QUALITY FOR AFRICA

PAN-AFRICAN QUALITY INFRASTRUCTURE

A GAP ANALYSIS AND NEEDS ASSESSMENT STUDY ON THE ROLE AND IMPACT OF QUALITY INFRASTRUCTURE IN CASSAVA VALUE CHAIN IN AFRICAN COUNTRIES

Final Report

– June 2020 –

This document is available at www.paqi.org

This publication was prepared by BDO East Africa Advisory Services Limited, on behalf of the Pan African Quality Infrastructure (PAQI) institutions comprising the African Organization for Standardization (ARSO), the African Accreditation Cooperation (AFRAC), the Intra-Africa Metrology System (AFRIMETS) and the African Electro-technical Standardization Commission (AFSEC).

The PAQI initiative is supported by

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LIST OF ACRONYMS AND ABBREVIATIONS

AFRAC	African Accreditation Cooperation
AfCFTA	African Continental Free Trade Areas
AFRIMETS	Intra-Africa Metrology System
AFSEC	African Electrotechnical Standardization Commission
AOAC	Association of Official Analytical Chemists
ARSO	African Organization for Standardization
AU	African Union
AUC	African Union Commission
BIPM	International Bureau of Weights and Measures (BIPM, Bureau International des Poids et Mesures)
CABs	Conformity Assessment Bodies
CAMI	Conference of African Ministers of Industry
CEN–SAD	Community of Sahel–Saharan States
CETA	Comprehensive and Economic Trade Agreement
CIPM	International Committee for Weights and Measures (CIPM, Comité International des Poids et Mesures)
CGPM	General Conference on Weights and Measures (CGPM, Conférence Générale des Poids et Mesures)
COMESA	Common Market for Eastern and Southern Africa
CRESAC	Centre Régional d'Evaluation en Education, Environnement, Santé et d'Accréditation en Afrique
DRC	Democratic Republic of Congo
EAC	East African Community
ECCAS	Economic Community of Central African States
ECOWAS	Economic Community of West African States
IGAD	Intergovernmental Authority on Development
IITA	International Institute of Tropical Agriculture
ISO	International Organization for Standardization

MRAs	Mutual Recognition Arrangements
MT	metric tonnes
NGO	Non-Governmental Organization
NMI	National Metrology Institute
NPPO	National Plant Protection Organization
NQII	National Quality Infrastructure Institutions
NSBs	National Standards Bodies
PAQI	Pan African Quality Infrastructure
QI	Quality Infrastructure
RIA	Regulatory Impact Assessments
RTAs	Regional Trade Agreements
SADC	Southern African Development Community
SADCA	Southern African Development Community Accreditation Service
SMEs	Small and Medium-sized Enterprises
SPS	Sanitary and Phytosanitary
SQAM	Standardisation, Quality assurance, Accreditation and Metrology
SOAS	West African Accreditation System (SOAC).
TOR	Terms of Reference
TBT	Technical Barriers to Trade
WFP	World Food Program
UMA	Arab Maghreb Union
UNHCR	United Nations High Commissioner for Refugees
WTO	World Trade Organization
USD	United States Dollar

ACKNOWLEDGEMENT

Slow trade exchanges among African countries were often caused by the absence of harmonized certifications and conformity assessment procedures that are mutually recognized. The Pan African Quality Infrastructure (PAQI) composed of the African Accreditation Cooperation (AFRAC), Intra-Africa Metrology System (AFRIMETS), African Electrotechnical Standardization Commission (AFSEC) and African Organisation for Standardisation (ARSO) have observed the need of standardized set of practices and procedures to international market requirements to ensure compliance with international standards, transparent inspection and certification systems, simplified trade environment to fulfil the AfCTFA requirements that relate to SPS / TBT requirements and during their 8th Joint Committee meeting, they agreed to cooperate in undertaking a joint project to improve the quality and competitiveness of the Cassava and Cassava products in all levels of the value chain.

The choice of the cassava value chain was motivated by continental strategic decisions such as the African Union Development Agency – New Partnership for Africa's Development (AUDA-NEPAD) identified cassava as a 'poverty fighter' capable of spurring industrial development in Africa and later cassava has been prioritized as a strategic commodity in the Comprehensive Africa Agriculture Development Programme (CAADP) Pillar III and Framework for African Agricultural Productivity (FAAP) Pillar IV as a means to increasing food supply, reducing hunger and improving responses to emergency food crises. The role of PAQI is as a contribution to the successful achievements of these continental initiatives.

Activities of this project are distributed into three Phases which include:

1. **Phase 1**: Gap Analysis and needs assessment
2. **Phase 2:** Capacity Building and harmonisation of standards and conformity assessment systems
3. **Phase 3:** Implementation of Conformity assessment and Mutual Recognition Arrangements (MRA)

As Phase 1 is concluded, I would take this opportunity to express the PAQI gratitude to all institutions and individuals who were involved in the successful study which identified gaps and needs with regard to the role and impact of quality infrastructure in cassava value chain in African countries. This report is the result of work of numerous specialists from countries and regional and international organisations.

Availability of data and information is essential for any study to add value. PAQI thanks all the organizations, public, private and civil society and individuals who provided information and data to support the study. A lot of information is available from websites, reports and other documents. Information on quality infrastructure was particularly obtained from national standards bodies in Africa and international Quality Infrastructure organizations.

The report was drafted by a team of consultants representing BDO East Africa, their effort in consolidating data is recognised.

We would like to specifically thank the bureau of standards of Angola, Democratic Republic of Congo (DRC), Ghana, Nigeria, Uganda, and Zambia for providing detailed information enabling us to find other related data.

The East Africa Community Secretariat, PAQI Institutions namely AFRAC, AFRIMETS, AFSEC and ARSO, and AUC are highly appreciated for insightful contributions on the development of quality infrastructure in Africa which informed all the chapters of this report.

PAQI immense and sincere thanks to the Government of Germany through the Physikalisch-Technische Bundesanstalt (PTB), this work would not have been possible without their financial support.

EXECUTIVE SUMMARY

The overall objective of this assignment was to analyse the current state of the cassava sector in African top producing and consuming countries, and also examine the existing national or regional standards and technical regulations and conformity assessment regimes, for cassava and cassava products. The analysis was used to identify gaps and draw recommendations that will guide the development of plans to improve the quality of cassava and cassava products, in-turn, boosting Intra-Africa international trade cassava and cassava products.

In the conduct of the assignment, samples of value chain actors were contacted directly or studied from literature, across the entire cassava value chain starting from the farmers, processors, consumers of intermediate, final or derived cassava products. Desktop reviews of articles from these stakeholders, emails, WhatsApp, Skype and visits were made with / to these stakeholders. Further enquiry was made through the Uganda WTO TBT National Enquiry Point to the selected countries – DRC, Ethiopia, Ghana, Mozambique, Nigeria, Uganda, and Zambia and two other countries in Asia (Thailand and Indonesia) that are major producers and exporters of cassava products.

Existing good practices were identified for land preparations, agronomic practices; standards for inputs, harvested roots, intermediate and final products from cassava or its derivatives. The state of competence development in the area of quality infrastructure as well as various production related skills was reviewed. Gaps in quality infrastructure requirements are highlighted generally and specifically using a case study between Nigeria, Uganda and Zambia. Ways to close the gaps and improve practices are discussed.

MAIN FINDINGS

A. Overview of the Competitiveness of the Cassava Value Chain

Cassava "Manihot Esculenta" remains one of the most consumed food crops in Africa. It is a perennial crop present in most of Sub-Saharan Africa that has gradually transited from a food security crop to a cash crop because of the recent demand for it globally.

The top four producers Nigeria, DRC, Ghana and Angola contributed between 54 % and 61 % of the continent's cassava production over the last 5 years, and all producers kept a more or less gradual, slow growth.

In Africa, cassava is cultivated both as food, animal feed and as industrial raw material. In Zambia, for example, about 25 % of farmers sell 8 %–10 % of their crop, while the balance 90 %–92 % is for home consumption. 75 % of the farmers cultivate cassava only for home consumption.

In tripartite (EAC-COMESA-SADC) region, on average, cassava produced is consumed as food (51 %) or feed (31 %), while only 5 % was for other uses. An insignificant quantity (1 %) is processed, while the rest is accounted for by post-harvest crop losses. The 12 % of the total quantity of cassava wasted in the tripartite region, was 33 times higher than the quantity of cassava imports (160,000 tonnes) in 2013 (FAOSTAT, 2016), implying that the region could be self-sufficient in cassava.

The main nutritional value of cassava roots lies in their potential ability to provide one of the cheapest sources of dietary energy, in the form of carbohydrates. Cassava also facilitates a protein-energy balance, provides dietary fibres and special dietary benefits due to its ability use in baking non gluten based products.

Within the tripartite region (EAC-COMESA-SADC), cassava is traded (imports and exports) mostly in processed form as chips, starch and flour for food, feed and industrial use. Fresh roots are rarely traded as imports or exports, because they are bulky and highly perishable with a low value per unit weight. Technologies that reduce post-harvest losses such as waxing and high relative humidity storage, temperature control, pre-harvest defoliation / pruning have been tested but not been widely disseminated. Some have been shown to extend post-harvest life up to 4 weeks, offering a potential for regional overland trade.

The value of exports of cassava value added products (chips and pellets, flour, and starch) from the tripartite increased at an annual compounded rate of 54 percent between 2012 and 2015, from USD 3.45 million in 2012 to USD 5.927 million. Although, the growth of exports is high, the starting base is low for all value added products. This is expected: commercial use of cassava and value added products started only recently, in line with commercial production, which started in the 2000s.

