loans and replace capital equipment when needed.**

e) The way forward

- The inclusion debate needs to be settled. It is important that Government establishes a sensible and achievable set of targets for HQCF inclusion in the bread industry. These targets should take cognisance of the views of scientists who have evaluated the use of HQCF and improvers. Trials with bakers and biscuit manufacturers need to be supported. In addition, it is important to have a realistic understanding of the potential capability by the processors to produce HQCF of appropriate quality at competitive pricing.
- Obviously, it would be hoped that the inclusion could be encouraged because of cost savings and not being forced to use it – because it is very difficult to measure to measure the

amount of HQCF in wheat flour. Therefore, the cost savings associated with using HQCF need to be accurately evaluated and publicised.

- The inclusion policy pursued by Government is based on “hiding” HQCF in products and hoping that any changes in quality are so small that the end-user does not notice them. However, a more interesting policy could be to advertise the fact; as one large baker does with its bread, sausage rolls and snack foods. If biscuit companies introduced new biscuit brands that contained a significant amount of cassava flour; they could produce a cheaper product; but they would need a consistent supply of good quality HQCF¹¹.
- Consideration needs to be given to the potential for “encouraging” the paperboard industry to make their own glues using HQCF – or indeed the slightly more expensive cassava starch. It is recommended that the C:AVA Nigeria team prepares a paper to highlight the opportunity for using HQCF in glues for the paperboard industry.
- The economics of HQCF production need to be much more clearly understood, especially the impact of raw material costs. Currently the high cost of cassava roots in the Lagos/Abeokuta corridor makes HQCF production very expensive.
- Different market approaches should be considered for the larger producers of HQCF than the SMEs. The larger factories can produce HQCF more cheaply and perhaps should target the larger bread and biscuits manufacturers in the main cities whilst the SMEs should consider market opportunities much nearer their factories.
- In order to try and establish markets that would pay the higher price needed by the SMEs, it is important to evaluate market opportunities near to where flash driers are operational. It is there suggested that a number of flash drier factories, preferably the ones who will benefit from the C:AVA retro-fit, take part in a basic marketing training exercise to enable them to research nearby market opportunities. After the training, they would research potential HQCF buyers in their locality and devise strategies to supply them.
- The issue of the quality of HQCF needs to be continually addressed. One user of HQCF interviewed stated that they had only five suppliers of HQCF of consistently acceptable quality.

¹¹ Interestingly, if a new biscuit line was launched, a rule of thumb would be that they would need to produce about 15t of biscuits per day to be viable. This would require about 2 to 3t/day, or about 500 to 750t per year, of HQCF.

2. Instant odour-less fufu

a) Background

- Most flash dryer owners interviewed expressed interest in developing instant odour-less fufu because it would make use of their equipment and sold for a much higher price than HQCF. However, the downside to this product is the much smaller market opportunity when compared to HQCF.
- The selling price of instant fufu is between N250 to 300 (US\$1.67-2.0)/kg, ex-factory. Some flash dryer owners reported that they could sell in the order of one to three tons per month (equivalent to 4-12 tons FCR per month for each factory). The manufacturing process has some similarities to HQCF in that it needs to be dried quickly and hygienically; but does need some extra steps and equipment to facilitate the fermentation required. The fermentation step involves some additional labour and access to containers to use as fermentation tanks. In addition, it is necessary to pack in smaller bags as instant fufu is typically sold as a retail product, but these extra costs are offset by the much higher selling price of instant fufu when compared to HQCF (US\$1.13-1.47 higher for instant fufu when compared to HQCF). One flash dryer owner stated that it was not worth operating his factory for 1 to 3 tons per month of fufu despite its good margins. However, if he could make even a small margin on HQCF, then the combination of the high margin low volume instant fufu and the low margin high volume HQCF could be a profitable business strategy.
- **Therefore, making a better margin on HQCF could be one of the important drivers for developing instant fufu but other factors such as market potential must be taken into consideration.**
- **In addition to having the potentially attractive margin, another reason why instant fufu should be evaluated is that its small market size makes it very unlikely that the larger HQCF factories will be interested in competing with the SMEs.**

b) The market

- The market for instant fufu is not well understood. It is a relatively new product and it has a slightly different taste and texture to traditional fufu, but it is much more convenient. It is assumed that customers will have to pay for the convenience; it has been assumed that instant fufu is more expensive than traditional fufu per kg of finished product.
- During the February 2013 mission, a market dedicated to wet fufu was visited and traders interviewed. There were a large number of traders a significant amount of wet fufu traded and many actors in the value chain.
- A number of retail packs for wet cooked fufu were purchased and weighed at FUNAAB. These packs would retail in Lagos at N30 each and weighted between 20 and 25grams each with an average of 21grams. Therefore, the retail price of traditional cooked fufu was equivalent to N1,429/kg; which is an exceptionally high price. If the dry instant fufu is retailed at N300/kg; then when hot water is added, the actual retail value of it becomes in the order of N150/kg – assuming that the added water doubles the weight.
- This analysis shows that instant fufu is considerably cheaper than traditional wet fufu as well as being more convenient. It would also be useful if the increase in weight of instant fufu is recorded when hot water is added.
- Traditional wet fufu is in high demand by some groups in certain parts of Nigeria. Most of this traditional demand is supplied by wet fufu; the instant fufu is a more convenient

product due to its being easier to prepare and having a longer shelf-life. It is currently sold in 1 or 2 kg packs either in the immediate vicinity of the flash dryer or the international supermarkets in the major towns.

- The assumption is that being a convenience food and that wet fufu is not always available in all parts of Nigeria, there will be a growing demand for instant fufu.
- In addition, instant fufu could be exported to neighbouring countries, the EU and the USA. However, it is reported that other countries are also targeting these markets and it will become an issue of which country has the competitive edge. In the short to medium-term, Nigeria should focus on its own internal market before starts to think about exports.
- In 2010/11, NICAPMA reported that 470t of odour-less fufu was sold by its members, with half of this sold by one processor.
- It is difficult to estimate the overall market size for instant fufu, but at the international supermarket level, it is small. One supermarket manager thought his store sold “probably no more than 400kg per month”. Therefore, in total, these supermarkets could account for less than 4 or 5 tons per month. But this needs to be confirmed.
- In addition to the international supermarkets, there are a myriad of smaller local shops/supermarkets that sell dry foods and goods. These shops are often referred to as “corner shops”. They have not yet been surveyed or targeted as potential retail outlets for instant fufu. It is important that some of these shopkeepers are interviewed to assess their potential for marketing instant fufu.
- The current ex-factory selling price is currently N250 to 300/kg, which gives the manufacturers a very healthy margin; therefore, if the flash dryer owners start to seriously target this market, it must be expected that the price will decrease. Retail prices in International supermarkets are in the order of N450/kg
- **It is obvious that the market size for instant fufu needs to be quantified and an appropriate strategy needs to be developed to maximise the opportunity.** Given that it will be manufactured by the SMEs, it would seem sensible for the researching into the market size and opportunity to be included with the rural marketing course being developed for the SME owners and managers.

c) Economics of instant fufu production

- As with HQCF, the cost of fresh roots dominates the costs of production. It should be assumed that the roots could be purchased at an average of N10/kg. On average, the ratio of fresh roots to instant fufu is 4:1, making raw material costs of N40/kg. One producer of instant fufu noted that his other costs (including overheads and drying) came to N45/kg; which would give total costs of production about N85/kg.
- Therefore, with reported selling prices of N250 to 300/kg, the margins are extremely attractive.

d) The way forward

- Given the attractive margins for this product and its potential importance in developing businesses strategies to start flash driers operating and producing HQCF, it is important that further consideration is given to understanding the opportunities for this product.
- Therefore, it is important to gain further knowledge on the traditional fufu value-chain, including checking the retail price per kg.

- Then the next step is quantification of the market size for instant fufu and development of a coherent strategy to exploit it. It has been recommended earlier that some flash dryer operators are given some marketing education and encouraged to research opportunities for selling HQCF in the immediate vicinity of their factories. It is therefore recommended that they also research the opportunity for instant fufu at the same time.
- The strategy for Instant fufu marketing will be very dependent on its retail price compared to traditional fufu. If the weights recorded during the February 2013 are correct, then instant is cheaper than traditional and it can be marketed as a cheaper product. However, if the weights were incorrect and the instant fufu is more expensive, then it has to be marketed for its convenience.
- If it is sold as a convenience food, it is expected that the market opportunity for instant fufu will be small in the vicinity of the flash dryer factories; therefore research is needed to evaluate the market opportunity in the larger cities too.
- It could be useful if the flash dryer owners coordinate their marketing strategies for selling instant fufu in the larger urban market to maximise their margins on this profitable line. If they compete too aggressively with each other, then the current margins could fall dramatically.
- If the flash dryer operators can cooperate in developing local HQCF marketing strategies, then they could also work together to increase the market opportunity for instant fufu. Depending on the size of the market, it could be possible for the flash dryer factories to market their product under a common brand name with one person/company responsible for organising the marketing in the major towns.

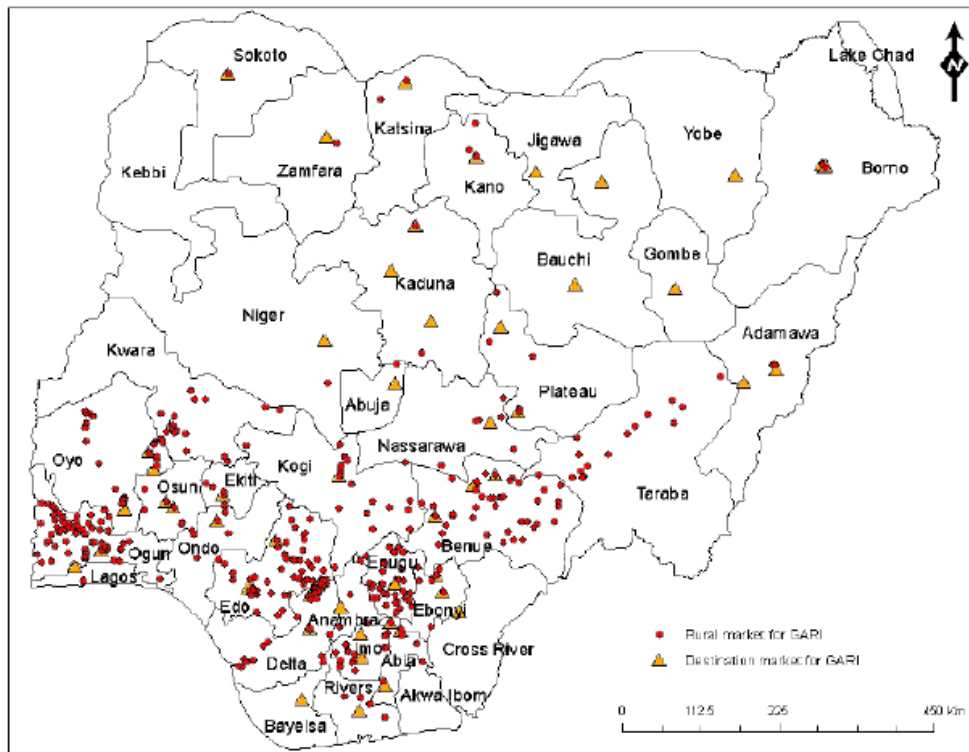
3. Packaged garri

a) Background

- Garri (gari) is the finished product obtained by artisanal or industrial processing of cassava roots. The processing consists of peeling, washing and grating of the roots, followed by fermentation, pressing, fragmentation, granulation, sifting and roasting. Garri is presented as a dried product of variable granule size.
- Garri is a highly popular convenience food in Nigeria and is widely accepted in both rural and urban areas. Processing into garri is the main use for cassava (about 70% of FCR production or ~26 million tons /year is used for garri).
- The vast majority of garri is produced by small-scale processors on open fires; about half is produced at the household level for consumption by the family. Although formal standards with grading specifications exist (most notably the Codex Standard 151-1989 rev of 1995), these are not applied in practice. Traditional markets rely on informal grading systems and are extremely competent at charging different prices depending on the type and quality of garri as well as the supply/demand situation.
- The demand for fresh roots for garri production (~26 million tons FCR/yr) is the main determining factor for the price of cassava roots. Unlike most of the other processors of cassava roots, garri manufacturers are more able to pass on increases of fresh cassava roots since the demand is extremely inelastic.

- Entry barriers for new entrants in the market are low – it is easy for producers to obtain pans, charcoal and fresh roots and start production. At village level it is often possible to hire the most expensive equipment such as graters and presses.
- Garri is mainly sold in open markets. Market chains are informal, but they work remarkably well and very large amounts are transported to retail markets across Nigeria.
- The increasing rate of urbanization and demand for convenient way of shopping is also changing the way garri is sold. In addition to bulk sales, garri is now being packaged in small size bags (1 to 2 kg) for sale in major supermarkets like Shoprite and “corner shops”.
- Some processors have invested in, or been given, stainless steel pans and automated stirrers that should improve the efficiency and hygiene of the garri process. There have been attempts to build automated garri factories to produce garri on an industrial scale, but their capital expenditure means that they cannot compete with the traditional methods.
- A small company, established in 2007, claims to dominate the market of packaged garri sold in supermarkets and to hotels; the manager claims that his company has a 50% to 75% market share.
- The garri sold through supermarkets was expected to be of excellent quality and well packaged. However, samples obtained as part of the study were of variable and often inferior quality with a high fibre content. It is likely that some of this product is purchased on the open market and simply re-packaged.