Overall, the marketability of cassava and its derivatives have improved the finances of farmers, and businesspersons, and the availability of foreign exchange. There is, therefore, a pressing need to commercialize the production and domestic use of cassava. Increasing the production of a crop well-adapted to the local (and changing) climatic conditions would improve food security and livelihoods in the East and Southern Africa (ESA) region. Furthermore, the income generation and employment opportunities for smallholder farmers, processors, marketers and other stakeholders; the easing of sourcing raw materials for import substitution by local industries; and the savings in foreign exchange expenditure by governments that can emanate from a commercialized sector, are potentially significant. The special initiatives on commercialization that commenced in West Africa show that there is potentially great scope in ESA for successfully commercializing production, processing, and marketing, including its industrial use. A commercialization framework similar to that of West Africa can be suggested for ESA.

The release of high yielding cassava varieties coupled with regular extension messages to promote improved agronomic practices, is urgent, and it will help bolster cassava production levels in Africa. More support is needed to disseminate technologies from research done under the centres of excellence already set up with the assistance of the African Union programs (like the Pan African Cassava Initiative). The potential of high yielding varieties cannot be realized unless they are given appropriate nutrition and crop protection. The programs should therefore simultaneously support the adoption of fertilizer use and integrated pest management strategies.

This should be followed by appropriate mechanization of at least the harvesting operations to reduce the cost of production. Then it should be followed by post-harvest mechanization using cassava peelers and graters to quicken drying and enable the lighter chips to be transported to distant markets from remote areas with poor road networks. For mechanization to take root, support is required to train and equip rural workshops to fabricate the graters and mills.

B. Quality gaps along the cassava value chain and areas of improvement

The cassava value chain generates a multitude of products whose quality determines the fitness for purpose. The quality of both the products and the services is a subject of regulations and standards to ensure consumer and environment safety and health; and that trade is fair and vibrant.

The most useful parts of the crop for food are the roots from which hundreds of products are obtained using multitudes of methods. Leaves are also processed. Cassava is also widely used for animal feeding. Cassava value added products such as chips and starch can be used to derive tertiary products such as animal feeds, food, glucose, sorbitol and alcohol. Cassava derivatives are used in foods industry (bakery, brewing and distilleries, confectionary), paper, plywood and textiles industries, animal feeding, plastics and packaging industries, pharmaceutical and cosmetics industries, and energy industries for biofuel for motor vehicle and industrial processes.

Cassava still suffers from many myths and half-truths ranging from being perceived as not nutritious, a poor man's food, and a potentially poisonous food. Other negative perceptions of cassava still prevail in terms of quality, consistency, and impact on product both from a technical and marketing perspective.

Cassava production, processing and distribution of inputs, can benefit from a robust quality infrastructure. Standards define safety and quality characteristics of products, and information necessary for consumers or users of the products. This facilitates production and distribution of products of the right quality and enable regulators to protect consumers and open markets for producers. National standards bodies represent their countries in regional and international standardization organisations to harmonize or develop regional or international standards facilitating international trade.

Certification allows buyers on one side to trust the quality of suppliers, while on the other side, testing laboratories help show that a product or process satisfies technical requirements. Measurement standards and their supportive metrology infrastructure play an important role in industrial competitiveness. On the other hand, inspection, market surveillance and enforcement ensures the implementation of standards and technical regulations aimed to uphold safety and health and prevent deceptive practice whether products are imported or locally produced.

A review of availability of standards and test methods at national, regional and international level and the assessment of the conformity assessment and measurements infrastructure shows that many efforts have been made to develop standards and conformity assessment processes for cassava and cassava products. Additionally, measurement systems exist to support investment in cassava value chains.

There are several notable successes including the following

a) There are more than 75 common cassava products named by several authors as common in African countries including from cassava roots and leaves and some tertiary products that have commercial values.

b) At national, regional (RECs), and continental level (ARSO) and international level (Codex and ISO), there are at least a couple of standards for cassava products. The most common are standards on cassava chips, cassava flour, and gari. This indicates that there is a general move towards commercialization and trading in cassava products in the continent and at international level.

c) At international level, there are many test methods that apply to cassava and cassava products such as methods for analysis of contaminants including microbiological contaminations and general management and conformity assessment standards.

d) There are several accredited laboratories and certification bodies among the countries that have the credibility to offer conformity assessments services such as testing for heavy metal contaminants, composition elements and microbiological contaminants, and to provide certification of products and management systems. In addition, AFRAC is running an MRAs on certification services. This indicates a feasibility for Intra-Africa recognition of conformity assessment through the use of PAQI infrastructure.

e) Some countries have accredited calibration laboratories with measurements that are traceable to international standards. NMIs from African countries collaborate at sub regional level and at continental level under AFRIMETS, which provides an opportunity to create a database for Intra-Africa recognition of measurements capabilities and a feasibility for linking to international measurements standards.

However, several gaps still exist, and were identified in the following categories of standards:

a) Membership affiliation of NSBs in Africa with regional and international quality infrastructure institutions is limited. For example, only 40 NSBs out of 55 are members of ISO and only 15 participate in the CIPM MRAS. Moreover, only 39 out of 55 are members of ARSO and only 17 are members of AFSEC. Such gaps affect the ability of members to harmonize standards within the African continent as well as participate in development and have access to international standards.

b) Standards developed by ARSO for cassava and cassava products have not been widely adopted among members. All the three cases study countries (Zambia, Uganda and Nigeria) have not adopted the standards for dried cassava chips for example. This shows that there is need to have harmonized standards adopted in countries to promote trade.

c) The standards developed for cassava and cassava products among members vary in the number of parameters specified and the limits of requirements for key parameters such as moisture content, heavy metals contaminants and pesticide residues. This shows that there is need not only to harmonise to promote trade.

d) There are cases where more parameters are set in local standards that are provided for in international standards as well as cases of higher limits of contaminants (worse products), limits for contaminants not provided for at international level and no limits for those provide for in international standards. This could be an indicator of limited use of international standards when adopting local standards and inadequate use of international standards in particular codex and inadequate consideration scientific approach such as food safety risk analysis and regulatory impact assessment by standardizers.

e) There are no standards in the cases study countries (Zambia, Nigeria and Uganda) for many named African cassava products such as Abacha, Abloyoki, Agbéli klaklou, agbelilakia, Greedy (goma séché au four), Agbelima, Agelikaklo, Agléli mawè, Akpissi, Alebo, Attiéké, Attoupkou, Autkpu, Ayan (Purée de manioc), Bêdêkouma, cassava sticks, Chickwangwe, Cossette, Cossettes de manioc, dry semolina, Dumby, Eberebe, Farine de manioc, Fede, Fingnin, flour, foufou, Foutou, fritters, Fufu, Galikponnon (pain de manioc), garba, Goman (amidon), Goman kluiklui (snack), ground fresh tuber, Ikivunde, Imikembe, Inyange, Kabalagala (Uganda), Kapok pogari, Kenkey, Kivunde, Kokondé, Kokonte, Kponnonvi (biscuit de goma), Kuté dida (manioc bouilli), Kuté founfouin (manioc pile), Kuté libo, Kuté mime (manioc grillé), Kuté siso (manioc frit), Kutéta (snack), Kwadu, Lafun, Efubo, Loi-loi, Meduame-Mbong, Mihogo, Mokopa, Pasta, pastries, Placali, ragout, sourdough, tapioca (amidon granule), Ubuswage and Yakayake. The unit operation for producing many of these products are similar meaning that it is feasible to standards then processes and products to improve quality and safety of these products. The nomenclature of these products appears to vary from one country or community to another causing difficulty in communication and probably limiting trade in such products. A terminology standards for cassava sector could be a good starting point.

f) The level of accreditation of test and measurements laboratories in cases study countries is limited and varies between countries. 10 countries have national accreditation bodies with an additional 24 countries accessing accreditation through multi-economy accreditation bodies SADCA and SOAS. Although about 20 countries do not have national accreditation bodies they are or can be served the existing accreditation bodies. Setting up accreditation structures is till desirable, however. There is therefore a need to focus on produce reference materials, develop specific test methods, proficiency schemes to make it easier for laboratories in Africa to attain accreditation for Cassava conformity assessment services.

Recommendations have been made for frameworks and process criteria for designing and implementing effective plans to improve the quality of cassava through harmonization and application of standards, testing methods and accurate measurements across the continent. Special attention has been put to examining the role that National Quality Infrastructure Institutions currently play, their accessibility to the users and to identifying ways in which differences between regulations and standards can be reduced while protecting legitimate public interests. Essentially:

1) Enhance the engagement of stakeholders across all sectors including regulators, quality infrastructure, production and marketing sectors. The use of a power / interest or expertize willingness grid plot, to analyse different stakeholders and grouping them into categories that determine the level of engagement required could be beneficial.

2) Because of differences in legal and regulatory frameworks amongst countries, the preferred approach would be to gain recognition of the systems including harmonized standards, conformity assessment MRAs and Measurements MRAs defined at the level of PAQI. Thus, the AUC needs to play a role. This matter could be taken up by the regulatory committee of the AU.