Figure 1 – Major source (rural) and destination (urban) markets of garri in Nigeria



Source: Ezedinma et al. (2007)

b) The market

- Main drivers for the growing demand of packaged garri have been identified in: urbanization, emergence of middle-upper class, higher demand for hygienic food, convenience of multiple purchases at a single supermarket (also in consideration of the traffic that make difficult to move from one market to the other). An additional reason is the desire of modern retailers to sell some locally produced items.
- The main constraints seem to be the high retail price (in supermarkets packaged garri is sold at N270-330/kg (USD1.80-2.20/kg). One of the problems of selling staple foods through supermarkets is that the extra cost of packaging leads to a significant increase in price which then puts it at a disadvantage over the traditional suppliers. Also, buyers of garri prefer to be able to touch it and check the moisture content and smell before buying it.
- The price of packaged garri appears to be stable over the year but the price of traditional garri sold in bulk is subject to strong fluctuations. As such the price differential between the two products varies considerably over the year.
- According to our interviewees at the production company and at Shoprite the profile of the average buyers is: single man or employed woman, young (18-40 years old), full-time employee. Furthermore it is likely that some of them are non-traditional garri consumers. This group is of particular interest since it represents an additional demand for garri (and hence cassava roots) rather than a shift from traditional to modern purchasing places.

- At the moment, the demand by shoppers in supermarkets is still very low. For example, sales of packaged garri at one Shoprite in Lagos have been estimated at 200kg/month, i.e. around 2.5tons/year. There are six Shoprite stores in Nigeria (plus 3 more in pipeline for next year): if we assume similar sales, volumes of packaged garri sold by Shoprite should be 10 to 20tons/yr.
- The main manufacturer claims to produce 25 to 35tons/yr and if his hypothesis about his market share is correct, this would translate into 30-70tons/yr (equivalent to ~130-300 tons of FCR) of packaged garri sold through supermarkets and hotels.
- Besides Shoprite other major supermarkets selling packaged garri are Spar and Megaplaza. Since sales are 'slow' supermarkets are not demanding for increased supplies. Conversely, wholesale sales to hotels (currently 30% of manufacturer's turnover) are growing.
- Despite sales being slow at the moment, it is expected that they will increase as the supermarkets start to become more and more important in Nigeria, but it is doubtful that they will increase very quickly and it is unlikely that packaged garri sold through the modern food retailers will replace traditional garri other than marginally.
- The volume of garri sold in retail pack in 'corner shops' is reported to be increasing but we cannot validate this information.
- In addition, garri can be exported to neighbouring countries, the EU and the USA. However, there are many other countries trying to target these markets; for example, there are a number of exporters doing this from Ghana. It will become an issue of which country has the competitive edge.
- In conclusion, the market for traditional garri is very large, but the opportunities in this segment for interventions are limited. If significant sales are achieved, it will be at the expense of the traditional segment.
- There might be some opportunities in the higher end, higher priced market in the international supermarkets. But this is very small.

c) The economics of garri production

- The ratio of fresh roots to garri is ~4.3:1. Root costs are similar to HQCF and peeling and labour costs are also about the same. However, processing costs are much less when compared to HQCF produced using artificial drying technologies.
- Selling price is about N100 (US\$0.67)/kg; therefore, the margins for traditional garri should be better than for HQCF.
- The packaged garri is sold wholesale to supermarkets at 225N (US\$1.5)/Kg and, while this is more than double than the retail price of traditional garri, the high transport, packaging and labelling costs lead to limited profitability

d) The way forward

- It is important that the production costs of traditional garri production are properly understood because this product effectively sets the market price of fresh cassava roots.
- However, the potential opportunities for developing market opportunities for improved garri seem very limited.
-

4. Starch

a) Background

- Starch is an important ingredient for food processing industry. Starch is also an ingredient in the glue and adhesive industry. In paper production, cassava starch is used as glue to achieve brightness and strength. Starch also has many other uses such as in the pharmaceutical, textile, plywood and cosmetics industries and as an additive in cement (to improve the setting time). In detergent soap manufacture, starch is used to get better recovery and to improve the shelf life of detergents.
- While starches from different crops (such as cassava, corn and potato) can readily be substituted especially if modified starches are used, native cassava starch has a number of characteristics including high paste viscosity, high paste clarity, and high freeze-thaw stability, which are sought after by some industries. For instance, in the textile industry, where starch is used as a yarn sizing and finishing agent, higher preference is given to cassava starch because corn starch may give a dull finish and change the colour.
- There have been a number of attempts to establish starch factories in Nigeria. Most factories built in the 60s and 70s are now closed. There are currently 4 cassava starch factories in Nigeria with an installed capacity of 67,200t/yr.
- However, actual output is much lower, the current output is ~14,000t/year.
- The most established starch factory would require 35,000t of fresh root in order to operate at full capacity (1,750ha assuming a yield of 20t/ha). The companies' initial plan was to procure the fresh roots from a 30km radius of the factory. Although small-scale farmers in the surrounding have been supported by various donor initiatives they have never been able to ensure regular supply of raw material to the factory. The factory is currently purchasing roots mainly from a few large farms in Kwara State (1-2 days journey by lorry from the factory) at 14,000Naira/ton inclusive of transport. Local farmers were supplying roots at 8,000Naira/ton in February 2013 but supplies were limited.
- The factory was formally relying on supplies from small farms with 1-2ha of cassava close to the factory. They are continuing to develop a supply base in Ondo State but are moving away from large numbers of very small farms towards a smaller larger of larger farms. They would prefer a minimum farm size of 12ha but are most happy with farms of 100ha or larger. These farms achieve a better yield (~20t/ha as compared to ~10t/ha for the small farms) and are more reliable in terms of supply. The company have negotiated purchase agreements with several bigger farms with a planting plan, crop budget and a price of 8,500Naira/ton farm-gate and 10,000Naira/ton delivered to the factory.
- In addition to the large mills, CTAP reports hundreds of small, village-level processors who produce starch for consumption among the ethnic groups Urhobo and Isoko in Delta State.

b) The market

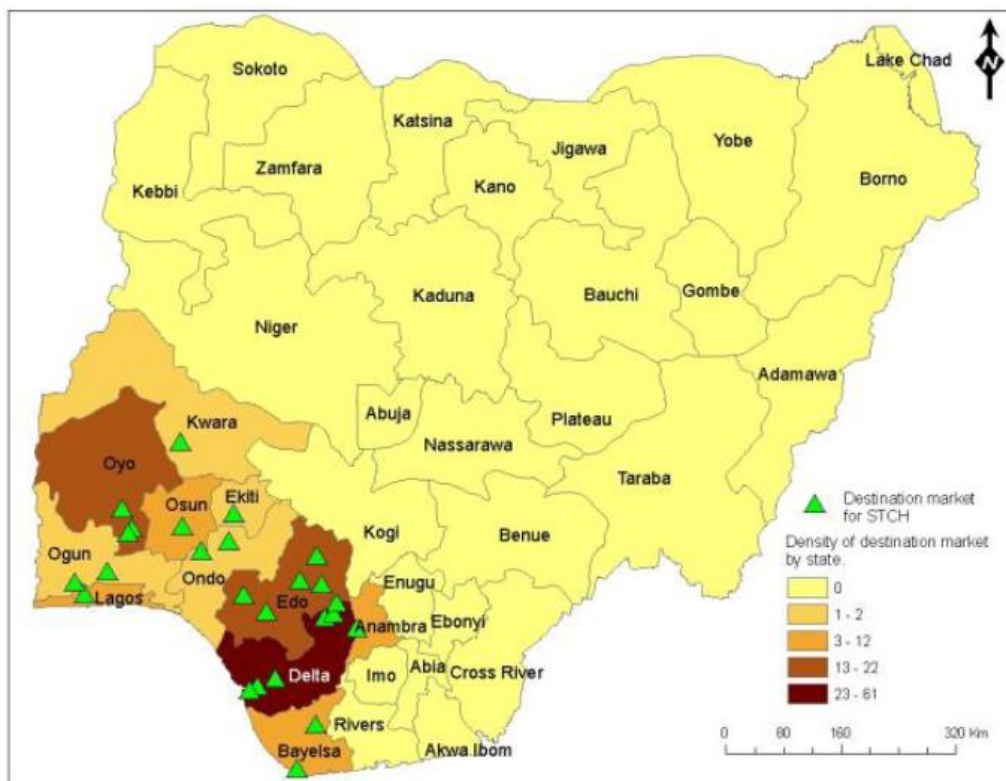
- The action plan for the CTAP estimates the annual domestic demand for starch at 230,000t, requiring 1.15 million tons of fresh cassava.
- Domestic demand is mainly met by import of corn starch. It has proved to be extremely difficult to obtain reliable figures about the imported volumes. External trade national official statistics are poor or lacking and different key-informants met during the visit had very different perceptions (ranging between 5,000 and 200,000t/year).

- The WTO/UN International Trade Centre (ITC) Trade Map database reports total import of starches (HS 4-digit level) in 2010 at 23,400t (US\$15.8 million) with a CIF average import price of US\$673/t. The ITC Market Access Map database presents more detailed information (HS 6-digit level) but provides figures only about the CIF value and not the volumes. Maize starch represents almost 95% by value of total imported starches. Assuming similar prices this would translate in around 22,000t of corn starch imported annually. China is by far the main supplier (40% of total imported volumes) followed by India (30%). CIF prices vary considerably in the range of US\$400-2,000/t according to type of starch (native or modified), quality and origin. Average unit value of all starches imported from China and India in 2010 was US\$498 and US\$D784, respectively.
- Illegal, and hence unreported, imports are relatively common. Among the other things this is a way to avoid the relatively high import duty: Nigeria Custom Service reports import duty for starch at 35%, reduced at 10% for pharmaceutical grade and 5% for modified starch. However, PIND value chain report (2011) states that starch is usually imported by the pharmaceutical firms who take undue advantage of the low tariff to import more than the amount they require for sale to other end users.
- If we assume the volume of illegal imports to be as high as the volume officially recorded, this would translate in total annual import of starch at around 40,000t to 50,000t. By adding the current actual production of starch in Nigeria the domestic demand for industrial processing can be roughly estimated at 45,000 to 60,000t/year (requiring 200,000 to 300,000t/year of fresh roots and 10,000 to 15,000 ha). While this estimation does not include cottage-level production for local consumption in the Delta State it suggests that the domestic demand might have been overestimated by the CTAP. However, the current domestic production of starch is far away from being able to meet this demand. Yet, if the current large starch factories, including the non-operational ones, worked at full capacity they should be able to supply the domestic market either fully or in large part.
- There is general agreement that most starch is used by **food industries** (probably between 70 and 90%).
- Factories producing custard are considered among the main users of starch. We can roughly estimate their annual demand of starch at 4,000-7,000t (the annual growth of this market is around 10%). Two of them have been visited during the mission. Both currently use imported corn starch but have already experienced cassava starch in the past facing some quality issues, in particular related to colour, fermentation, viscosity and gelatinization properties (however they claim to be keen to be involved in trials).
- Nigerian **packaging industries** usually import directly ready-to-use starch based pre-mix glue. One of them claims to import 650t of pre-mix glue annually. The purchase of cassava and maize starch by packaging companies for the own production of glue is likely to be very limited (a few hundred tons per year). While the own production of glue might offer opportunities for cost saving it would determine an additional technical and organizational burden for the company. Pros and cons should be carefully assessed. Moreover, while the use of cassava starch should offer technical advantages over HQCF as ingredient for glues (no fibres), the key question is whether cassava starch would be able to compete with imported (or locally produced) corn starch.
- Historically **textile industries** have been among the largest buyers of starch but it has been reported that the industry shrank considerably over the last decades and presently only a few textile companies operate in the country. It should be noticed that, in Nigeria, the

textile industries are located in the north, far away from the port. There might be an opportunity for local starch factories to service textile industries if transport costs are proved to be considerably lower.

- It seems that **paint industries** in Nigeria do not use starch.
- Although it was not possible to build a clear picture of the demand of starches by these different sectors in such a short mission (and some sectors were not covered at all, such as the pharmaceutical one) the volumes reported by the interviewees in the business give credence to the fact that domestic demand might have been overestimated by CTAP.

Figure 2 - Locations of main starch users



Source: PIND, 2011

c) Economics of starch production

- While in the past one of major starch processors attempted to have supply contracts in place with surrounding farmers, presently the company purchases roots on the spot market, preferably delivered at the factory gate. The current price paid for good quality roots is N12,000 (US\$80)/t at the factory gate.
- The ratio of fresh roots to starch is about 5:1 with good quality root.