3) To preserve and promote indigenous African technologies and production methods and processes, promote Intra-Africa trade and to advocate for the preparation of international standards concerning products of special interest to African countries, such as cassava. This means harmonization of requirements for cassava products to promote trade of cassava products within the region coupled with advocating for a mandate to adopt ARSO standards by Member States from AU and or RECS to enhance the benefits of ARSO standards. This requires advocacy for an AU mandate to adopt ARSO standards by Member States and the building of technical regulations based on harmonized standards to facilitate Intra-Africa trade.

4) In addition, standards on Electrotechnology that are relevant for the cassava sector should be examined under AFSEC to create harmony and promote adoption of technology in the cassava sector in the continent.

5) Basing on existence of standards for the products in many of the countries in Africa, a sign of progress in commercialising those products, the following products could be certified as a pilot scheme to promote movement of products in the continent: cassava chips, cassava flour, High Quality Cassava Flour (HQCF), cassava starch and gari.

6) Implement sector wide MRAs to support conformance in specific sector by sector approach. In the case of cassava, implement a sector wide MRAs to cover cassava and cassava products with focus on Intra-Africa recognition of conformity assessment and measurements results.

7) In the area of conformity assessment, ILAC MRAs and IAF MRAs based on AFRAC MRAs can link the cassava sector conformity assessment systems to international arrangements. African countries will require to hasten capacity building in conformity assessment infrastructure- certification, testing, calibration, inspection- that are essential for the cassava sector to enable accreditation of these services and link them to international recognition system through AFRAC.

8) In the area of measurements, A CIPM MRA based on AFRIMETS MRA can link the cassava sector measurements to international measurement. There is also a need for increased participation of NMIs in the Metre Convention through BIPM to facilitate linking national measurements standards and calibration to international measurements systems through AFRIMETS.

1 INTRODUCTION

1.1 Background and Context

The 20th Ordinary Session of the Committee of African Union Ministers of Industry (CAMI) held on 10th-14th June 2013 recognized the Pan African Quality Infrastructure (PAQI) institutions composed of African Organization for Standardization (ARSO), the African Accreditation Cooperation (AFRAC), the Intra-Africa Metrology System (AFRIMETS) and the African Electro-technical Standardization Commission (AFSEC) as the continental platform for all matters related to standardization, metrology, accreditation and conformity assessment in order to strengthen the competitiveness of Africa's goods and services and contribute towards the industrialization of the continent and its sustainability in line with international good practices with regard to Quality Infrastructure (Standards, Metrology (Measurement) and Accreditation).

The PAQI institutional platform was officially launched in 2013 by the Director of Trade and Industry, African Union Commission (AUC) and on 30th August 2013 the four institutions signed a Memorandum of Understanding with the following objectives;

- To promote the development of a coherent PAQI, supporting the objectives of African integration in accordance with the Abuja Treaty (2000) that established the African Economic Community;
- To strengthen the development and implementation of African policies on Standards, Measurement, Conformity Assessment and Accreditation that supports the realization of Africa's Economic Integration and Environmental Sustainability;
- To provide timely Standards, Measurement, Conformity Assessment and Accreditation solutions to the region whilst upholding the values of openness, transparency and consensus;
- To develop effective relations with the AU and RECs (EAC-COMESA-SADC) in order to promote and reinforce the role of PAQI as a tool for supporting AU policies that will enhance Intra-African and global trade to improve quality of life;
- To represent Africa on all matters pertaining to Standards, Metrology, Conformity Assessment and Accreditation;
- To secure adequate funding for the PAQI in order to support capacity development in Standards, Measurement, Conformity Assessment and Accreditation.

The work of the four PAQI institutions is critical for economic Integration in Africa as envisioned in the agreement that established the African Continental Free Trade Area (AfCFTA), especially its annexes on Technical Barriers to Trade (TBT) and Sanitary and Phytosanitary (SPS).

In their 8th Joint Committee meeting that took place in Abidjan, Cote d'Ivoire on 4th August 2016, the four PAQI institutions agreed to cooperate in undertaking a joint project to improve the quality and competitiveness of Cassava and Cassava products at all levels of the value chain.

Today, there is growing international recognition of the importance of cassava as a staple crop. Also, its contribution in fighting hunger and poverty, as well an export commodity, is well documented. Cassava has gradually transited from a food security crop to a cash crop because of its growing demand in the world. The value of exports of cassava value added products (chips and pellets, flour, and starch) from the tripartite RECs (EAC-COMESA-SADC) increased at an annual compounded rate of 54 % between 2012 and 2015, from USD 3.45 million in 2012 to USD 5.927 million as shown in Fig. 1. Although, the growth of exports is high, the starting base is low for all value added products. This is expected: commercial use of cassava and value added products started only recently, in line with commercial production which started in the 2000s.

The PAQI joint Project, therefore, aims to exploit the above opportunity by enhancing the competitiveness of the cassava value chain using quality infrastructure. This will entail supporting African economies to offer cassava and its derived products as well as related services (i) of the quality demanded by the markets (ii) prices that maximize returns on resources employed.

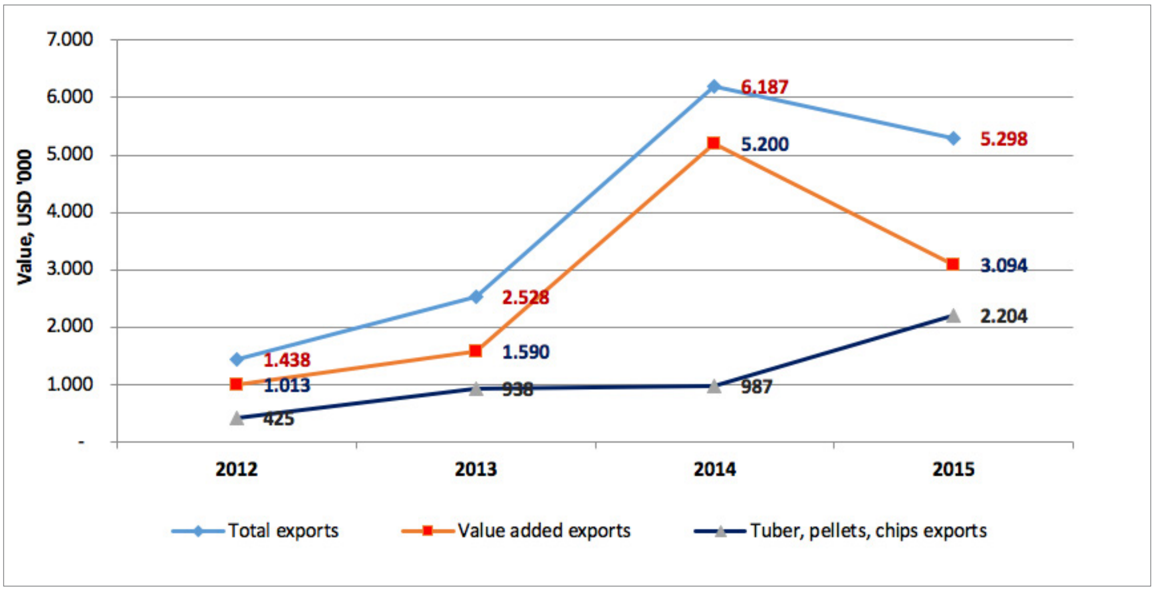

Figure 1: Exports of Cassava and Value added products within the AU by value (USD, 000s), 2012 – 2015.
Source: ITC/TradeMap (2017)

The PAQI joint cassava and cassava products project will be implemented in three (3) major phases:

1. **Phase 1:** Gap analysis and needs assessment
2. **Phase 2:** Capacity building and harmonization of standards and conformity assessment systems
3. **Phase 3:** Implementation of conformity assessment and mutual recognition arrangements

It is against this background that PAQI commissioned a study to undertake Phase 1 of the Project; a gap analysis and needs assessment study on the state of existing developments' and gaps in standardization and conformity assessment for cassava and cassava products. The study examined the role that national quality Infrastructure institutions currently play, their accessibility to the users, in addition to identifying ways in which discrepancies between regulations and standards can be reduced while protecting legitimate public interests. This study report recommends frameworks and process criteria for designing and implementing effective plans to improve the quality of cassava through harmonization and application of standards, test methods and accurate measurements across the African continent.

The report is presented in seven (7) sections. **Section 1** (this section) presents the background and context in which this assignment was commissioned. **Sections 2 to 5 are** the core of the report, and presents findings (gap analysis and needs assessment) from the review of literature and key informant interviews, on the role and impact of quality infrastructure in the cassava value chain. Each of the core sections address one or two of the nine (9) specific objectives (TORs) of this assignment as delineated below;

- **Section 2** presents information on cassava production and uses; and product maps and charts for possible food and non-food products obtainable from cassava. The section also analyses gaps in the different qualities of cassava, and the need for improved specifications, guidelines and conformity assessment systems in targeted countries

- **Section 3** examines the role of quality infrastructure in the cassava value chain and identifies existing cassava standards and gaps in standards and conformity assessment schemes. The section also studies existing and missing methods of testing for the cassava value chain. A list of existing electrotechnical standards for processing equipment and gaps is also presented. Basing on the existing standards, a priority African Standards for certification are pointed out.

- **Section 4** discusses stakeholder engagement, including criteria to identify and select 200 cassava value chain players in targeted countries to participate in various project activities including capacity building and certification.

- **Section 5** proposes an Intra-Africa regional MRA framework for linking the cassava sector quality infrastructure to the international standards and measurement systems. The section also presents a methodology to gain Intra-Africa mutual acceptance of measurement standards.

- **Section 6** presents the Recommendations.

- The report concludes with **Section 7** on areas of research collaboration. The Report is appended with References and four (4) Annexes.

1.2 Objectives of the Assignment

The overall objective of this assignment was to analyse the current state of cassava sector in African top producing and consuming countries, and also examine the existing national or regional standards and technical regulations and conformity assessment regimes, for cassava and cassava products. This analysis was used to identify gaps and draw recommendations that will guide the development of plans to improve quality of cassava and cassava products, in-turn, boosting trade volumes among African Countries and outside Africa.

The specific objectives of the assignment were:

- To develop product maps and charts for possible food and non-food products obtainable from cassava and technical realization of the products including authoritative references.

- To identify gaps between different qualities of cassava and needs for improved specifications, guidelines and conformity assessment systems in targeted countries

- To identify existing cassava standards and gaps in standards and conformity assessment schemes

- To identify existing Electro-technical standards for processing equipment and gaps in the same

- To identify existing and missing methods of test for the cassava Value Chain

- To identify priority African standards to pursue certification

- To propose criteria to identify and select 200 cassava value chain players in targeted countries to participate in various project activities including capacity building and certification.

- To propose a methodology to gain Intra-Africa mutual acceptance of measurement standards and;

- To formulate a regional MRA framework for Intra-Africa acceptance by linking measurements in Cassava processing to the international measurement system.

1.3 Summary of Approach and Methodology Adopted

1.3.1 Selection of Countries for In-depth Analysis of the Cassava Value Chain

Seven countries were selected / sampled to participate in this study, based on the volumes of cassava they produced, over the period 2013 to 2017. The countries are Democratic Republic of Congo (DRC), Ethiopia, Ghana, Mozambique, Nigeria, Uganda and Zambia.

The countries were divided into tiers depending on the quantities of cassava produced so as to select from different tiers to represent different levels of production. As illustrated in Table 1, Nigeria and the DRC were selected to represent Tier 1 cassava producing countries (the highest cassava producers in Africa). Nigeria is the largest producer of cassava crop in the world, with over 70 % of the total production in West Africa. DRC is the second largest producer of cassava crop in Africa after Nigeria.

Among the Tier 2 cassava producing countries, Ghana and Mozambique were selected. With an annual production of over 40 million metric tonnes (MT), Ghana is another country in West Africa that produces cassava, contributing up to 25 % of the produce from the West African Region. Mozambique is in southern Africa and is the fifth largest producers of cassava in Africa.

Uganda was selected among the countries in Tier 3, while Zambia was selected among those in Tier 4 (Table 1). Ethiopia was added to this list because its data is not listed in FAOSTAT and yet it is among the countries proposed for the study.

Country	2013	2014	2015	2016	2017	Total
Tier 1 Cassava producers						
Nigeria	47 406 770	56 328 480	57 643 271	59 565 916	59 485 947	280 430 384
Democratic Republic of the Congo	33 918 252	34 867 925	34 930 687	34 024 295	31 596 046	169 337 205
Tier 2 Cassava producers						
Ghana	15 989 940	17 798 217	17 212 756	17 798 217	18 470 762	87 269 892
Angola	16 411 674	7 638 880	7 727 413	10 182 973	11 747 938	53 708 878
Mozambique	4 303 000	8 272 530	8 103 000	9 100 000	8 773 712	38 552 242
Tier 3 Cassava Producers						
United Republic of Tanzania	4 755 160	4 992 759	5 886 440	5 384 315	5 014 624	26 033 298
Cameroon	4 596 383	4 914 984	5 193 749	5 499 407	5 798 909	26 003 432
Malawi	4 813 699	5 102 692	5 012 763	4 996 843	4 960 556	24 886 553
Sierra Leone	3 810 418	4 102 845	4 651 707	4 532 415	4 761 385	21 858 770
Côte d'Ivoire	2 436 495	4 239 303	5 087 000	4 548 000	5 367 000	21 677 798
Benin	3 910 036	4 066 711	4 189 530	4 301 882	4 341 848	20 810 007
Uganda	2 979 000	2 812 000	2 897 955	2 882 863	2 436 857	14 008 675
Madagascar	3 114 578	2 929 743	2 676 952	2 629 478	2 500 000	13 850 751
Burundi	2 233 790	2 242 352	2 757 583	2 394 982	2 293 595	11 922 302
Tier 4 Cassava Producers						
Congo	1 328 213	1 367 248	1 406 283	1 445 318	1 484 353	7 031 415
Guinea	1 218 925	1 306 772	1 426 625	1 516 192	1 384 447	6 852 961
Togo	902 860	1 153 109	1 039 135	1 027 476	1 041 682	5 164 262
Zambia	1 114 583	919 497	952 770	1 031 484	1 036 908	5 055 242
Rwanda	948 100	900 227	924 651	930 220	1 041 986	4 745 184
Kenya	935 089	858 461	709 926	571 848	1 112 000	4 187 324
Central African Republic	671 904	696 177	708 376	716 738	725 100	3 518 295
Liberia	514 321	518 103	521 884	525 665	529 446	2 609 419
Zimbabwe	230 000	234 572	235 569	237 718	240 724	1 178 583
Grand Total	**158 543 190**	**168 263 587**	**171 896 025**	**175 844 245**	**176 145 825**	**850 692 872**

Table 1: Cassava Production in Sub-Saharan Africa, metric tonnes (MT), (2013-2017)
Source: FAOSTAT Data (2019)

1.3.2 Data Collection and Analysis Methodology

A combination of mainly Participatory Analytical Techniques (PAT) of consultation and data / information collection were employed. They included;

- Comprehensive review of relevant materials / documents (mainly using the Content Analysis technique),
- Key Informant Interviews, and
- Use of qualitative data collection instruments.

Individual contacts with networks within the selected countries were used to collect data and information on the cassava and cassava product standardization. In addition, information available from website sites of national, regional and international institutions and the Internet was examined.

In each of the seven countries selected to participate in this study, a sample of value chain actors were contacted from all segments of the cassava value chain starting from the farmers, processors, consumers of intermediate products and consumers of the final cassava or cassava derivative products. From the sample selected existing good practices in land preparations, weed management and herbicide application, standards for pesticides, tubers, intermediate and final products from cassava or its derivatives were established.

Information was sought from national, regional and international standards bodies, research institutions, and academicians, small, medium and large industries available in the seven countries covered in this study (DRC, Ethiopia, Ghana, Mozambique, Nigeria, Uganda and Zambia). A case study to identify differences among the available national standards in three of countries were established. In addition, availability of accredited laboratories and certification bodies in the three countries was examined to illustrate a possible scenario in Africa.

In the course of interactions with these stakeholders, their needs were identified and analysed at different stages of the cassava processing value chain. Ways to address these needs were discussed with these stakeholders.

Additionally, an enquiry was made through the Uganda WTO TBT National Enquiry Point to the selected countries in Africa (DRC, Ethiopia, Ghana, Mozambique, Nigeria, Uganda and Zambia; and two countries in Asia (Thailand and Indonesia) that are major producers and exporters of cassava products. The goal was to obtain information that businesses would possibly need through the mandated National Enquiry Point. Thailand and Indonesia were included in the enquiry as bench marks and to compare their response and the kind of information that could be got.

Annex A, illustrates the framework (tool) that was used to gather data on available standards for products, processes, methods, software, equipment and machinery along the cassava value chain.

2 CASSAVA AND CASSAVA PRODUCTS

2.1 Cassava Production – An overview

In Africa, small-scale farmers who manage cassava farm sizes of 1–5 hectares (ha), dominate production (over 90 %), followed by Medium Scale Commercial Farmers who manage about 6–10 ha, at 5 % and Large Scale Commercial Farmers with cassava farm size from 10 ha and up to 1 000 ha. Large scale commercial farmers are quite few because of the huge cash investment involved. The large scale farms are fully owned by manufacturing companies who consume their cassava produce. The large scale cassava farms receive financial support from the manufacturing companies or from Agricultural Support Commercial Banks.

Cassava production is afflicted by abiotic, biotic as well as management and socioeconomic constraints. Cassava is highly resilient to abiotic factors i.e. low soil fertility and moisture stress. Biotic constraints include insect pests and diseases that attack cassava plants. Breeding programs can provide farmers with new drought tolerant and pest and disease resistant cassava varieties.

Cassava cultivation is very labour intensive because most practices are not yet mechanized. It comprises four main activities: land preparation (clearing, ploughing); planting (laying-out, tilling, planting); weeding / farm maintenance and harvesting / transportation for post-harvest activities. Planting materials, fertilizers, insecticides, herbicides and tools are the main inputs used by producers. Application of herbicides and pesticides, however, is an area that requires technical assistance and of course more funds because most of these chemicals are imported. As the yield of cassava is directly related to the soil nutrients, weed management and herbicide application techniques, these inputs are critical, since their absence can have an adverse effect on cassava farming.

In view of the above, some governments like that of Nigeria have assisted in making these inputs available by establishing the National Fertilizer Procurement and Distribution Division (FPDD), the National Fertilizer Company (NAFCON) which is now known as Notore Chemical Industries. Private investors have also been licensed and have commenced fertilizer production in Nigeria. Some privately owned fertilizer companies in Nigeria are as follows: Indorama Eleme fertilizer and chemical ltd, Earthcare Nigeria ltd, Golden Fertilizer (division of flour mills of Nigeria), Dangote Fertilizer Ltd, Black Earth Nigeria Ltd, Elsahal Group Ltd.