- The company is currently selling higher quality starch to food processors at N170,000 (US\$1,133)/t and lower quality one mainly for packaging and mosquito coils at N150,000(US\$1,000)/t (delivered).
- Imported corn starch is delivered at about N130,000 (US\$ 867) to N140,000 (US\$933)/t. It was mentioned that the price of cassava starch from China sets the price for locally produced starch and Nigerian processors are selling cassava starch at around N135,000 (US\$900) to N140,000(US\$933)/t.
- The current total production cost of cassava starch in Thailand (the world leading cassava starch producer) are estimated at around 13,000-14,000Baht/t (N65,000- N70,000/t; US\$ 433- US\$467/t), of which around Baht10,000 (N50,000; US\$333) for the fresh roots. The latter is slightly cheaper than in Nigeria thanks in particular to better conversion rate due to higher starch content in the roots and more efficient starch extraction. But the main gap with the Thai industry lays in the difference in production cost net of raw material: in Thailand is around 3,000Baht/t, i.e. N15,000 (US\$100)/t while in Nigeria it is considerably higher due to lower scale economy (an average starch factory in Thailand produces 200 to 400t/day), higher utility and transport costs, high transaction costs, inefficient management and a poorly functioning credit market.
- Assuming the US\$500/t indicated by the ITC database as realistic CIF price for corn starch imported from China, the 35% import duty, a cost of handling at the port of N150,000 (US\$1,000) per 40ft container (30t of starch) and a transport cost of N100,000 (US\$667) per 30t lorry this would translate in a Delivered Duty Paid (DDP) price of around N 110,000 (US\$733)/t. DDP price might be even considerably lower if starches are passed off as pharmaceutical standard and, as such, unduly paying lower import duty. This may indicate that room exists for further lowering the price of imported starch in case of stiffer competition by local industries.
- A major food processor confirmed that they are buying Nigerian cassava starch at N170,000 (US\$1,133)/kg and imported corn starch at N140,000 (US\$933)/kg. However they pointed out that until recently Nigerian starch was slightly cheaper than imported starch (N135,000/t or US\$900/t) since the price of fresh roots had not yet rocketed.
- The high prices of fresh cassava (coupled with inefficient backward integration) have been indicated as one of the major constraints to the viability of cassava starch business. The need to purchase fresh roots from Kwara and Nasarawa leads to high transport costs that translate into prices offered to farmers being non-competitive with the local traditional markets.
- While there is considerable room to improve the management inefficiencies and tackle some of the problems abovementioned, with the current high cost of fresh roots (and their relatively low starch content affecting negatively the conversion rate) and potential downward pressure in the price of cassava starch, there is difficulty in expanding value added along the chain. This may result in insufficient value added to cover both the full cost of the processing activities as well as provide a return to equity.
- However a value chain analysis funded by CIDA and the WB (2007) states that until the end of July 2004, corn starch was being imported at prices about 10 to 20% lower than cassava starch. The import tariff applied to corn starch had been then raised from 15 to 80%, thereby providing some room for cassava starch producers to raise their prices. This information could not be validated during the mission and the questions about how this

initiative affected the long-term sustainability of the domestic processing factories and the impact it had on consumer prices remain unanswered.

d) The way forward

- High selling price of starch seems to offer opportunities for starch factories in comparison to other starch products, such as HQCF despite the higher conversion rate. However it is important to understand the cost structure of starch production in order to determine the full cost recovery price of cassava starch.
- A benchmarking exercise is envisaged in order to identify potential areas of inefficiencies and possible solutions to tackle them.
- A comparative analysis about the feasibility and profitability of locally producing starch using either cassava or maize as feedstock should be conducted.
- All the above should include sensitivity analyses to key parameters such as cost of the raw material and price of imported starches.
- The economics of starch and other cassava-based products (including traditional food) need to be compared in order to find out what sub-sector is likely to be able to pay higher prices for roots and, hence, secure a reliable supply of raw material.
- There has been some talk of the potential for HQCF SME's to diversify into starch as a way to add value to their production. Two approaches have been used SME's attempting to enter the starch business. One approach is to buy wet starch from rural starch extraction groups. This business is undermined by quality control issues due to variations in water quality and processing technique that make the quality of the end product unsuitable for large-scale food industries. Another approach is to install a starch extraction facility at the HQCF factory. An SME of this type was visited in February 2013. Sadly the locally fabricated equipment was mostly unsuitable for efficient starch extraction and unsurprisingly the factory had failed to get into the cassava starch business. Proper equipment could be sourced but this would involve a major capital investment so this option is unlikely to attract the failing HQCF SME's. In addition water supply and effluent disposal are issues that the typical Nigerian HQCF SME is ill equipped to deal with.
- Illegal import and unduly lower tariffs may undermine the profitability of the domestic industry. Stronger enforcement of the regulation at the custom clearance should be in place. Consideration should be given to conduct a study to understand opportunities and threats raising from increased import tariffs for starches.
- High quality is demanded by large buyers such as Nestle and Unilever. Any effort in increasing the economic viability of the sector has to be coupled with consistent focus on delivering a product whose quality has to meet the technical specifications of the customers.

5. Sugar Syrups & Sweeteners

a) Background

- Cassava (fresh, dry, cake or starch) can be used as raw material for sweeteners, primarily glucose syrups, pure glucose, high fructose syrups (HFS) and sorbitol.
- Sweeteners are obtained by acid or enzyme hydrolysis of cassava starch or flour or wet cake to produce glucose syrup (mixed chain length maltodextrins) or pure glucose. Glucose syrup can be converted to high fructose syrup (HFS) using glucosyltransferase. Raw HFS contains ~42% fructose but this is typically refined commercially to produce 90% fructose syrup which is then mixed with 42% fructose syrup to produce 55% fructose syrup that closely matches the sweetness of sucrose for use in beverages. Glucose syrup can be hydrogenated in the presence of a Raney Nickel catalyst to produce sorbitol.
- Around 4.6 tons of fresh cassava are required for 1 ton of glucose syrup; while for a ton of HFS around 5 tons of roots would be processed.
- In Nigeria imported glucose syrup is used mainly by the biscuit, snack, and brewing industries. Pharmaceutical companies may be using glucose too but we could not verify this information. The current consumption of HFS appears to be very low but large potential may exist as potential replacement of import sugar particularly in the soft drink and juice industry.
- In Nigeria there are only two factories with the capability of producing glucose syrup, Ekha Agro Nigeria Ltd, established in 2007 in Ogun and Tempo Starch also in Ogun, but Tempo have never produced glucose syrup.
- Ekha Agro has an installed capacity to process 400t/day of fresh roots, i.e., around 20,000t/y of glucose syrup. The factory has never worked at full capacity and has always struggle to secure enough roots. The maximum amount they have exceptionally processed is 250t/day, while it was uneconomical to process less than 100t/day. As a result the maximum annual volume produced has been 6,000t/y of glucose (27% of installed capacity). Since July 2012 they have stopped operating.
- In order to work at full capacity the factory would need around 130,000t/year of fresh cassava. Assuming a yield of 20t/ha this would require 6,500ha. During the visit it was mentioned that the initial plan was to purchase the roots from small-scale farmers in the surroundings. They have been also supported by the USAID-funded project "Markets" to strengthen their linkages with Ekha Agro. Due to insufficient and inconsistent supply of roots the factory started purchasing roots from Osun and Kwara States, hundreds of kilometres away. The factory has also a small nucleus farm of 50ha. Presently this is not cultivated anymore due to lack of funds.
- It seems that several reasons have contributed to the lack of viability of this company. The location where it was established was not ideal since they suffered the competition of the traditional food market for the procurement of the roots. Furthermore it was reported that they raised very high expectations in the surrounding areas and, as a consequence, many farmers increased the cultivated area allocated to cassava. Due to lack of working capital and delayed approval by the main buyers they did not have enough liquidity to buy and pay for the roots. This situation left a number of farmers with no market for their harvested roots and some of them dumped the roots at the gate and let them spoil as a form of protest. By the time they obtained the approval and could start selling their glucose the relationships were already deteriorated and farmers refused to commit themselves to

supply the factory. Additional reasons for their failure were the lack of access to the expected gas pipeline and, hence, necessity to rely on expensive diesel, unreliable water supply, lack of sufficient land for proper wastewater treatment and weak management capacities.

- No HFS or sorbitol factories exist in Nigeria.

b) The market

- The sweeteners market shows a steady growth and CTAP estimates a growth of 50% over the next ten years.
- Apart from the low volumes that have been marketed by Ekha Agro until recently, the demand of sweeteners has been fully met by importation, mainly from China and the US.
- CTAP estimates the potential demand of sweeteners that could be met by locally processed cassava as follows: 40,000t/yr of glucose and 150,000t/yr of HFS (the later assuming 50% replacement of imported sugar)
- The ITC Market Access Map database reports 2010 import of glucose and glucose syrup at US\$24 million that should equate with around 40,000 to 50,000t. FAOSTAT database estimates imports at 67,000t (with a peak of 120,000t in 2008). CIF prices can vary considerably but US\$500 to 600 per ton should be a safe range.
- We can conclude that glucose demand in Nigeria can be estimated at 50,000 to 70,000t/year. Assuming that locally produced glucose syrup is unlikely to fully replace importation the estimation of 40,000t/year by CTAP is likely to be right. This would require about 240,000t/year of fresh root from 12,000ha.
- Recent import of fructose and fructose syrup are reported in the ITC Market Access Map database at US\$0.6 million, probably less than 1,000t/year.
- Major opportunities for HFS exist as a potential replacement for imported sugar. The ITC database reports 2010 import of sugar at USD373 million and 440,000t. The FAO database reports substantially different figures estimating import at US\$650 million and 1.3 million tons. Further research is required to validate these information. Similarly average CIF prices for year 2010 are reported at US\$850/t, exceptionally high if compared with prices 2006-09 rather stable at around US\$500/t.
- Most sugar is imported in the raw form (mainly from Brazil) and refined in the country. This is in part due to the high import tariff that refined sugar face: 20% import duty plus 10% levy. In comparison the import tariffs for raw sugar and sugar syrups are significantly lower, at 5% and 10% import duty, respectively.
- Soft drink and juice industries are the major consumers of sugar and are the most likely to be interested in replacing refined sugar with HFS. For instance it has been mentioned that just two companies, Coca Cola Nigeria (5 plants in the country) and 7-UP bottling company (9 plants, producing among the others the brand Pepsi) import around 200,000t a year of sugar.
- A total import of 300,000t/year of sugar by soft drink and juice industries seems to be plausible and, as such, the 150,000t/year of HFS (50% substitution) targeted by CTAP may be realistic. This would require around 1.5 million tons of fresh roots (around 75,000ha).
- In conclusion glucose syrup and HFS appear to offer an opportunity for processing about 1.75 million tons of fresh roots, considerably higher than what indicated by CTAP (950,000 tons).

c) Economics of sweetener production

- Price paid by Ekha Agro for good quality roots with >20% starch content was N10,500 (US\$70)/t at the factory gate. The lower the starch content, the lower the price, eg. N10,000(US\$67)/t for 18-20% and N7,000(US\$47)/t for 10-15%. Roots with <10% starch were rejected.
- Ekha Agro used to sell glucose syrup to Guinness at N105,000(US\$700)/t - N125,000(US\$833)/t.
- Price of imported glucose syrup from China is around N140,000(US\$933)/t. Hence, at first sight, the price of locally produce glucose seems attractive, therefore creating opportunity for local production of glucose.
- However, at current root price the cost of raw material would be around US\$322 per ton of glucose syrup (conversion 4.6:1). Ekha Agro claims that the cost of raw material represented roughly 25% of their variable costs. If this is confirmed the production cost of glucose syrup would be around US\$1,288/t taking into account the variable component only. Even though the factory was affected by all the issues mentioned above, it is difficult to imagine how this business could have been profitable.
- Furthermore assuming the CIF price of glucose syrup at US\$550/t, the import duty (10%) and cost of handling at the port and transport cost similar to the ones assumed for starch this would translate in a Delivered Duty Paid (DDP) price of around US\$667/t indicating that room exists for further lowering the price of imported glucose syrup.
- Price of refined sugar is N160,000(US\$1,067)/t (delivered).
- At current cassava root prices (N10,000 to N12,000/t or US\$67 to US\$80/t) and assuming the conversion rate of HFS at 5:1, around US\$ 335 to 400) would be required for purchasing the roots for one ton of HFS. Even though the economics of HFS production are still unclear there appear to be little room for a profitable business.
- Again current high prices of roots and relatively cheap imports seem to offer limited possibility of value addition to cover the processing cost and remunerate the capital invested.

d) The way forward

- The economics of glucose and HFS production need to be much better understood.
- A detailed comparative analysis should be conducted in order to understand the economics of using different raw materials, including cassava other than fresh (e.g. chips), maize grains and maize starch.
- Consideration should be given to conduct a study to understand opportunities and threats from increased import tariffs for raw sugar and sweeteners.

6. Dried cassava chips

Dried chips in domestic livestock and aquaculture feeds

a) Background

- Dried cassava products can be used for a number of different processes and have the advantage that they are shelf-stable unlike fresh cassava roots or wet mash which are highly perishable.
- Dried cassava can be used in the production of compound animal feed and this is/has been a common practice in Latin America, South East Asia and Europe. However in Africa, while cassava inclusion in animal feed is not a novelty, it has never been consistently used in large volumes due to the prevalent role of cassava as a staple food. Furthermore cassava is often more expensive than the grains used in the traditional cereal-based rations.
- In Nigeria the production of dry cassava, in particular cassava chunks produced by peeling and sun-drying of roots, is concentrated in the Middle Belt region. Nassarawa, Benue, Taraba, Plateau and Kaduna are the States where the vast majority of dried cassava is produced, especially between the dry months of December and March. The production of dry cassava is minimal in the Southern part of the country due to the unfavourable conditions for drying and the predominant processing of fresh roots into garri and fufu.
- The principal market for dried cassava currently is the Dawanu market in Kano State, a major foodstuff market serving the Sahelian West African region. Cassava chips and chunks, mainly from Nassarawa, Benue and Taraba, are informally exported to Niger, Chad and Burkina Faso. It is reported that trade of cassava products has been increasing over the last 20 years and it is particularly noticeable during the dry months as a response to food scarcity in the neighbouring countries. It is extremely difficult to have reliable estimates of the volume of dried cassava traded. As an indication an IITA study estimates that the volume of fresh roots equivalents dedicated to cross border trade through the Dawanu market alone was ~550,000 tonnes in 2005.
- In Nigeria, dry chips are mainly produced for human consumption and, as such, from peeled roots. The conversion rate into dry chips is about 3.2 during the dry season (November to April) and 4.1 during the wet season (May to October). However, for the use of cassava in animal feed there is no need to peel the roots if proper processing is undertaken in order to reduce their toxicity. For unpeeled roots the conversion rate is 2.5 and 3.2 in the dry and wet season, respectively.
- Cassava in commercial settings is usually in the form of dried root chips or chunks which are milled into powder (meal or flour) before incorporation into compound feeds usually for commercial poultry.
- Traditionally cassava is manually sliced in chips of different size. Often the whole root is cut in just 2 or 3 big chunks before drying. Recently simple machines have been developed for chipping cassava roots.
- The most common way for drying chips and chunks is by sun-drying. However, when the weather conditions are not favourable, artificial drying is possible by simple batch dryers often used for drying grains on farm.
- An alternative cassava product than can be used in animal feed is the grit. Grits are produced by grating the washed unpeeled roots to produce a mash. The mash is then

dewatered to form a cake that will be spread thinly and allowed to sundry on a polythene sheet. One of the advantages of grits in poultry is that they do not need to be milled (and hence lower losses due to dust) and can be supplied directly to the birds. Moreover they present a relatively uniform particle size.

- In the animal feed industry cassava can be used as a replacement for maize as a source of energy. The results, in terms of its feeding value, nutritional problems encountered, biological responses and productive performances of animals fed with cassava products, have exhibited wide variability. The variations, apart from being caused by the varying types of cassava used, are due to differences in animal species, types, development stage, level of production and ecological conditions. In addition, the form, and composition of diets, level and types of supplementation are additional factors contributing to these conflicting results. Accordingly, the literature presents contradictory findings regarding what products can be used, how they can be fed and how much of cassava product can successfully be fed to each poultry and fish type.
- A typical poultry ration includes about 50% maize, 25 % vegetable protein source, 5% animal protein source and the balance made up of minerals, vitamins and filler ingredients. Results in the literature do not provide clear answers about the potential replacement level of maize with cassava. However, in general, there is agreement that broilers tend to tolerate diets containing higher levels of cassava better than layers, where egg production and quality are particularly susceptible to the type of imbalances commonly found in high cassava diets. As an indication, suggested rates of substitution of maize with cassava range between 30% and 100% for broiler chickens and between 20% and 40% for laying chickens. Partial substitution of cassava for cereals tends to support better performance than where total substitution occurred. Some studies report that at high level of substitution, efficiency in feed utilization tends to be depressed before growth reduction is noticed.
- Intensive and semi-intensive commercial fish farms largely use feed pellets, either sinking or floating. In fish feed protein content need to be much higher than in poultry feed (40 to 50%). Carbohydrates, such as starches and sugar are the most economical and inexpensive source of energy for fish diets. Carbohydrates are included in aquaculture diet to reduce feed costs and for their binding properties during feed manufacturing. In Nigeria, maize and, to a lesser extent, wheat are the common carbohydrate sources used for fish feed. Cassava, though not popular for compounded fish feed has been used in many parts of the world for this purpose.
- A typical fish ration contains between 10% and 30% of maize (depending mainly on the type of pellet and fish species and development stage). In tilapia cassava can replace 100% of maize provided that all nutrients are properly balanced. In catfish it has been indicated that substitution rates can be in the range of 25 to 50%. However, unlike for poultry, floating pellets are produced by extrusion and, in their processing, cassava has some comparative advantages over maize, mainly in terms of its binding properties (and thus replacing expensive ingredients such as starches and cellulose) and better floatability of the pellets.
- Cassava roots are an excellent source of carbohydrate but the protein and vitamin content is very poor. It is important to correctly balance cassava based diets for all nutrients to appropriately satisfy the needs of each class of animal. Therefore there is need to supplement the cassava products with protein, amino acids, fat, minerals and vitamins at higher levels than when using cereal-based diets. Typical protein rich ingredients used as supplements are soymeal, fishmeal and groundnut cake.

- Cassava products are deficient in carotene and other carotenoids. Consequently, supplementation with these compounds is needed in poultry production for the maintenance of normal egg yolk and broiler skin pigmentation.
- Cassava leaves are another potential protein supplement. Leaves can be harvested within 4 to 5 months of planting, without adversely affecting root production. After drying the foliage can be ground into meal which is a good source of protein and carotene for poultry. However, other researches point out that their high level of crude fibre and the lack of the full range of essential amino acids make them only a fair source of protein for non-ruminants. Furthermore the leaves are characterized by low energy, bulkiness and high tannin and cyanide content.
- The issue of toxicity due to the content of cyanogenic glycosides, namely linamarin and lotaustralin, is a source of concern for the feed industry. However, properly dried products are considered safe feed for all classes of livestock. Nevertheless, the residual glycosides in the products can still cause some degree of deleterious effects on the performances of cassava-fed animals. It has been suggested that in poultry the supplementation of methionine helps the metabolism to detoxify the cyanide. It was also mentioned that soaking the root for a few days before drying reduces the cyanide content.
- Dry cassava products are of highly variable quality and usually contain significant levels of contaminants like sand and fungi (e.g., *Aspergillus flavus*) above all when dried on bare ground and in humid areas for more than two days (as it is the case for chunks and larger size chips). These can have more deleterious effects than the residual cyanide in cassava.
- Physical properties such as dustiness and bulkiness limit feed intake. Furthermore dustiness increases the likelihood of Chronic Respiratory Disease in the birds. Cassava meal is characterized by high bulkiness and dustiness. Ways to reduce the dustiness of cassava meal include feed pelletization and the addition of molasses and fat (in particular palm oil and full fat soya) to the mash in order to reduce dust and improve texture of the diets. Apart from reducing the dustiness, pelletizing is done to make bulk storage and transport easier.
- It has been suggested that a more effective and economic way of producing pellets would be by grating washed unpeeled roots, dewatering and passing them straight into the pelletizer where it is steamed and the resulting hot pellets are sun-dried or oven dried.

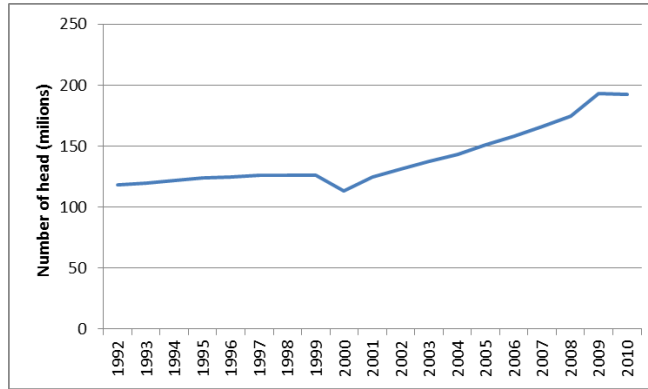
b) The Market

i. Poultry market

- In Nigeria poultry feed constitutes the largest proportion of commercial ration produced by feed millers. It is estimated that it absorbs over 90% of total feed commercialized in the country. Therefore the use of cassava as substitute for maize will have its greatest impact if it can be incorporated into commercial poultry feed.
- In spite of difficulties faced in the past, including stiff competition from imports and high cost of animal feed, the poultry industry is growing and there is a steady trend towards a consolidation of the sector with fewer but larger companies.
- Between 1992 and 2010 the chicken population has increased from 120 to almost 200 million heads (Figure 1) and the annual poultry meat production from 160,000 to 270,000 tonnes (Figure 2). As shown in Figure 3 poultry stocks are distributed throughout the

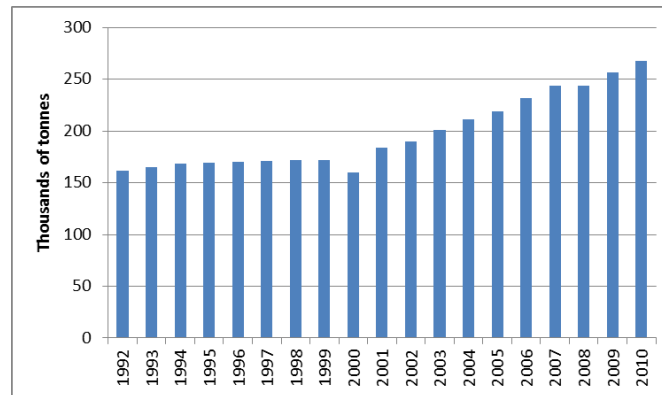
country but the highest density of birds is recorded around the major cities in the Southern regions of the country.

Figure 1: Chicken population in Nigeria (1992-2010)



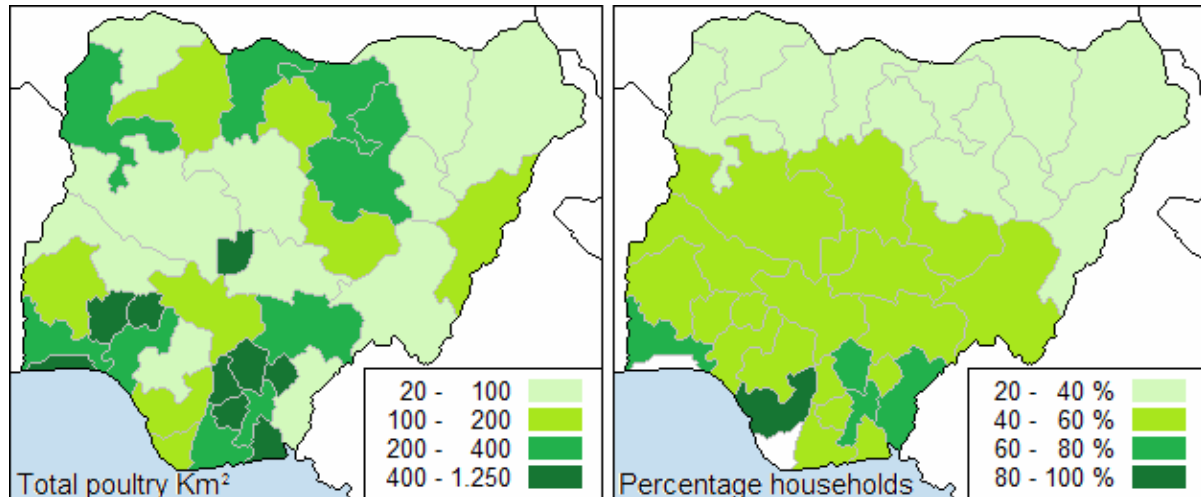
Source: FAOSTAT (2013)

Figure 2: Poultry meat production in Nigeria (1992-2010)



Source: FAOSTAT (2013)

Figure 3: Distribution of poultry population in Nigeria (2011)



Source: FAO Global Livestock Production and Health Atlas (2013)

* Poultry includes chickens, turkeys, and ducks.

- Poultry production falls under two main categories, traditional rural systems and intensive commercial operations. In between these two categories, intermediate, semi-intensive systems are also developing in rural towns and urban areas.
- Traditional poultry keeping takes place throughout the country, with almost every rural household raising poultry, mainly for household consumption. The traditional poultry system is estimated to account for around 70% of the total poultry population. Birds in traditional systems are allowed to roam freely and poultry keepers typically provide a handful of corn, millet, or sorghum grains once a day. Scavenged plants and insects make up the remainder of birds' diets.
- Commercial poultry production is concentrated in the southern part of Nigeria, particularly in South Western states near Lagos. The commercial operations specialize in non-indigenous, exotic poultry breeds. Commercial production takes place at a range of scales, from very large facilities, some foreign-owned, to smaller, independent operations. At the top end of the scale, a small number of fully vertically integrated facilities operate near Lagos. These facilities manage their own feed mills, processing facilities, and hatcheries, which produce tens to hundreds of thousands of day-old chicks weekly. Small- to medium-scale operations have capacities ranging from 1,000 to 20,000 birds. These facilities often buy day-old chicks and other inputs from the large-scale operators.
- The intermediate category, the semi-intensive system, shares characteristics of both rural, traditional systems and commercial operations. Backyard flock sizes range from 50 to 1,000 birds and may include indigenous breeds, exotic varieties, or a mix.
- While for smallholders, poultry keeping is a low-input activity, requiring few financial resources, in commercial operations, feed accounts for a large portion (60% to 80%) of production costs.
- Current commercial feed production is estimated at around two million tonnes per year. There are both formal regulated feed mills and the informal mills constituting 50% each in terms of total output of feed production. Few major feed mills, mostly located in the South Western part of the country, dominate the formal market.

- The use of cassava chips for poultry has been a relatively common practice since the 80s following the ban on import of maize in 1984. When the ban was lifted feed mills kept on using cassava because it was still cheaper than cereal grains (maize and wheat mainly). But, due to the increase of cassava prices in the following years, it has been estimated that the proportion of total cassava used as livestock feed dropped from 10% to less than 5% between 1990 and 2000. Currently only a few companies are thought to regularly use dried cassava (e.g., Vital Feed in Jos).¹² Some large feed mill use cassava chips during times of scarcity of maize. Apart from economic considerations it appears that most feed mills have little or no experience in the use of cassava in feed, in particular from unpeeled roots.
- If the figures that have been provided are correct and assuming unpeeled cassava chips' inclusion rate of 25% in poultry diet (50% maize substitution) a potential demand of around 450,000t/year dry cassava exists, this would translate into 1.1 to 1.4 million t/year of fresh roots.
- The vast majority of compound feed is in the form of mash. Pelletizing machines are not yet widespread but they are increasingly used in the production of commercial feed. A number of large poultry farms have their own pelletizing machines and do not purchase ready-to-use commercial feed.