In Ghana, the government developed a fertilizer policy (March 2013), which outlines the country's plan to attend to the soil nutrient deficiency issues and restrictions on poor handling of fertilizers. There are a few of fertilizer manufacturing companies in Ghana. Notable ones include the Agricultural Manufacturing Group Ltd, Bragha Company Ltd, and Glofert fertilizer company Ltd. There are no fertilizer manufacturing factories in DRC. All fertilizer supplies are imported from other African countries like South Africa, Kenya and Uganda. It is the soil experts / technicians that can give the exact fertilizer that is required in an area at a given time.

On herbicides, it was established that the majority of cassava farmers hardly use herbicides and other agro-chemicals for two major reasons: (i) the extra cost implications and (ii) initial attempts to use herbicides without proper guidance had a negative effect on the crops. In recent times, some rich farmers have commenced to apply herbicides for weed and pest control. The change in practice for the rich farmers is because government and research institutions like IITA and Natural Resources Institute / Crop Research Institute (NRI / CRI) have developed training programs for the privileged farmers who they come in contact with, on the right technique needed for herbicide application, weed and pest control management. Interest in pest management and disease control appears to be increasing, especially with recent high demand of cassava roots with high yield.

Agricultural tools and machines used in cassava crop farming and processing have also been of interest. Although cassava farmers in Africa are already used to the manual style of cultivating their farms, new machines have been invented and are already in use in other countries, like Thailand, where they have helped farmers to cover large areas in less time. Some of the equipment used for cassava farming are as follows: Cutlass, hole, knives, manual / automated grater, manual / automated milling machines, frying pans and manual / automated pressing machine.

Overall, the release of high yielding cassava varieties coupled with regular extension messages to promote improved agronomic practices is urgently needed to bolster cassava production levels in Africa. More support is needed to disseminate technologies from research done under the centres of excellence already set up with the assistance of the African Union programs (Pan African Cassava Initiative). The potential of high yielding varieties cannot be realized unless they are given appropriate nutrition and crop protection. The programs should therefore simultaneously support the adoption of fertilizer use and integrated pest management strategies.

This should be followed with appropriate mechanization of at least the harvesting operations to reduce the cost of production. This should be followed by post-harvest mechanization using cassava peelers and graters to quicken drying and enable the lighter chips to be transported to distant markets from remote areas with poor road networks. For mechanization to take root, support is required to train and equip rural workshops to fabricate the graters and mills.

Lack of knowledge of improved high yielding cassava varieties with longer shelf life and resistance to local pests and diseases and their production technologies, use of poor quality stem cuttings (seed) to establish a new crop, poor or no organization of farmers into cassava producer groups, and poor marketing strategies for cassava products constrain cassava production in Africa.

The relevant standards and arrangements from this perspective are those that:

a) Promote production and distribution of sound planting material.

b) Promote the cost effective production of cassava roots.

c) Promote the effective control of cassava pest and diseases.

d) Promote the conversion of cassava raw material into more readily consumable products.

e) Help promote widest and most efficient use of infrastructure for inland bulk distribution of fresh and wholesome cassava roots.

f) Promote the establishment and management of regional biotic risk assessment, audit and compliance systems across the industry.

2.2 Cassava Uses

2.2.1 Overview of Cassava Uses

Cassava is cultivated both as food (for human and animals) and as industrial raw material. Around 800 million people consume cassava in their diet in one form or another. This is due, in part, to its broad agro-ecological adaptability and its ability to produce reasonable yields where, with the exception of banana, the other staple crops would fail. Other staple commodities such as bananas, sweet potatoes, maize, rice and plantains, compete fiercely for investment funds from governments. From the point of view of food security cassava competes with other staples as a source of energy, protein and other nutrients.

Globally, average per capita cassava food consumption has been stagnant or falling (in Latin America, the Caribbean and in Asia) apparently as urbanization has advanced. The level of consumption has however, remarkably kept pace with income growth among both low and medium income groups, although with a weak negative correlation between disposable income and consumption. Such patterns suggest that cassava is important to low income groups. This implies that cassava could see more demand if it were more conveniently available to urban dwellers, who have less time to prepare meals. Empirical evidence on the influence of prices on the demand for cassava food products at the country level is poor but the sheer convenience of preparing meals from cheap cereal-based sources suggests that competition is stiff indeed.

Utilization	Total Supply Quantity (tonnes)	Percentage (%)	Number of Countries (EAC-COMESA-SADC)
Food	22 955 000	51	18
Feed	13 967 000	31	8
Processing	451060	1	2
Other uses	2 378 000	5	12
Waste	5 355 000	12	17
Total	45 106 060	100	18

Table 2: Utilisation of Cassava Produced and Imported in the AU (EAC-COMESA-SADC), 2014
Source: FAOSTAT (2016)

In Africa, cassava is primarily grown by smallholder farmers for food. In Zambia[1], for example, only about 25 % of farmers sell some of their crop implying that three quarters of famers only produce cassava for consumption. The quantities of the cassava sold are also reportedly low varying from 8 %–10 % indicating still most of the cassava is for home consumption even among households that sell cassava.

In the EAC-COMESA-SADC region tripartite (Table 2), cassava produced is consumed as food (51 %) or feed (31 %), while only 5 % was for other uses. Only 1 % of the cassava was processed. The quantity of cassava that is wasted due to post harvest losses (5 355 million tonnes) accounted for 12 % of the total quantity of cassava in the tripartite, and was 33 times higher than the quantity of cassava imports (160 000 tonnes) in 2013 (FAOSTAT, 2016). This implies that Africa could be self-sufficient for cassava is loses were prevented.

2.2.2 Cassava as a Food Security Crop

2.2.2.1 Dietary Energy

Cassava is the third most important source of calories in the Africa, exceeded only by rice and maize or bananas in the banana farming systems. The main nutritional value of cassava roots lies in their potential ability to provide one of the cheapest sources of dietary energy, in the form of carbohydrates. However, energy from fresh cassava is about one-third of that of an equivalent weight of a cereal grain, such as rice or wheat, because fresh tubers have a high water content. That said the high yields of cassava ensure a considerably higher energy output per hectare per day than that of grains and only surpassed by sweet potato.

Because of the low energy content of root crops compared to cereals on a wet basis, it is often assumed that root crops are not suitable for use in baby foods. This is not necessarily true if their energy density is increased by drying as is the case for tapioca, for instance, used as a composite in a number of commercial baby foods in industrialized countries. In fact, addition of germinated (malted) cereals to cassava flour increases the energy density of gruels prepared from it, by reducing their viscosity through the action of amylolytic enzymes.

Infants and young children, pregnant and lactating women have specifically higher nutrient requirements to meet the high physiological demand for growth and lactation. However, the use of fresh cassava products as infant weaning tends to be discouraged, on account of probable cyanide toxicity, low protein content and energy density. It is the challenge of technology to promote the incorporation of cassava into these foods. Standardization of composites and processed foods incorporating cassava provides effective means by which potential consumers could be reassured of the value of cassava.

1 GRZ, 2010.

Crop	Growth duration (days)	Dry matter (kg/ha/day)	Edible energy ('000 kcal/ ha/day)	Edible protein (kg/ha/day)	Production value (US$/ ha/day
Potato	130	18	54	1.5	12.60
Yam	180	14	47	1.0	8.80
Sweet potato	180	22	70	1.0	6.70
Rice, paddy	145	18	49	0.9	3.40
Groundnut in shell	115	8	36	1.7	2.60
Wheat	115	14	40	1.6	2.30
Lentil	105	6	23	1.6	2.30
Cassava	272	13	27	0.1	2.20

Table 3: Comparison on average energy and protein production of selected food crops in developing countries (per hectare and per day)

Source: Adapted from Horton et al., (1984).

2.2.2.2 Dietary Protein

Under-nutrition is often the outcome of either an insufficient food intake or poor utilization of food by the body, or both simultaneously. Recent surveys show that very few people in tropical countries suffer from a simple protein deficiency but rather the prevalent deficiency is protein-energy, in which an overall energy deficiency forces the body metabolism to utilize the limited intake of protein as a source of energy. Traditionally in Africa, cassava is always eaten with a soup or stew made of fish, meat or vegetables, providing an excellent occasion for balance in nutrients. This is an area in nutrition in which cassava plays an indirect role as an ingredient in meals that tend towards rich dietary energy and protein.

2.2.2.3 Dietary Fibre

Cassava like all other plant food sources provides carbohydrates in two categories, with distinct, contrasting and important impacts on the diet and health of humans. The first category is storage carbohydrates, particularly starch, but also oligosaccharides and sugars. The second category is the cell wall polysaccharides, which are derived in our diet mainly from plants, but also from fungi and algae (either directly or added as ingredients). Available starch is readily digested in the small intestine, but not resistant starch and cell wall polysaccharides (or non-starch polysaccharides, NSPs), which because of this comprise the dominant components of dietary fibre that is fermented by the colon microbiota to produce short chain fatty acids (SCFAs).

The composition of fibre in plant foods is still an emerging study area. More specifically, the fibre in edible processed cassava product and the potential to make fibre supplement from the otherwise waste products have yet to be appreciated. Indeed, cassava has yet to be included in several studies on antidiabetic plants. It is established that soluble fibres in cassava include uronic acid, pectin and β-glucans have nutraceutical value needed in diabetes management. These can be extracted to produce supplement of naturally-occurring dietary fibre that lowers plasma LDL, VLDL-cholesterol and triglycerides and blood glucose. Muffins and biscuits from cassava-wheat bran blends have been found to have low starch digestibility suggesting their use in medical nutrition therapy. This potentially improves the competitiveness of cassava with respect to diabetes and dyslipidaemia management.