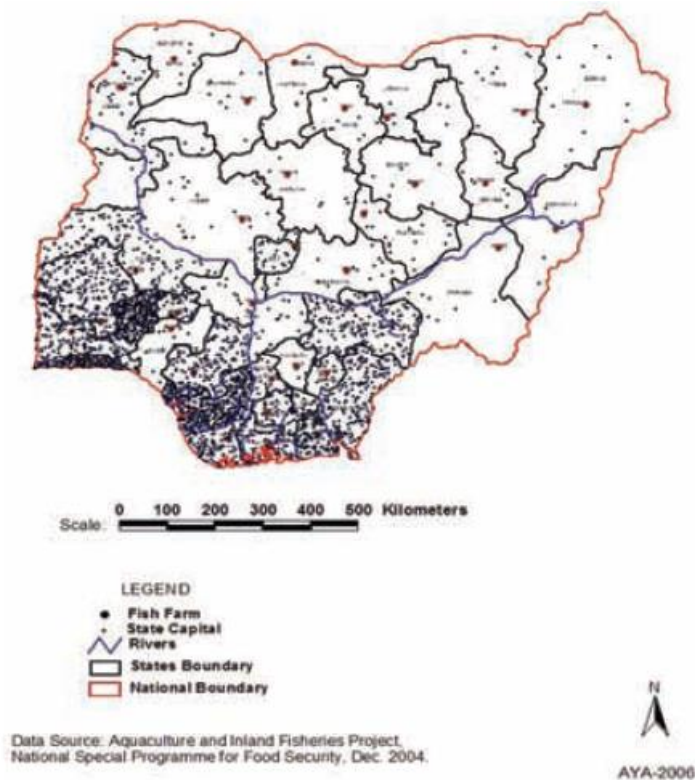
ii. Farmed fish market

- In 2010, the total landings from marine and inland capture fisheries amounted to some 817,000 tonnes. Capture fisheries in Nigeria are more important than aquaculture. It is widely recognized that the progressive development of aquaculture is essential if the projected annual fish demand of 1.5 million tonnes is to be met.
- After a series of false starts, aquaculture is now entering an exciting phase of its evolution. Between 2000 and 2010 the annual aquaculture production has increased almost tenfold, from 25,700 to 200,500 tonnes, and Nigeria is presently the second largest African producer of farmed fish, after Egypt. Currently aquaculture contributes to around 25% of total fishery production.
- Catfish is by far the most important species, representing between 60% and 80% of total farmed fish. Tilapia production ranks second and its relevance is steadily growing. Earthen pond culture is the dominant production system. More recently, fish culture in water recirculation systems has been developed and is being practiced in several urban and peri-urban areas.
- Aquaculture farms can be classified into large, medium and small-scale businesses. Small-scale fish farmers account for over 70% of producers and this group can be further divided into commercial and a large number of non-commercial farmers (estimated at about 50,000 producing mainly for household consumption). These farms comprise of holdings ranging from one pond of 0.05 ha to several ponds with a total water surface area of around one hectare. Feeding practices of the small-scale operators include the addition of manure (or compost) to stimulate primary productivity and the supply of low quality feeds such as agricultural by-products (cassava peels, rice bran, etc.) and kitchen wastes at irregular intervals. Non-conventional animal protein sources such as earthworm are also used as supplementary feeds.

¹² Unfortunately we had not the possibility to interact with them since they are located in the Northern part of the Middle Belt of the country.

- Medium-scale fish farming enterprises contribute between 10 and 20% of the total aquaculture production. These enterprises mainly use concrete tanks for intensive catfish culture and/or earthen ponds (2–10 ha total surface area). The farms are sometimes complemented by a medium sized hatchery and feed mill. Management practices show a greater level of environmental control. Ponds are generally fertilized with manure and on farm-made feeds or locally produced, complete, pellets are often supplied as supplement.
- Large-scale fish farms, of which there are approximately 50 in the country, are enterprises covering 15 ha or more and they account for 5–10% of total aquaculture production. They normally have concrete tanks and/or around 20 to 30 ponds (nursery and production ponds), a hatchery and a feed mill to supply the required inputs.
- Intensive and semi-intensive aquaculture farms, mainly located in the Southern regions of the country (Figure 4), depend on formulated feeds, either as a supplement to natural food generated by high pond fertilization rates or as a complete diet (in mash or wet or dry pellet form). Fish feed represents the main production cost in intensive systems in Nigeria.

Figure 4: Distribution of fish farms in Nigeria



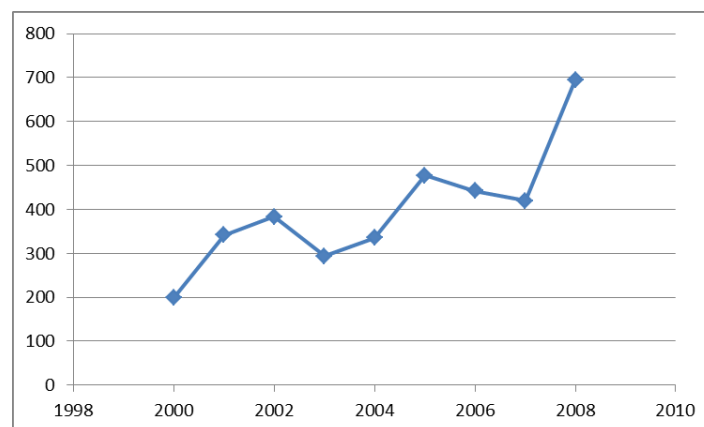
Source: Abdullah (2007)

- Fish feed is processed by compression pelleting or extrusion. Existing pelletizers in Nigeria are not adequate for production of highly demanded fish feeds like floating types that can be done through extrusion. This is because they sink rapidly when thrown in pond or tank, any raw starch in the diet is left uncooked, pollutes the water in the pond and tendency to crumble, produce much dust and gets wasted due to inability to detect when the fishes are satisfied with feeding. Food extrusion is a process in which food ingredients are forced to flow, under one or several conditions of mixing, heating and shear, through a die that forms and/or puff-dries the ingredients. Extruded floating feeds are preferred by many farmers because they allow observation of the feeding process thereby preventing wasteful feeding, facilitates the inactivation and destruction of heat labile anti-nutritional factors and other contaminants (including the cyanogenic glycosides) and they are extremely stable in water. Also, the higher temperatures employed during extrusion cooking facilitate the rupture of the cellulose membrane surrounding the plant cell and individual starch granules of cereals and oilseeds, with consequent starch gelatinization and increased carbohydrate and calorific bioavailability. Thus, the use of extruded floating fish feed comes with a host of advantages in terms of digestion, growth, water protection, zero water pollution, optimized labour usage and zero wastage of raw materials. In spite of the several advantages of using floating pellets, demand is constrained by the high cost of extruded pellets.
- It is estimated that only about 10 dedicated aquafeed plants exist in Nigeria and these are located in Lagos, Ibadan, Jos and Ilorin. Some foreign companies are currently considering establishing fish feed mills in Nigeria. Furthermore, a number of feed mills specialized in poultry feed produce aquafeeds as an incidental product. Most fish feed processors produce sinking pellets only. However it has been reported that, over the last few years, a few extruders have been imported and distributed for the production of floating pellets whose demand is expected to grow in the coming years.
- Availability of high quality fish feed is one of the greatest problems that affects the expansion of the small-scale fish industries in Nigeria. Local production of high quality fish feed is insufficient to meet the demand and currently large amounts of fish pellets, in particular floating ones, are imported at high cost, mainly from South Africa and the Netherlands. It is believed that most of the total demand of floating pellets is still met by imports (estimated at 10,000 to 20,000 t/year).
- As previously mentioned intensive and semi-intensive farms are the ones using fish pellets, either sinking or floating. They contribute to about 15-30% of total aquaculture production (30,000 to 60,000 tonnes a year). Assuming a feed conversion rate of 1.5:1, this translates into a theoretical demand of 45,000 to 90,000 tonnes of pellets per year. Cassava flour is used by some of the fish feed mills we have interacted with, mainly because of its binding and floating properties in extruded pellets. However also producers of sinking pellets have mentioned their past experience in using cassava flour at the time of maize scarcity. Some of them complained about the lack of regular availability of cassava flour. It was reported that fish pellets can contain up to 10% or 40% of cassava (it depends on several factor, e.g. for fingerlings it seems that is advisable not to use more than 10% of cassava to avoid excretion problems). Assuming a 25% cassava inclusion this translated in a potential demand of 11,000 to 23,000 tonnes of cassava flour per year (equivalent to 28,000 to 74,000 tonnes of fresh roots) but this is expected to increase with the projected growth of the aquaculture sector. Obviously the higher the domestic production of floating pellets, the higher the potential for cassava inclusion.

c) The economics

- In order to envisage a higher inclusion of cassava in the animal diets it is necessary that the price favourably dictates a competitive advantage for cassava. The price of cassava is the major limitation to its large-scale use in commercial feed milling. IFAD (2004) suggests that prices of cassava chips should range between 60% and 70% of that of maize to be economically feasible. However, poultry feed mills we have interacted with, have indicated lower figures due to the high cost of required supplements.
- The vast majority of maize used by the feed industry is domestically produced. Nigeria imports limited amount of maize (ranging between 0 and 17,000 tonnes per year between 2000 and 2010).
- The rapid development of intensive poultry production in Nigeria has been accompanied by an increase competition between humans and animals for maize, which is a major staple food in Nigeria. This resulted in shortage of maize and increase in its price. Figure 5 shows the rise in the producer price for maize between 2000 and 2008.
- So far, it has not been possible to obtain price information of maize and fresh cassava roots across different States of Nigeria. Furthermore, in Nigeria cassava is characterized by a cycle of glut (excess cassava) with depressed prices that regularly occurs every three to four years following a period of scarcity and high prices. However it has been reported that in last couple of years the price of maize delivered at the mill gates in South Western part of the country fluctuated between 40,000 and 90,000 N/t (US\$ 265 to 600/t).

Figure 5: Producer price of maize between 2000 and 2008 (US\$/t)

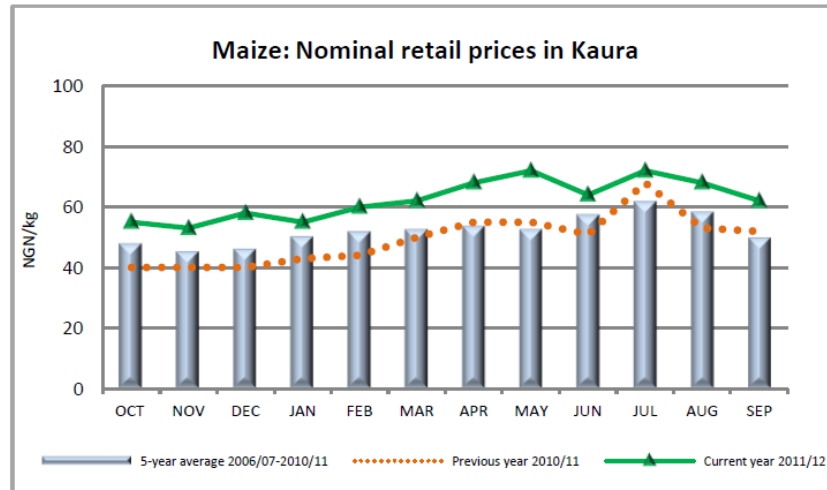


Source: FAOSTAT (2013)

- Maize is predominantly produced in the Middle Belt of Nigeria, far away from where main poultry and fish farms and feed mills are located. This is the same area where most of dried cassava is produced. On the other hand, the production seasons between the two crops differ significantly. The harvesting season for maize is during the dry months while cassava, although potentially harvested all year round, is mainly harvested during the wet months

when uprooting is facilitated by the soil moisture. Therefore, a window of opportunity may exist to replace maize with cassava especially in the wet season when the price of maize is at the highest. For instance, Figure 6 shows how in Kaduna state, the price of maize is significantly higher between the months of April to August. However, the sun-drying of cassava can be a serious challenge during those months and the option of artificially drying has to be taken into account.

Figure 6: Nominal monthly prices of maize in Kaura, Kaduna State



Source: FEWS (October 2012)

- In order to assess the potential of cassava inclusion in poultry feed two typical rations without cassava were compared with three rations containing cassava. These diets were either taken from the literature or provided by Nigerian animal nutritionists involved in this study. These rations present different inclusion rates of different cassava products (from either peeled or unpeeled roots). This exercise was carried out for both broilers and layers.
- The results did not provide a clear answer. In some cases the cost of the diet including cassava was significantly higher than the one exclusively maize-based due to high cost of required supplements. But the sensitivity analysis (assuming price of maize ranging between 50,000 N/t and 90,000 N/t) showed that, when the price of maize is at the highest, some cassava diets compare favourably with the maize ones. For instance, in the case of broilers, in the most favourable situation, when the maize price is 80,000 N/t (US\$ 533/t) the feed millers would break-even the production cost by paying the delivered dried cassava up to 60,000 N/t (US\$ 400/t). With maize price at 90,000 N/t (US\$ 600/t) the break-even point would be as high as 65,000 N/t (US\$ 433/t).¹³
- In order to calculate the price that the chip processors would be able to pay for the fresh roots the following assumptions were made: price of maize at 60,000 N/t (US\$ 400/t) and 80,000 N/t (US\$ 533/t) in the dry and wet season, respectively; peeling cost at 600 N/t of fresh roots (when required); chipping cost at 1,500 N/t of fresh roots; drying cost at 2,000

¹³ At the time of the study (February 2013) one fish feed miller in Abuja reported a price of cassava flour purchased from intermediaries at 60,000 N/t, up from the 45,000 N/t of the previous year.

and 6,000 N/t of chips for sun-drying (in the dry season) and artificial drying (in the wet season), respectively; bagging costs at 3,000 N/t of chips; and conversion rates as previously discussed. Without taking into account processor' profit margin and transport costs, in the most optimistic scenario, this would be equivalent to a farm-gate price of fresh roots for the production of unpeeled chips of 16,500 and 14,500 N/t (US\$ 110/t and US\$ 97/t) in the dry and wet season, respectively. But, assuming a transport cost of 7,000 N per tonne of chips (this is an indicative price for a 30t lorry from the Middle Belt to South Western Nigeria) the maximum price payable for fresh roots at the farm-gate for processing into unpeeled chips would be 14,000 and 12,500 N/t, in the dry and wet season, respectively. Even though presently we have no exact figures about the price of fresh roots in the Middle Belt in the different seasons, these prices seem to offer an ample margin for ensuring a regular supply of fresh roots and allowing a reasonable margin for the processor.¹⁴ The processing into chips in the wet season is likely to offer better margins due to the lower price of roots that outweigh the additional cost for the artificially drying. However these results should be taken with caution since they refer to the most favourable comparison between cassava and maize-based diets and further research is required to fully understand the economics of the different compound feeds.¹⁵ Moreover it should be noticed that the production of chips from peeled roots seems not economically feasible due mainly to the cost of peeling and the higher amount of roots required for producing one unit of chips (higher conversion rate).

- While for broiler there might be room for a profitable inclusion of cassava in compounded feed, the results for layers were much more consistent and deny this possibility. Even in the best scenario, the price that the processors would be able to pay for the fresh roots is well below that currently offered by the traditional market.
- Fish feed millers with current or past experience in the inclusion of cassava in pellets pointed out that, despite the several advantages of using cassava in floating pellets, they tend to switch back, at least partially, to maize as soon as the price of cassava flour approaches the one of maize, due to the high cost of the required protein rich supplement. However, because of the better quality of pellets, they claim to be happy to keep on using cassava as long as the ration does not become considerably more expensive than the maize-based one. In case of sinking pellets, the only consideration seems economical, i.e. in lowering the cost of ingredients (no interest in floatability and better binding properties without extrusion).
- It has been mentioned that the price of protein rich ingredients, such as soybean meal and groundnut cake, has almost doubled over the last two years and if this trend continues this would be an additional impediment to wider use of cassava in animal diets.
- Minimal investment is required to switch and use cassava chips in animal feed. The key issue is the delivery of quality cassava chips at a price competitive with maize.
- An additional constraint to the wider adoption of cassava in South Western Nigeria consists in the fact that it does not compete only with maize but with the food industry's by-products too. These industries, mainly located around Lagos, supply discarded products,

¹⁴ It had been reported that in the last three years farm-gate price of fresh roots in the Middle Belt has been in the range of 5,000 to 10,000 N/t (US\$ 335 to 670/t). Conversely, offering those prices would not be competitive in the South Western region where traditional garri and fufu processors demand high volumes of roots to supply the urban markets and are able to offer prices currently well above 15,000 N/t (US\$ 100/t).

¹⁵ Some feed millers we have interacted with mentioned that they would be interested in cassava chips if they could be delivered at around 1/3 of maize price. However this information may be biased.

such as spaghetti, noodle and biscuits, to some nearby small and medium enterprises that find their nutritional value (higher energy and similar protein content compared to maize) and price (40,000 to 70,000 N/t) very attractive, especially at the time of maize scarcity. However the supply of by-products is quite irregular, unpredictable and not able to meet the demand of the feed mills.

d) Conclusions and recommendations

- Assuming unpeeled cassava chips' inclusion rate of 25% in poultry diet (50% maize substitution) a potential demand of around 450,000t/year dry cassava exists, this would translate into 1.1 to 1.4 million t/year of fresh roots.
- Intensive and semi-intensive fish farms are the ones using pellets. Assuming a 25% cassava inclusion this translated in a potential demand of 11,000 to 23,000 tonnes of cassava flour per year (equivalent to 28,000 to 74,000 tonnes of fresh roots).
- There is general agreement that there are no major technical impediments to the use of dry cassava in compound animal feed. Some of the constraints to its use (e.g., low protein content, texture and toxicity) can be overcome by adopting good processing practices and appropriate technologies. The key issue is to understand the economics of cassava inclusion.
- For the time being, the economics of dried cassava in poultry feed are not sufficiently clear mainly because of the lack of consensus about the diet formulations and the fragmented information about the price of fresh roots across different regions and seasons.
- The poultry feed millers have shown interest in using cassava in their formulations if this translates in lower production costs (and indeed a few of them have occasionally used cassava at the time of maize scarcity). However, likewise, they are fast in switching back to maize when inclusion of cassava is not economically convenient as proved by the lack of cassava orders by poultry feed millers in the last couple of years that have been characterized by lower cassava production (following a period of glut) and high prices of roots.
- The same applies to fish feed millers producing sinking pellets. Conversely, in the processing of floating pellets the use of cassava flour seems conducive to the production of better feed. While processors of sinking pellets expect to pay the cassava flour at a price considerably lower than maize, the ones producing floating pellets seem willing to buy cassava as long as its price is not too close to the one of maize.
- The price of fresh roots remains the main limiting factors for greater inclusion of cassava in commercial feed. This is a cross-cutting issue for all sectors using cassava as raw material.
- Preliminary results suggest that there may be an opportunity to supply feed mills with dry cassava from the Middle Belt, particularly during the wet season when the price of roots are lower and the price of maize is at the highest. However this would imply the use of simple dryers for farm level processing. While this technology is not an absolute novelty, the transport costs, the present low quality of cassava products, the poor commercial orientation of farmers in that region with regard to cassava, the linguistic and some socio-cultural differences that may hamper effective communication and trust are impediments that should be addressed. Moreover the general status of insecurity in the Middle Belt should be taken into account if any intervention is envisaged.

- On-farm feeding trials to evaluate the performance and economic value of cassava-based rations need to be carried out extensively in order to gain the full picture about the feasibility of cassava inclusion in the diets.
- Inclusion of cheaper protein sources such as rumen contents and blood meal from slaughter houses can be explored to reduce the high cost of additional proteins.
- Diffusion of information on cassava-based feed formulation and on-farm data on performance of poultry and fish reared need to be widely disseminated and demonstrated in order to win the confidence of the commercial feed millers and livestock farmer to adopt them.
- Farm gate processing into chips in the Middle Belt region seems to offer the most potential. This would enhance rural income and create agro-based enterprises. While value adding may be limited this would require limited capital investments and reduce transport costs.
- Cost saving technologies such as use of unpeeled roots which eliminates the peeling costs should be promoted.
- The need to develop efficient dryers for chips and pellets must be addressed particularly for allowing the production during the wet season, which coincides with periods of abundance of cassava and when room seems to exist for the substitution of high-priced maize with cheaper cassava.
- Pelletized products developed from locally fabricated pelletizing machines are still of low quality as soft rather than hard pellets are obtained and the starch is still rather powdery rather than being gelatinized. The need to source affordable and suitable pelletizers has to be addressed. Furthermore the process of first producing dried chips before pelletizing still raises the problems of re-milling and rehydration before pelletizing.
- The poor storability of dried cassava products limits its usage to short periods when prices are competitive and cassava is produced in abundance. Chips are stored for no more than three months by commercial feed millers in Nigeria. Further research is required to understand whether extending the shelf-life would allow its procurement and storage when prices are low and can be competitively used with escalating prices of maize.¹⁶
- The usual poor quality of chips should be addressed in order to become more attractive for the feed industry.
- Cassava cyanide “scare” is still a problem for its adoption in commercial feed milling. Feed millers should be made aware that properly processed cassava (including sun-drying, soaking, heat, supplementation of amino acids) eliminates most of the cyanide to levels below the acceptable 100 ppm.

¹⁶ It has been mentioned that properly dried and stored chips can have a shelf life of one year but this information has to be validated.

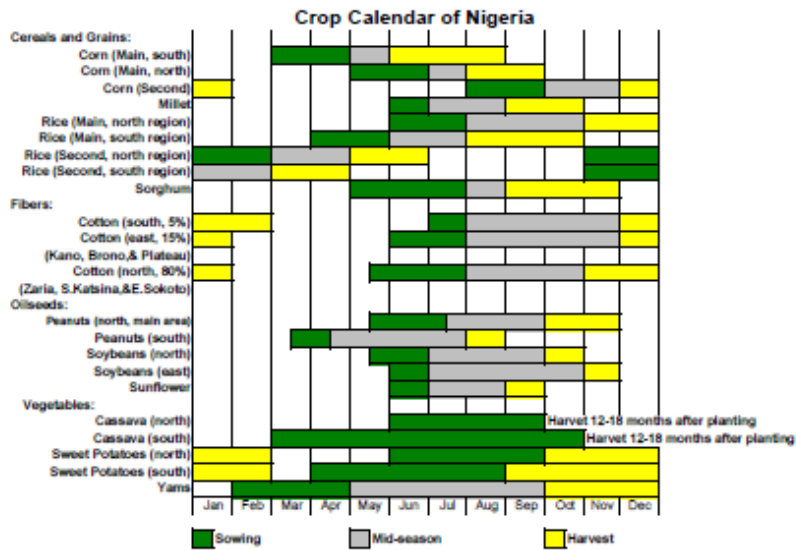
Annex 7: Geographical distribution of poultry in Nigeria

This distribution does not take into account the fact that there are commercial poultry farms based on exotic birds operated on a backyard poultry basis and that subsistence household poultry rearing can be based on exotic birds.

State	Poultry *			Percentage of households rearing subsistence poultry **				
	Traditional	Exotic	Total	Chicken	Guineafowl	Duck	Turkey	Other Birds
Abia	1 282 050	127 339	1 409 389	58,5	0	1,1	0,6	1,2
Abuja FCT	3 465 000	347 288	3 812 288	41,7	0	7,1	0	0
Adamawa	3 780 000	347 288	4 127 288	26,5	2,9	5	0,1	0
Akwa Ibom	2 772 000	277 830	3 049 830	48,1	0	0	0	0
Anambra	2 483 250	248 889	2 732 139	44,6	0,4	0	0,7	6,7
Bauchi	5 832 750	5 846 006	11 678 756	22,3	11,4	5,2	0,2	0,4
Bayelsa	900 900	90 295	991 195					
Benue	6 121 500	613 541	6 735 041	51,2	0	3,5	0,4	0
Borno	5 313 000	532 508	5 845 508	17,3	1	1,5	0,1	0,1
Cross	1 155 000	115 763	1 270 763	59,6	1,7	0,6	0	0
Delta	2 356 200	236 156	2 592 356	100	0	0	0	0
Ebonyi	2 347 514	3 542 333	5 889 847	49,1	0,3	0,5	0,3	0
Edo	1 120 350	112 290	1 232 640	53,6	0	1,7	0	0
Ekiti	2 656 500	266 254	2 922 754	47,7	2,4	2,2	0,4	0
Enugu	1 859 550	1 863 776	3 723 326	58,9	0,1	0	1	0
Gombe	462 000	46 305	508 305	27,3	4,7	4,6	0	0,5
Imo	5 832 750	584 601	6 417 351	48,8	0	0	0,9	0
Jigawa	4 389 000	439 898	4 828 898	16,4	4,3	2,2	0,1	0,4
Kaduna	2 564 100	256 993	2 821 093	34	2,8	5,1	1,1	0,4
Kano	3 528 000	324 135	3 852 135	17,3	7,1	3,7	0,4	0
Katsina	4 735 500	474 626	5 210 126	19,8	8,4	7,1	1,2	1
Kebbi	6 930 000	694 575	7 624 575	26,5	1,8	0,3	0	0
Kogi	3 349 500	335 711	3 685 211	42,1	0,3	8,4	0	0
Kwara	3 037 650	304 455	3 342 105	43,6	0,3	3,6	0,7	0
Lagos	2 852 850	285 933	3 138 783					
Nassarawa	531 300	53 251	584 551	40,1	2,6	4,9	0,1	0
Niger	2 772 000	277 830	3 049 830	43,4	3,1	6,1	0	2,1
Ogun	3 234 000	324 135	3 558 135	71,2	2,8	0	0	0
Ondo	3 003 000	300 983	3 303 983	54,7	1,1	0	0	0
Osun	3 234 000	324 135	3 558 135	56,6	0	0,3	0,1	0,3
Oyo	2 829 750	283 618	3 113 368	41,5	0	0,9	0	0
Plateau	3 453 450	346 130	3 799 580	41,7	2,4	4,9	0	0
Rivers	3 465 000	347 288	3 812 288	56,4	0,4	0	0	0
Sokoto	1 339 800	134 285	1 474 085	21,1	2	0,5	0,2	0
Taraba	2 460 150	246 574	2 706 724	43,7	0	2,4	0	0
Yobe	3 118 500	312 559	3 431 059	18,2	2,2	1	0,4	0
Zamfara	5 313 000	532 508	5 845 508	14,7	8,3	0,8	0,7	0
Nigeria	115 880 864	21 798 084	137 678 948	27,2	4,6	3,3	0,4	0,4

* Source: Federal FDL&PCS, February 2006 (data from 2003)

** Source: Estimates based on raw data, National Bureau of Statistics, 2006



Production Estimates and Crop Assessment Division (PECAD)
 Foreign Agricultural Service (FAS)
<http://fas.usda.gov/pecad/pecad.html>

Rain Seasons:

Rainfall is seasonal with distinct wet and dry seasons, except for the coastal zone where it rains all year round. Rainfall is concentrated in the period June-September, with the south receiving 50-60% of its rainfall and the north receiving 90%.

Average Rainfall:

Rainfall varies from under 500 mm/year in the northeast to over 3000 mm/year on the coast.