Unfortunately, diabetes patients are being discouraged from consuming cassava in favour of wheat, and indeed a running furore exists over cassava as an affordable staple carbohydrate food crop losing out to imported foods products on health grounds. For instance, the Australian National Survey Food Nutrient Database compared cassava with three other carbohydrate foods including wheat, and revealed that the energy with dietary fibre intake of wheat is 1119 kJ and without the fibre content is 784 kJ; whereas cassava is 587 kJ and 550 kJ respectively. What is silent is that when the fibre content of the products is removed in processing, wheat loses more calories than cassava. Moreover, while in the unprocessed food materials, calorie / fibre ratio is best in wheat compared to the others, fat / fibre ratio is lowest in cassava. Such gaps call for elucidation of information, including standards, on international databases to facilitate proper labelling of designer foods and improve competitiveness of cassava in international trade.

2.2.2.4 Speciality Foods

Allergens-free Diets

Individuals with food allergies benefit from using cassava root in cooking and baking gluten-free, grain-free and nut-free products.

2.2.3 Cassava in Animal Feed

Cassava is widely used in most tropical areas for feeding pigs, cattle, sheep and poultry. Dried peels of cassava roots are fed to sheep and goats, and raw or boiled roots are mixed into a mash with protein concentrates such as maize, sorghum, groundnut or oil-palm kernel meals and mineral salts for livestock feeding.

In many African countries cassava leaves and stems are considered a waste product but analytical tests established that the leaves have a protein content equivalent to that of alfalfa (about 17 %–20 %) in the fresh or dried form. Yet a market for dried alfalfa exists mainly in Japan for about 240 000 MT a year. Brazil and many parts of Southeast Asia, use large quantities of cassava roots, stems and leaves by chopping and mixing into a silage for the feeding of cattle and pigs. Therefore, a large potential exists for the exportation of dehydrated stems and leaves of cassava. However, cassava is deficient in protein and vitamins, and must be supplemented by other feeds that are rich in these elements.

The amount of cassava and its products fed to animals as scraps in Africa is presumed to be fairly large, but difficult to estimate. Barnyard fowls, goats and pigs probably feed on cassava roots and leaves regularly, but a true livestock feeding industry based on cassava is only still developing. In the European Union (EU) the compound animal-feed industry uses dried cassava roots as an ingredient, and large quantities of cassava chips, pellets and meal are imported into these countries for this purpose.

The maximum content of cassava products in compound feedstuffs is subjected to official standardization in many countries e.g. in Germany, it is: 10 %–40 % for pigs, 20 %–25 % for cattle and 10 %–20 % for poultry. In the Netherlands and Belgium, however, the figures are much lower. Large and small manufacturers have access to software for determining the composition of compounds to optimize feed values and price. Therefore, the relevant standards and arrangements from the perspective of animal feed are those that:

a) Promote the wholesomeness or raw material i.e. leaves, stems and roots.

b) Guarantee the reliability of claims made by manufacturers on the quality of feeds.

c) Enable the cost effective fabrication and trade of quality machinery and equipment for the production of feeds.

d) Promote truthful, informative non-misleading labelling on packaged pet foods and livestock feed.

2.2.4 Industrial Uses of Cassava

2.2.4.1 Cassava Starch

Cassava starch is somewhat special for food processors because (a) it is readily gelatinized by cooking with water and the solution after cooling remains comparatively fluid and (b) the solutions are relatively stable and do not separate again into an insoluble form (retrogradation) as is the case with maize and potato starch.

Cassava starch and non-starch polysaccharides (NSPs) undergo modification during processing. This affects its properties such as cell wall structure, particle size and water absorption. Milling for example affects the portion of starch in the flour and distribution of the soluble or insoluble NSPs in the milling portion. All these have implications on the end-use properties and digestion.

Gelatinization makes it easier for the starch to be hydrolysed by the enzyme amylase, an important gateway stage in putting starch to a variety of applications e.g. commercial manufacture of glucose sugars from starch.

Unmodified starch, modified starch, glucose and dextrose are used in the food, pharmaceuticals and other industry a variety of applications.

2.2.4.2 Starch in the Food Industry

The special features of cassava starch, such as its viscosity, resistance to shear stress and resistance to freezing, make it amenable to produce the following main classes of starch-based products:

- Unmodified or native starch;
- Modified (physical, chemical, biological) starches for industrial purposes; and
- Sweeteners, including high fructose syrup, glucose (dextrin, monosodium glutamate, monosodium glutamate- serve as binders in seasoning production.

Starch is used in food industry for one or more of the following purposes:

- Directly as cooked starch food, custard and other forms;
- Thickener using the paste properties of starch (soups, baby foods, sauces and gravies);
- Filler contributing to the solid content of e.g soups and ice cream;
- Binder, to consolidate the mass and prevent it from drying out during cooking (sausages and processed meats);
- Stabilizer, owing to the high water-holding capacity of starch (e.g. in ice cream).

Therefore, the relevant standards and arrangements from the above perspective are those that:

a) Promote the purity of starch, glucose and dextrose

b) Promote the safe treatment and disposal of acids and other chemicals used in the conversion of starch to glucose and dextrose

c) Promote the production, purity, handling, storage and distribution of enzymes

d) Test methods for the quality of raw and intermediate products in the various processes of starch extraction and conversion.

2.2.4.2 Starch in Pharmaceutical Industries

Different studies have cited cassava starch as a known raw material in pharmaceutical industries. Cassava starch is used as an excipient, a tablet and capsule diluent, a tablet and capsule disintegrant, a glidant, or as binder as well as filler for pills and tablets and other pharmaceutical products.

2.2.4.3 Starch Adhesives

Starch makes a good natural adhesive. There are two types of adhesives made of starches, modified starches and dextrins: roll-dried adhesives and liquid adhesives. The application of cassava in adhesives continues to be one of the most important end uses of the product, new synthetic substitutes notwithstanding. In the manufacture of glue, the starch is simply gelatinized in hot water or with the help of chemicals. For conversion into dextrin it is subjected separately or simultaneously broken down using chemicals and heat in the presence of enzymes. In gelatinized starch adhesives, quality requirements are such that the medium-low quality flours can be used.

Dextrins are a group of low-molecular-weight carbohydrates produced by the hydrolysis of starch or glycogen. Dextrins made from various starches such as potato, corn, tapioca, rice, arrowroot or wheat. In dextrin manufacture, the demands are much more exacting: only the purest flours with a low acid factor are acceptable. Cassava dextrin is preferred in remoistening gums for stamps, envelope flaps and so on because of its adhesive properties and its agreeable taste and odour.

There are three primary groups of dextrins; British gums, white dextrins and yellow dextrins. British gums are formed by heating the starch alone or in the presence of small amounts of alkaline buffer salts to a temperature range of about 180 °C–220 °C. The final products range in colour from light to very dark brown. They give aqueous solutions with lower viscosities than starch.

White dextrins are prepared by mild heating of the starch with a relatively large amount of added catalyst, such as hydrochloric acid, at a low temperature of 80 °C–120 °C for short periods of time. The final product is almost white, has very limited solubility in water and to varying degrees retains the retrogradation tendency of the original starch paste.

Yellow dextrins are formed when lower acid or catalyst levels are used with higher temperatures of conversion (150 °C–220 °C) for longer conversion times. They are soluble in water, form solutions of low viscosity and are light yellow to brown in colour.

The following are some of the major uses of dextrins in non-food industries.

Dextrins for corrugated cardboard manufacture: One of the large users of dextrins is the corrugated cardboard industry for the manufacture of carton boxes and other packing materials. The layers of board are glued together with a suspension of raw starch in a solution of the gelatinized form. The board is pressed between hot rollers, which effects a gelatinization of the raw starch and results in a very strong bonding. Medium-quality flours are suitable for this purpose provided the pulp content is not too high.

Dextrin for re-moistening gums: These adhesives are coated and dried on surfaces, such as postage stamps and envelope flaps, for moistening by the user before application to another surface. Cassava dextrins in aqueous solution are well suited for this purpose as they give a high solids solution with clean machining properties.

Dextrin for wallpaper and other home uses: Various types of starch-based products are used as adhesives for wallpaper and other domestic uses.

Dextrins for foundry fine art: Starch is used as an adhesive for coating the sand grains and binding them together in making cores which are placed in moulds in the manufacture of castings for metals.

Dextrins for drilling oil and gas wells: Starches and modified starches mixed with clay are used to correct viscosity and water-holding capacity in drilling water and oil bores. They are preferred to other commercial products for making the muddy materials widely used in the industry. Pre-gelatinized starch is soluble in cold water which is convenient for making pastes of the required consistency on the spot.

Dextrins in the paper industry: In the paper and board industries, starch is used in large quantities at three points during the process:

a) at the end of the wet treatment, when the basic cellulose fibre is beaten to the desired pulp in order to increase the strength of the finished paper and to impart body and resistance to scuffing and folding;

b) at the size press, when the paper sheet or board has been formed and partially dried, starch (generally oxidized or modified) is usually added to one or both sides of the paper sheet or board to improve the finish, appearance, strength and printing properties;

c) in the coating operation, when a pigment coating is required for the paper, starch acts as a coating agent and as an adhesive.