Dried cassava for export to China

e) Background

- Dried cassava chips can be used for a number of different processes and have the advantage that they are shelf-stable unlike fresh cassava roots or wet mash which are highly perishable.
- The CTAP has suggested that there is a good opportunity for export of dried chips to China. It has been previously reported that there have been two main exporters, One company interviewed in early 2012 claimed to have exported 10,000t in 2010, mainly to China.
- The FAOSTAT and the World Bank database showed minimal exports of dried cassava from Nigeria. Annual exports of **all** roots were in the range of 10,000 to 15,000t/year. Therefore, Nigeria has minimal experience in exporting dried chips.
- In Nigeria, dry chips are produced from peeled roots and the conversion rate is about 3:1. In Thailand chips from unpeeled roots have a conversion rate of 2.5:1.

f) The Market

- FAOSTAT reported exports from Thailand of over 4 million t at a price of US\$139/t and Vietnam exported over 700,000t valued at US\$178/t.
- According to the Government of Nigeria it has orders from China for 2.2 million tons of chips worth US\$272 million (US\$124/ton). CTAP says it has issued Local Purchase Orders (LPOs) for the purchase of 1 million tonne of dried chips and grits for export to China and the first shipment of 150t took place in July this year and 200t was exported in the following month. There was no feedback from the customer regarding the acceptability of the dried cassava. A delegation from the Ministry of Agriculture travelled to China to negotiate prices for the dried cassava chips and it was decided that the price received by the Nigerian exporters would be based on “the world market price”.
- Traditionally, the main exporters of dried cassava chips in the world have been Thailand followed by Vietnam. However, it is reported that they are not able to meet the rapidly increasing demand from China. But these major players will be important in setting the prices for cassava.

g) The economics of export

- The first point to consider is that the competitive advantage for cassava chip production to China lies in Thailand and they will therefore set the prices. In Thailand, the chips are not peeled, they are sun dried and the industry is mechanized and large; also it is nearer to the end market than Nigeria. In addition, the average farm yields are much higher in Thailand. Therefore, these all give Thailand processors cost savings. Nigeria is only aiming for a very small share of the market, but market prices would be set by product from Thailand and Vietnam.
- It might be possible to use chips from very remote areas where there are very few alternative uses for surplus cassava.
- Data provided by one company that was considering production and export of dried chips showed that the anticipated price would be US\$210/t. Previous research has shown that dried chips are exported to China in 40ft containers that hold about 25t of product at a cost of about US\$2,000/container. Transport to the port at Lagos from the mid-Nigeria is about N120,000 (US\$800) per lorry, administration at the port is about N150,000 (US\$1,000). If

- the lorry also holds about 25t, the total transport costs of moving cassava chips from mid-Nigeria N23,000(US\$153)/t which equates to a price in the middle of Nigeria of N9,350(US\$62)/t of dried chips. Assuming that three tonne of cassava roots is needed to produce one tonne of dried chips, this is the equivalent of about N3 (US\$0.02) /kg. This quick calculation makes no allowance for costs associated with chipping and drying.
- Therefore, it does not appear that the exports of dried cassava chips to China would be very attractive. It is obviously important that these numbers are confirmed.
 - Currently, the export of cassava chips does not benefit from Export Expansion Grants (EEG) that are awarded to some industries. In theory, as cassava chips would be regarded as a raw material, it might benefit from a 5% grant, but even this is unlikely to make the operation attractive. At the best of our knowledge, so far no company has applied for EEG for chips.

7. Ethanol/bio-fuel

a) Background

- Nigeria has a policy to include ethanol in petrol; the initial target is 10% substitution – it is often referred to as the E10 policy.
- In addition, there are two other market segments for ethanol; for industrial uses and for home-cooking in place of charcoal or kerosene. The industrial segments could be further divided into potable alcohol and industrial uses, but in this report both are included in the industrial alcohol segment.
- Cassava can be used as a base for producing ethanol. It must be recognised that the best plant raw material for producing ethanol is sugar cane, but cassava is often regarded as one of the next best feed-stocks for the industry.
- Cassava has been used to produce ethanol in Nigeria for a number of years. For instance a small factory (10,000litre/year) that used to use molasses was converted to using cassava in 1995. It uses both fresh roots and dried chips.
- One ton of fresh cassava roots produces about 167 litres of ethanol – a ratio of about 6 to 1. However, this ratio will vary according to the starch content of the cassava roots. Most cassava-based distilleries in Asia and Latin America quoted ~6:1 but a few gave ratios as high as 6.6:1.
- The logic for concentrating on cassava as a base for ethanol is that Nigeria is a long way from self-sufficiency in sugar and, if there are more plantings of sugar cane, it is likely that they would be processed into refined sugar. In addition, other significant cassava producing countries, eg Thailand and Vietnam use cassava for producing biofuel.
- The logic for using ethanol for home cooking is that it is a much cleaner fuel and it is estimated that 3% of child mortality in Nigeria is associated with pollution within homes due to the use of solid fuel.
- One of the key issues that has to be evaluated before investment in ethanol production, and indeed with any other significant investments in cassava processing, is **the impact on food security (It is interesting to note that China is restricting production of bio-ethanol from cereals and is concentrating on cassava which is not an important food crop in China)**. It is important that before significant investments are undertaken consideration is given to the

compilation of best practices by investors and producers developed by FAO to reduce risks and increase opportunities¹⁷.

- The CTAP is committed to supporting ethanol production from cassava. In January 2012, it was reported that it has supported one company Primera Agricultura¹⁸, based in Koggi State to establish a small-scale commercial ethanol plant (capacity 1,000 litres/day) to evaluate the production of ethanol. The equipment was to be sourced from Brazil and was expected to arrive in Nigeria in March 2012 and be operational by April 2012. However, it has reportedly been delayed. The equipment for this small bio-ethanol factory, which is funded by National Biotechnology Development Agency (NABDA), is now expected to arrive in Nigeria in March/April 2013.
- A feasibility study for this factory was reviewed; which probably painted an optimistic picture to the potential profitability of the investment. The viability of the investment depends on the selling price of the ethanol and its uptake by the public. However, it will provide an invaluable opportunity to learn more about the processing of bio-ethanol from cassava and the potential for using it as a fuel source for cooking.
- In addition to NABDA and Primera Agricultura, an NGO called Project Gaia is heavily involved with the development of ethanol for home cooking.
- Given that a 1,000l/day ethanol plant would use about 6t/day of cassava roots, it is a similar size operation to the Nigerian SME's equipped with flash dryers that produce HQCF. Therefore, issues associated with procurement of feed stock will probably be very similar to the flash dryer owners. Like the flash dryer experience, it is hoped that the imported technology can be adapted to the Nigerian conditions and the equipment eventually manufactured locally.
- The National Power & Technology Agency (NPTA), a para-statal tries to work with the private sector to drive forward investment in biofuel production. It is seeking finance to establish a 1,000 litre a day ethanol plant. This would use ~6t of cassava roots per day. It has imported 1,000 cooking rings that use ethanol for trialling in people's homes from a Swedish company called Dometic.
- In addition to sourcing cooking rings from Sweden, there are manufacturers in South Africa and it is hoped that eventually they will be made in Nigeria.
- Reportedly, the CTAP commissioned a report into the feasibility of promoting biofuels from cassava; but the C:AVA Nigeria team has not seen this report.
- In January 2012, it was reported by the CTAP that Government had agreed to buy ethanol at a price based on the cost of production plus a profit for the processor.
- It was reported that Government was considering the banning of imported alcohol to encourage local production, but this was not confirmed.
- A major investor has made a significant investment (N4.5 billion) in a factory producing industrial quality ethanol – with a capacity of almost 20 million litres per year. Assuming a price of FCR N12/kg, they claim that their production costs are in the order of N140 to 150/l, which compares very favourably with an import price (including duty) of about N300/l.
- This company have established their own agronomic department to provide inputs and advice to farmers growing for them. The investment in the agronomic department was N250 million. Even though they call this contract farming, it is really more like relational

¹⁷ www.fao.org/bioenergy

¹⁸ Primera Agricultura is owned by Chief Awoniyi, a member of the cassava transformation team.

farming; where the company and the farmers working relationship is based on trust more than a formal contract.

b) Market

- According to the US Energy Information Administration, in the mid-2000s, Nigeria was importing about 43 million barrels per year of petrol and about 7 million barrels of Kerosene. This equates to about 7 billion litres of petrol and 1 billion litres of kerosene per year.
- 10% substitution of petrol would be 700 million litres per year. To produce this from cassava would need about 4.2 million tons of fresh roots.
- The kerosene could be replaced by an equal amount of ethanol, which would require about 6 million tons of fresh roots.
- Data from different sources for imported industrial ethanol varied considerably; but the Federation of Statistics (2005) estimates that the annual demand for ethanol; in Nigeria was 160 million litres per year mainly for pharmaceutical, industrial and beverage uses. However, following trade interviews, it was estimated that about 60 million litres are imported each year. This would require about 360,000t of fresh cassava to produce.
- Currently there are two companies that import industrial ethanol. There are four large beverage companies that use imported ethanol. It was reported that the 4 large potable alcohol companies consume about 27 million litres of ethanol per year. The majority of ethanol (>90%) is imported (mainly from Brazil), the balance is purchased from local gin makers and redistilled to remove impurities. Ethanol distilled from local gin is cheaper (taking account of purchasing and distillation costs) than imported alcohol (US\$0.33 less per litre for local production). However, supplies of local gin are reportedly unreliable in terms of volume and consistency of supply due to limited availability of suitable sources of fermentable sugar (eg, molasses).
- The market opportunities for ethanol in Nigeria are, theoretically, very large and would require a very large increase in plantings to meet the targets. However, it is important to consider the economics of production before strategies are developed to exploit these opportunities.
- It was reported that an American NGO had given Nigeria 100,000 litres of cooking-grade ethanol for distribution to prime the market.

c) Economics

- The landed cost of petrol is N140(US\$0.90)/litre and it is officially sold at the pumps at N97(US\$0.65)/litre, or higher. It is reported that subsidies on petrol will be removed, so effectively the selling price will be about N140(US\$0.90)/litre.
- A sensible assumption is that ethanol sold to Government as part of the E10 programme should not increase the cost of petrol – so the maximum price would be N140(US\$0.90)/litre. If this assumption is correct, and it would take 6kg of fresh cassava roots to make a litre of ethanol. Then at N10/kg, the raw material cost to make a litre of ethanol would be in the order of N60. This would allow a further N65/litre to cover all other direct costs and make a contribution towards overheads, capital costs and profits. This needs to be further investigated.

- Kerosene is landed at N153(US\$1.02)/litre and sold officially by the NNPC at N50(US\$0.30)/litre; but effectively, the retail price is between N120 to 140/litre (US\$0.80 to 0.93). It would appear that the economics for producing kerosene are similar to petrol.
- The economics for imported ethanol are complicated by an import duty of between N100 to 150/litre (US\$0.67 to 1.00). The importers either buy refined ethanol at 96% purity for a landed price of about N300(US\$2.00)/litre or unrefined alcohol for about N100(US\$0.67)/litre. By the time the unrefined alcohol is purified, its value is about N300(US\$2.00)/litre. Sometimes small amounts of locally produced ethanol are traded, but because of impurities, it is only bought for N60(US\$0.40)/litre. Given the much higher market prices for industrial alcohol, it would appear that this would be the first market to target.
- The capital costs of installing bio-ethanol plants are significant. It was estimated that for a large factory of 60 million litres per year, the investment would be US\$60 million. A smaller plant of 20 million litres per year would require an investment in the order US\$30million.

d) The way forward

- Considerable more research is needed into the feasibility of supporting a bio-fuel industry based on cassava. If the feasibility study undertaken by Accenture could be obtained, it would be very useful.
- In addition, it is important that there should be an evaluation to ensure that there is both an adequate supply of fresh roots and that **there is no negative impact on food security.**
- The two market segments that need consideration are the production of ethanol for industrial purposes and the establishment of ethanol factories to produce fuel for home cooking. The first option should generate reasonable profits whilst the second would have considerable positive social and environmental impacts.
- The Governments position regarding the import of ethanol needs to be confirmed.

8. Beer

a) Background

- Cassava can be used as a feedstock by the brewing industry. SAB Miller is a pioneer in cassava beer and in October 2011 it launched a lager, named 'Impala', produced and commercialized in Mozambique. The brewing process uses 70% cassava and 30% barley.
- Due to the high perishability of the root SAB Miller have partnered with DADTCO who developed an Autonomous Mobile Processing Unit (AMPU) for cassava. The AMPU travels to remote agricultural regions to purchase the roots from smallholder farmers live. The roots are processed *in situ* into a wet cake and transported to the brewery for the brewing process.
- In the first 12 months of production, Impala sales were 9 million bottles (50,000 hectolitres) which equates with 2.7% of the market for beer in Mozambique. In the first year of production 500 small-scale growers produced 2,700 tons of fresh cassava roots for use in Impala beer. Cassava was processed into wet-cake (~40% moisture) in the village using mobile processing units known as AMPU (developed by DADTCO in Nigeria) and transported to the brewery. According to SAB-Miller Impala has been so successful that they plan to expand production in 2013 to involve 1,500 farmers and consume 10,000 tons of fresh cassava roots per annum.
- Building on the success of Impala in Mozambique, SAB-Miller launched a cassava-based beer in Ghana called "Eagle beer" in March 2013. It is believed that Eagle is a very similar product to Impala. SAB-Miller are known to be exploring the possibility of launching a cassava-based product in South Sudan.
- In December 2012 Guinness Ghana Limited launched a cassava-based beer in Ghana under the name of "Ruut Extra beer" with sales targeted to more rural areas and small towns. Ruut Extra is a clear beer with a rather sweet taste due to the amount of maltodextrins used in the formulation. The price of Ruut Extra is ~30% lower than conventional beers. Guinness are reported to be using dried cassava-grits rather than the wet-cake system favoured by SAB-Miller.
- In Mozambique and Ghana a major incentive for development of cassava-based beers has been provided through reductions in excise duty for beer containing cassava. This in turn has allowed the brewers to discount the price for cassava-based beers by ~30% when compared to conventional brands. Consumers find the relatively high alcohol content and slightly sweet taste attractive.
- Nigerian breweries use large volumes of refined sugar as sweetener. The wholesale price of refined sugar has been increasing over the last years (from US\$/t 750 in 2008 to US\$ 1,250 at the time of the survey – Feb 2013). Furthermore the price of sugar often records strong fluctuations over the course of the year. As such, all main brewing companies, are considering to invest in the own production of glucose syrup. They include Guinness Nigeria that in the past purchased syrup from Ekha-Agro.
- All major brewing companies are exploring the possibility to use cassava as raw material for processing into glucose syrup. Even though the Government is providing incentives to increase sugarcane production (and hence reduce dependence on imports), the use of cassava still seems more attractive due to sugarcane's longer cycle, higher demand of water (irrigation), higher initial investment and potential climatic issues in Nigeria.