Paper manufacture: Cassava starch has been widely used as a tub size and beater size in the manufacture of paper, in the past mainly on account of its low price. A high colour (whiteness), low dirt and fibre content, and, above all, uniformity of lots are needed in this instance.

An important new application of starch is in the machine-coating of magazine paper, formerly done exclusively with caseins. There are indications that cassava is particularly well suited to the purpose; however, definite specifications for the starch still have to be worked out.

Textile Industry: In the textile industry, cassava starch is used in operations such as warp sizing, cloth finishing and printing although its application in these particular textile segments is challenged by other starches with a different shape and size. An exception is the manufacture of felt, where cassava continues to be used exclusively in the finishing process.

Wood furniture: Cassava starch based glue is second only to plastic glues that are preferred for their water proof qualities. There are many applications where cassava starch glue still remains the preferred choice.

Starch in ceramics: Cassava starch is used in ceramic technology as a pore-forming agent and as a body-forming agent in a recently refined process known as starch consolidation casting. The starch polymers are burnt out without residues upon firing, to leave a pore structure that is determined by the size and shape of starch applied.

Dusting powders: Starch can be made into finely powdered substances free of grittiness. This can be applied to the skin to reduce friction and moisture. By cross-linking starch with other agents, starch can be sterilized in autoclave and used as a surgical dusting powder.

Plastic and packaging: Starch can be incorporated into plastics to improve the biodegradability of the plastic and finished product. Polylactic acid (PLA) or polylactide can be made from cassava starch and has wide application in 3D printing.

Stain remover: This can be applied directly to fabrics as a dry powder or as a paste, allowed to dry and then brush off.

Detergents: Starch is an effective dirt re-deposition inhibitor preventing the re-entry of dirt once it has been removed from the fabric.

Gypsum and mineral fibre: Starch is used as a binder in gypsum plaster, gypsum and mineral fibre board.

Concrete: Starch is often added to concrete to reduce the set-time in cement.

Coal: Starch is used as a binder in briquettes made from coal dust. Nappy / Diaper: Starch is used as a super absorbent gelling material capable of sequestering sometimes their weight of moisture.

Particle board from cassava stalks: As cassava cultivation increases, more stalks become available for disposal. Particle boards are made from cassava stalks reduced to appropriated particle size and mixed with resin binders. The strength of the board can be varied by altering the resin content or the density. Trials done in South African scientist produced particle boards that conformed to the ANSI A208.1-2009 Standard for particle boards.

2.2.4.6 Dried Yeast

Candida and saccharomyces yeasts are among the microorganisms that can be cultivated for production of protein, which is in high demand all over the world. The technology of production, the composition and the nutritive value of yeasts are well established. Cassava starch and cassava roots can be used in growth media to produce yeasts for animal feed, the human diet and for bakery yeast. Using mineral acid or enzymes cassava starch is hydrolysed into simple sugars (predominantly glucose) which is then assimilated by propagated yeasts to produce microbial cellular substances. Dry, inactive yeast contains about 7 % moisture and its raw protein content can vary between 40 % and 50 % depending on the quality of starch. The yield of yeast production also depends on the raw material. Some processes have yielded as much as 38 %–42 % yeast product with 50 % raw. It is clear that the efficiency and efficacy of this production process is variable and therefore important for safety, profitability and functionality of the end product. Starch, yeast cultures, mineral acids for the process, enzymes are all amenable to standardization in order to remove randomness in the process and its outcomes.

2.2.4.5 Biofuels

Emerging demand for biofuels could also be a future growth market for cassava, as evidenced recently in China. Cassava pulp, a low cost solid by product of cassava starch industry, has been proposed as a high potential ethanolic fermentation substrate due to its high residual starch level, low ash content and small particle size of the lignocellulosic fibres. For economic feasibility complete degradation of the polysaccharides to fermentable glucose must be achieved and here raw pulp subjected to a cocktail of enzymes can yield as much as 70 % dextrose equivalent (DE).

Cassava is one of the richest fermentable substances for the production of absolute alcohol for industrial use and for alcoholic beverages such as wine and beer. The fresh roots contain about 30 % starch and 5 % sugars, and the dried roots contain about 80 % fermentable substances, at par with rice as a raw material. Leading producers of alcohol such as Malaysia and Brazil have factories set up use cassava as the raw material. Saccharification using sulphuric acid under pressure cooking raises total sugars to 15 %–17 % of the substrate. The pH is raised again using sodium carbonate, and then yeast fermentation is allowed for 3–4 days to produce alcohol and carbon dioxide. Purified absolute alcohol yield can reach 70–110 L / per MT of cassava roots depending on the variety and method of manufacture. Quality is assessed among others by the absence of odours but the general product is an input in to the industrial production of cosmetics, solvents and pharmaceutical products. If the product is destined for human consumption, handling and post-harvest processing of the roots is designed to rid them of hydrocyanic acid.

In all the production systems outlined above, standardization of the measurements of raw and intermediate material quality parameters, as well as the reliability of the human resource behind the processes and measurements is extremely important for the industry to remain competitive in local and international markets as well as in the capital markets. Therefore, the relevant standards and arrangements from the perspective of animal feed are those that:

a) Promote the wholesomeness or raw material i.e. leaves, stems and roots.

b) Guarantee the reliability of claims made by manufacturers on the quality of feeds.

c) Enable the cost effective fabrication and trade of quality machinery and equipment for the production of feeds.

d) Promote truthful, informative non-misleading labelling on packaged pet foods and livestock feed.

2.2.5 Cassava as a Source of Income

A study by Abbas et al. (2013)[2] showed that apart from improving food security and livelihoods in Africa; the income generation and employment opportunities for smallholder farmers, processors, marketers and other stakeholders; and the supply of raw materials for import substitution by local industries, potentially significant savings in foreign exchange expenditure by governments can emanate from a commercialized sector.

The marketability of cassava and its derivatives have improved the finances of farmers and businessmen and enhanced foreign exchange inflows. Special initiatives on commercialization in West Africa showed that there is potentially great scope for successfully commercializing production, processing, and marketing, including its industrial use in other parts of Africa. Linking smallholders to commercial opportunities has a potential of increasing farmers' income from cassava production by 50 % to 300 % through increased use of inputs and hence improved yield as well as through potential increase in cultivated area[3].

There is, therefore, a pressing need to commercialize the production and domestic use of cassava.

2 Abbas et al., 2013

3 Koyama et al. 2015.

2.3 Cassava Products

2.3.1 General

Cassava products may be categorized into primary, secondary and tertiary products highlighting the versatility of cassava the crop. These are often called cassava and cassava derivatives or derived cassava products. Primary products are those that involve the direct use of the roots, the stem or the leaves of the cassava plant with no transformation. Figure 2 presents the cassava value chain and the different products and uses of cassava.

Cassava utilization in Africa takes a form of a multitude of products. A Collaborative Study of Cassava in Africa (COSCA) undertaken in 1998, revealed that 147 different names were used to describe 623 products[4] in 233 villages in six countries. The authors aggregated these products into nine product categories using key processing steps as indicators **(Table 4)**. The number of names (147) is lower than the number of product (623) found in the study. This implies that the same name could be used for different products in different communities for countries.

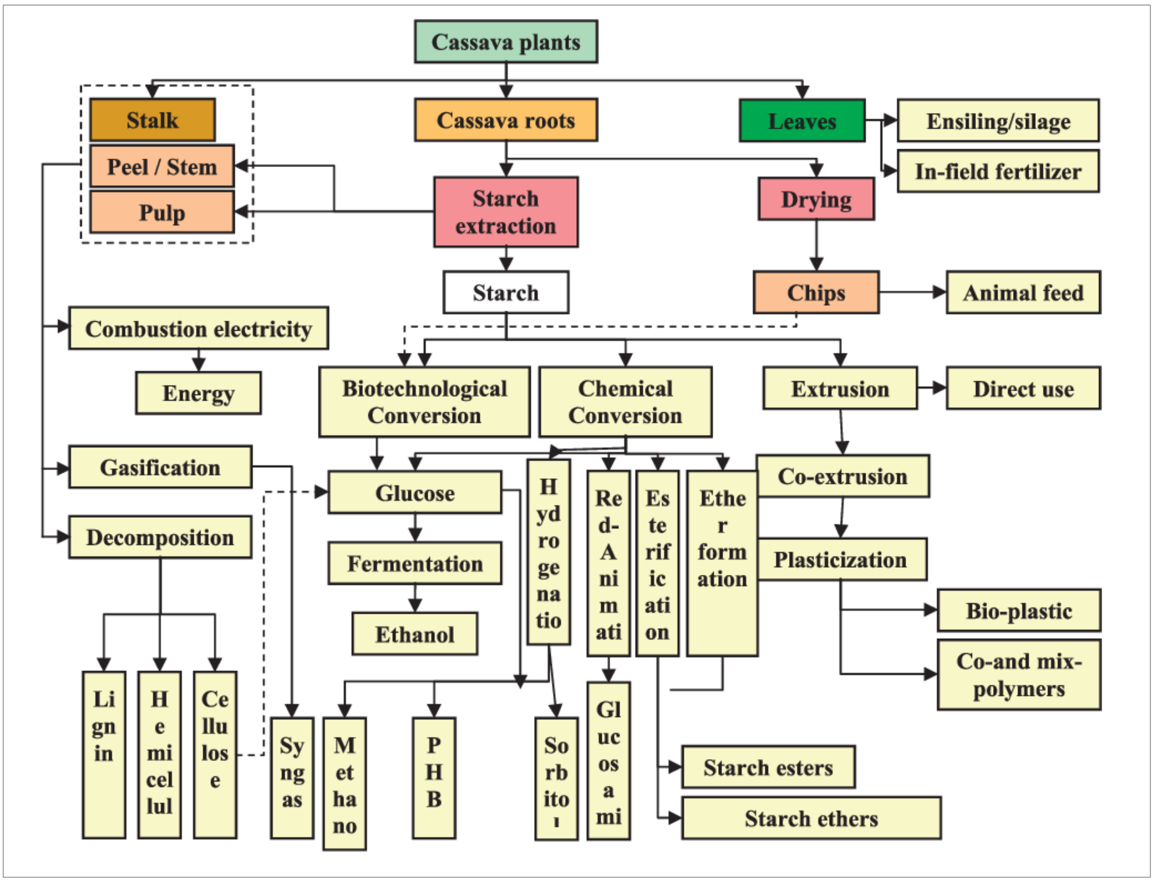

Figure 2: The cassava value chain; Piyachomkwan and Tanticharoen (2011)