b) Market

- Even as Western beer consumption slows down due to the global downturn, Nigeria's beer industry continues to thrive. The country has the second largest beer market in Africa, after South Africa.
- Beer recorded strong total value growth in 2011, with sales reaching N941 billion (~US\$6.3 billion). With a volume growth of 13%, total value sales increased by a very strong 26% over the previous year.
- With a population in excess of 160 million people, Nigeria is the most populous country in Africa. At the same time, annual beer consumption sits at ~10 litres per capita, which is low by international standards, and this situation offers ample room for significant market expansion. A growing, largely youthful population, with increased disposable incomes is expected to drive beer consumption and the Nigerian beer market is predicted to grow at an average of 8% over the next five years.
- The on-going ban on imported beer in order to support local industries gives free reign to locally based brewers.
- For decades, two brewing giants, Nigerian Breweries and Guinness Nigeria, have dominated the beer brewing space in the country. Dutch multinational Heineken acquired a 54.2% stake in Nigerian Breweries in 2000 raising Nigerian Breweries installed capacity which is now said to be about 12 million hectolitres.
- In 2009 SAB Miller entered the Nigeria market using three local companies for soft landing in the country. Currently it is operating five plants. A booming market for investors in the Nigeria beer market is predicted in the near future.
- It is reported that Nigerian Breweries is still the market leader, recording a volume share of 54% in 2011. If this figure is correct and the company is working at full capacity this would translate in a total domestic demand of over 22 million hectolitres. Nigerian Breweries' two leading brands, Star and Guilder, are well positioned and enjoy strong brand loyalty. SAB Miller is expected to have about 5% of the beer market.

c) Economics

- The economics of using cassava in the brewing process as replacement of other raw materials is unknown and very difficult to ascertain due to its business sensitivity.
- However, for the perspective of this study, it is important to gain a general understanding of the volumes of cassava that might be purchased and the locations. This information was not provided during the mission but the general impression is that the initial volume will be rather low. In fact it is estimated that a first attempt will be done with just 100,000 to 200,000 bottles to 'test' the market (this should require a few tens of tons of cassava roots). It would be a fair assumption that 5% to 10% (by volume) of Nigerian beer could be taken over by cassava-based beer in the short to medium-term. This would require 15,400-30,800 tonnes of grits that would equate to 61,600-123,200 tonnes of fresh cassava roots per annum.
- The economics of the production of glucose syrup by the brewing companies is similarly difficult to ascertain. However it has been mentioned that this would be cheaper than keeping on relying on refined sugar (mainly from imported raw sugar). As a matter of fact all three major breweries are considering to establish glucose syrup plants. If all brewing companies in Nigeria replaced half of their sugar requirement with cassava-based glucose syrup this would translate in a demand of 93,000 to 130,000 tonnes of syrup per annum,

equate to 430,000 to 600,000 tonnes of fresh cassava. The potential benefit for small-scale farmers might be significant. If the breweries opt for processing fresh cassava into glucose syrup they are likely to be willing to purchase part of the roots from large farms able to ensure a regular supply of raw material.

- In order to assess the achievable demand of cassava by the brewing companies, besides the potential volumes demanded there is need to understand at what price the roots will be purchased and what are potential additional costs incurred by the farmers (e.g., transport cost to the AMPU).
- These two elements would allow understanding what are the volumes that are likely to be diverted to the beer sector and how this might affect the profitability and sustainability of the other sub-sectors considered under the present study.

d) The way forward

- The cassava volume required by the brewing industry is potentially enormous.
- For the time being it is extremely difficult to predict whether the cassava beer will be accepted by the market but experience from Mozambique and Ghana indicates that cassava-based beers will prove popular if they are competitively priced and appeal to local tastes.
- If commercial production of cassava beer starts it will be important to monitor the volumes of roots purchased and the prices paid across the different supplying locations.
- Similarly it is not possible at the moment to understand if and when the brewing companies will enter into the business of glucose syrup production. However the fact that all three major companies are exploring this option might be considered as a signal that there is serious concern about the overdependence on imported sugar.

9. Other issues

- 1) **Raw material supply** – perhaps the biggest impediment to the use of cassava as a raw material for most of the processing for the end markets is the high cost of roots. This is partly because where most of the factories are located, there is a considerable urban population which creates a high demand for garri. As garri producers can much easily pass on the cost of raw material to the end-users, they will pay more for the roots. If new processing factories will be established, their locations must be chosen carefully, in particular in relation to proximity to affordable raw material and to the end-markets they are going to target. In this regard the development of a survey instrument for the purpose of reviewing recent cassava production and processing statistics (NAERLS crop survey) as envisaged by CTAP should be supported. In addition, the reliability of supply is very important; one flash dryer operator had been let down by a farmer on the day of the mission's visit to his factory. If the private sector is going to make large investments in say HQCF factories or ethanol plants, it is important that 65 to 75% of their root supply is grown either by themselves or large-scale commercial farmers. The balance can be supplied by smaller farmers, but they may have to accept the same prices as paid to the commercial farmers who will get higher yields.

- 2) **Keep researching opportunities for HQCF inclusion in bread and biscuits** – because the potential for substituting some of the imported wheat with HQCF, it is important that efforts to develop products made from the composite flours are continued. In particular, the possible use of products such as Wellance a novel bakery improver that mimics the function of gluten in bread dough need to be researched.
- 3) **Support efforts to promote products made from HQCF** – if significant replacement of wheat flour with HQCF is going to be achieved, it is important that this is not hidden but advertised. Not only is this important from a labelling point of view, it should also be regarded as a marketing opportunity.
- 4) **Let inclusion be based on economics** – there is considerable pressure from Government to have a law stating that a certain level of HQCF inclusion should be used in wheat flour and products made from it. This is a very difficult law to implement and the price differential between HQCF and wheat flour is now getting larger, and it is expected to keep getting wider, so there is an economic incentive to use HQCF. This approach is also sensible as the production of good quality HQCF is still well below the potential demand if inclusion rates are applied.
- 5) **Encourage flash dryer operators to seek buyers who are close to them and willing to pay N100/kg.** One of the interesting findings was that flash dryer operators claim that they need at N100/kg to cover their costs and make an acceptable profit. In contrast, the larger HQCF factories claim that they can make acceptable profits at N80/kg. Therefore, it would be preferable if these two scales of processors do not compete in the same market. It must also be recognised that flash driers will be able to make more money if they seek market opportunities near their processing sites, they should be able to make better margins. It is recommended that this opportunity is fully explored during the next mission and training materials for working with flash dryer management developed so they can undertake market research. It is expected that the materials and experiences used in Malawi will be used as the basis for the training programme. It is also hoped that a coalition of a selected flash drier operators will share their market research experiences and
- 6) **Continue working on quality of HQCF** – one of the over-riding comments by the users of HQCF is the extremely variable quality. It is important that this is addressed by working with SME's operators to improve management and quality assurance.
- 7) **Evaluate the market opportunity for instant odourless fufu** – the potential margins for instant fufu are attractive to help to increase profit margins from flash drier businesses that focus on the lower margin HQCF. It is recommended that new outlets are identified that will sell instant fufu and strategies are developed to exploit them. It is hoped that the identification of market opportunities and subsequent strategies can be developed as part of the same process for developing localised HQCF market opportunities.
- 8) **Only consider supporting dried chips for local market opportunities** – the potential for cassava chip exports to China are extremely limited. Therefore, it is important that cassava chips should only be considered for local market opportunities.
- 9) **Further investigation into the opportunities for biofuels; in particular the opportunity to supply ethanol for home cooking and industrial quality alcohol** – it is appreciated that more detailed analysis is required before the potential for biofuels can be fully confirmed. However, because of

the very significant duties on industrial ethanol, it would appear that there is a very significant opportunity to support the development of industrial ethanol production. This could either be one large factory or a number of smaller ones. The other market segment that needs to be explored in more detail is to produce ethanol for home use to reduce the amount solid fuel used for household cooking. Whilst at first evaluation, ethanol for home cooking might look less attractive than industrial ethanol, it has so many social and environmental benefits that it should be analysed.

Annex 2: List of meetings

Date	Name	Sector	Product range	Location
19/11/2012	Shoprite	Retail	Various (packed garri and fufu flour)	Lagos
19/11/2012	Lisabi Foods	Food industry	Custard, yam flour, choco drink	Lagos
19/11/2012	Spar	Retail	Various (packed garri and fufu flour)	Lagos
19/11/2012	Coca Cola Nigeria	Beverage	Soft drinks	Lagos
19/11/2012	Thai Farm International	Food industry	HQCF	Lagos
19/11/2012	UTC	Food Industry	Bread, snacks	Lagos
19/11/2012	Niger Biscuits (Oxford Biscuits)	Food Industry	Biscuits	Lagos
20/11/2012	Ekha Agro Processing Ltd	Food industry	Cassava glucose syrup	Ogun State
20/11/2012	Amsel Ltd	Food industry	Custard, breakfast cereal, baking products	Lagos
20/11/2012	Matna Food Company Ltd	Food industry	Cassava starch	Lagos
20/11/2012	Foods Ltd (Haansbro)	Food Industry	Biscuits	Lagos
20/11/2012	Flour Mills of Nigerai	Food Industry	Flour, HQCF,	Lagos
20/11/2012	Industrial Cartons	Packaging	Paperboard	Lagos
20/11/2012	Livestock Feeds	Animal Production	Livestock feed	Lagos
21/11/2012	Cassava Transformation Agenda Team	Gov. agency	-	Abuja
21/11/2012	Ministry of Trade & Investment	Gov. agency	-	Abuja
21/11/2012	Raw Material R&D Council	Gov. agency	-	Abuja
21/11/2012	Zenith Agroethanol	Biofuel	Ethanol	Abuja
22/11/2012	Joe Berg	Food Industry	HQCF & Instant fufu Production	Abuja
22/11/2012	Shadac Farms	Food Industry	Garri and chip Production	Abuja
23/11/2012	Intercontinental Distilleries Ltd	Beverage	Spirits, soft drinks	Ogun State
23/11/2012	Multichem Industries Ltd.	Chemical industry	Agrochemicals, flavours, enzymes, corn starch, inks, glues and adhesives	Lagos

23/11/2012	National Power & Technology Agency	Biofuel	Ethanol	Abuja
24/11/2012	Thai Farm International	Food industry	HQCF	Lagos
25/11/2012	FUNAAB	University	-	Ogun State
26/11/2012	Obasanjo Holding Ltd	Food industry	Livestock, agriculture, animal feed, starch, glucose	Abeokuta
26/11/2012	Animal Care	Animal health and production	Poultry, fish, animal feed, drugs, vaccines	Ogun State
26/12/2012	Nestle	Food	Cassava Starch	Lagos
26/11/2012	Peak Products	Food Industry	HQCF Production	Abeokuta
27/11/2012	Harvest Plus (IITA)	Research	-	Ibadan
27/11/2012	Zartech Ltd	Animal production	Poultry, poultry feed	Ibadan
27/11/2012	Durante Fish Feed	Animal production	Fish, fish feed (production of sinking pellets, distributor of floating pellets)	Ibadan
27/11/2012	Blopamed Nigeria Ltd	Food Industry	HQCF, Instant Fufu & Garri Production	Abeokuta
27/11/2012	Matsol	Food Industry	HQCF Production	Abeokuta
27/11/2012	Heron Agencies Ventures	Food Industry	HQCF Production	Abeokuta
28/11/2012	Free Range Farms	Animal production	Poultry	Abeokuta
28/11/2012	Mondata	Food industry	Packed garri	Lagos
12/2/2013	Ladmok	Export chips	Export of dry chips to China	Lagos
12/2/2013	Yakub Consult	Export chips	Export of dry chips to China	Lagos
13/2/2013	Cassava Transformation Agenda	Cassava	Government Programme under MoA	Abuja
13/2/2013	Agro Allied Services	Aquaculture	Fish feed & fish farm	Abuja
14/2/2013	Zenith Agro-ethanol	Biofuel	Ethanol for home cooking	Abuja
14/2/2013	World Bank	Donor	International Agency	Abuja
14/2/2013	Rahmaj Global Resources	Feed	Feed mill	Minna
15/2/2013	Joe Berg	HQCF	HQCF SME	Abuja
16/2/2013	BT Ventures	Aquaculture	Feed, Fish farm, Fabricator	Ibadan
16/2/2013	IITA	Research	CGIAR	Ibadan
18/2/2013	Matna Foods	Starch	Cassava starch	Akure
19/2/2013	OAMSAL	HQCF	HQCF SME	Ekiti
19/2/2013	Project GAIA	Biofuel	Ethanol for home cooking	Lagos
19/2/2013	Star Fuels	Biofuel	Ethanol for home cooking	Lagos
20/2/2013	FUNAAB	University	Research	Abeokuta
20/2/2013	Prime Heritage	Food Industry	Garri, starch & chips	Abeokuta
20/2/2013	Nobex Ltd	HQCF	Fabricator	Lagos

21/2/2013	Oval Animal Health Foundation	Feed	Feed Mill	Abeokuta
21/2/2013	Ogun State Development Programme	Aquaculture	Fish Farm / Govt Agency	Abeokuta
21/2/2013	Poultry Association	Poultry	National Association	Abeokuta
21/2/2013	Industrial Packaging	Packaging	Paperboard	Lagos
21/2/2013	UTC Foods	Bakery	Sausage rolls, bread & snacks	Lagos
21/2/2013	Rite Foods	Bakery	Sausage rolls	Lagos
22/2/2013	Nigerian Breweries	Breweries	Beer	Lagos
22/2/2013	Allied & Atlantic Distilleries	Ethanol	Industrial & potable alcohol	Igbara