4 Henry, Westby and Collinson, 1998.

Product Type	Cote d'Ivoire	Ghana	West Nigeria	East Nigeria	Tan-zania	Uganda	Zaire	Total	%
Cooked Roots	35	20	–	11	9	33	–	108	17
Roasted Granules	7	19	18	24	–	–	–	68	11
Steamed Granules	30	1	–	–	–	–	1	32	5
Flours/ Dry Pieces	21	27	17	35	61	52	66	279	45
Fermented Pastes	4	10	19	21	1	–	20	75	12
Leaves	–	–	–	–	1	3	2	6	1
Drinks	–	–	–	–	–	6	–	6	1
Sedimented Starch	22	–	3	3	–	–	–	28	4
Unclassified	–	5	4	4	2	2	4	21	3
Total								623	100

Table 4: Categories of cassava products in 233 villages in 6 countries in Africa.
Adopted from Henry, Westby and Collinson, 1998.

2.3.2 Primary Cassava Products

2.3.2.1 Cassava Leaves

Cassava leaves are vegetables. The edible green leaves of cassava are a good source of protein, vitamins and minerals and are often used to augment diet[5]. These leaves are dried to preserve them for export (See Box 1 below.), since they are also on high demand by indigenous nationals living outside the countries, where they are served as a meal.

The leaves are mostly consumed directly in dish preparation in DRC, Ghana, Rwanda and Uganda. In Nigeria, it is used as nutrients for growing edible fungi, caterpillars and snails. They are also used in combination with other herbs for traditional medicine treatments. Like other vegetables consumed by humans, there are no inherent known toxins contained in the leaves of cassava but different studies have shown that the leaves are attacked by ants and insects present in the farm.

Cassava leaves can be eaten as a fresh vegetable, ground fresh and frozen in plastic bags, or dried and ground for sale in plastic bags. The most important cassava leaf food products are fresh leaves, ground fresh leaves, frozen leaves and dried cassava leaves (powder). Cassava leaves can be processed for animal feed as follows: whole plant silage, cassava hay, leaf silage and stem silage.

5 Bayata, 2019.

Export of Cassava Dried Leaves – Sylva Foods and Catering Limited in Zambia

Sylva Foods and Catering Limited uses dry cassava leaves as vegetables, and high quality cassava flour added to soups. The current production capacity of the plant is 1 600 tonnes of meal per 8 h shift). The Sylva Foods exports the dried cassava meal, to the USA under the Africa Growth Opportunities Act (AGOA). Its products are also exported informally to the DRC and other countries. The company's focus is on food security and nutrition – it supplies products to the World Food Programme under its school feeding programme. Annually, Sylva Foods trains 20 700 farmers in cassava production and plans to expand to training 80 000 farmers in all provinces in Zambia, in 5 districts in Mozambique, and 2 districts in Tanzania The company also sells solar dryers to farmers through nongovernmental organizations for cassava drying. Sylva Foods has plans to engage in production of high quality cassava and has acquired land for this purpose, and has plans to establish a starch processing plant when it obtains the requisite financing support.

Box 1 Source: Key Informant Interviews in Zambia (2020)

Fresh cassava leaves including tender stems because of their high nutritive value, are utilized directly for ruminant feeding (goat, sheep and rabbits). For monogastric animals, the leaves are processed into a dehydrated leaf meal.

Dry cassava leaf meal[6] (also known as "cassava hay") is usually obtained by cutting the plant tops at 2.5 to 3-month intervals during the cassava growth cycle. The best quality foliage meal contains a large proportion of leaves and only very young stems, and is obtained from plants or shoots that are less than three months old. After harvesting, the foliage is chopped and spread out on a concrete floor for sun-drying. The moisture content needs to be reduced from about 70 % to about 14 % so that the foliage can be milled and stored.

Leaf silage[7] is made by mixing chopped leaves with 0.5 % salt and 5 % to 10 % cassava root meal or rice bran, and then placing the mixture in large plastic bags or air-tight containers. The leaves are compacted to expel all air and the bags are sealed. Under these anaerobic conditions, the leaves start to ferment, resulting in a sharp drop in pH, as well as in cyanide content. After about 90 days of fermentation, the silage is ready to be fed to animals, usually pigs and cattle. The silage can be stored in tightly sealed bags for at least five months without spoiling. The ensiled leaves contain about 21 % crude protein and 12 % crude fibre. Box 2, below shows a case example of commercial production of animal feeds from cassava.

2.3.2.2 Cassava Stems

The biomass of cassava stems can be as much as 50 % of the root mass, but the role of cassava stems in both starch and energy production has so far been overlooked[8]. About 10 % – 20 % of cassava stems are used for propagation. In some countries, a part of cassava stems is either used as fuel in form of pellets or briquettes for cooking, reincorporated into the soil to add organic matter and nutrients; abandoned or burned in the wild, causing emissions and environmental problems.

Cassava stems contain about 30 % starch (dry mass) mostly in the xylem rather than phloem tissue. Up to 15 % starch of the stem dry mass can be extracted using simple water-based techniques, potentially leading to an 87 % increase in global cassava starch production.

Cassava stems therefore are an opportunity to make animal feeds, starch, organic fertilizer,

6 FAO, 2013.

7 FAO, 2013.

8 Zhu et al. 2015.

Animal Feeds from Cassava – a case study of Tiger Feeds

Tiger Feeds Limited is the Zambian Division of the Astral Foods of South Africa. The company is the largest commercial feed supplier in the country with an annual production capacity of 66,000 tonnes of animal feed per annum and a strong distribution network of more than 40 outlets in Zambia. The company discontinued use of cassava in animal feeds in 2012 due to unreliable supply. Cassava production was highly seasonal, was available in low quantities, and was not competitive when compared to maize due to its lower protein content. Cassava needs to be competitively priced relative to maize and supplies should be reliable. 90 % of the feed production of Tiger Feeds Limited comprises poultry feed. The maximum composition of cassava required in poultry feed rations is 5 – 10 percent as compared to 60 % for maize. The company would therefore require a maximum of 500 tonnes of cassava for its operations. And, to be competitive the price would need to be about USD 100 per tonne as compared to the current price in the range of USD 200 – 250 per tonne.

Box 2 Source: Key Informant Interviews in Zambia (2020)

fuel wood including briskets and paper and wood board.

2.3.2.3 Cassava Roots

Cassava roots are used as food or animal feed without any transformation. Peeled sweet cassava roots are prepared and consumed raw, boiled, steamed, fried or roasted. Cassava roots are also the most processed part of the crop from which secondary and tertiary produced are derived.

2.3.3 Secondary Cassava Products

2.3.3.1 General

Cassava is mainly processed using traditional methods with minimal modern mechanised processing methods adopted. The type of products and the names vary from country to country and between communities. A study in Burkina Faso in 2016, identified that most of the products were based on the cassava root. The main cassava-based foods identified in villages according to their frequencies in households were boiled roots (96.90 %), raw roots (64.90 %), cassava flour (55.60), roasted root (43.10 %), attiéké (27.10 %), gari (16.90 %), and other cassava products (8 %). [9]

The methods used to process cassava roots reveals a complex array of processes leading to a multitude of products. **Figure 3** shows a cassava products map of at least 25 products i.e. Chikwangwe, Lafun, Alebo, Fufu, Farine, Cossette, Autkpu, Yakayake, Attiéké, Agbelima, Placali, Pancakes (Kabalagala in Uganda), Composite Flour (Atap, Kalo, Kuon in Uganda), Kokonte, Akpissi, Foutou, Eberebe, Pombe, Kwadu, Mihogo, Chips, Fresh tuber, Kenkey, Fede, Agelikaklo from cassava roots identified by Henry, Westby and Collinson (1998).

Kauakou et al., 2016 **(see Figure 4)** indicates another array of more than 13 products made from boiled cassava roots, fermented an unfermented cassava paste including: cassava sticks, dry semolina, pasta, pastries, sourdough, cassava beer, fritters.

A recent study by (Alamu et al., 2020) in Côte d'Ivoire identified six products in addition to fresh roots: cossettes, placali, garba, attiéké, foufou, and starch. In this study, cossettes are described as dried cassava chips. Placali is described as a kind of pulp that is obtained after peeling, washing, rasping / grating into pulp, fermenting, and pressing. It keeps longer than fresh roots and is less bulky and heavy. It is just the basic raw material to produce attiéké and garba. Garba is obtained by steaming crumbled placali directly without fibre removal.

9 Guira et al., 2016

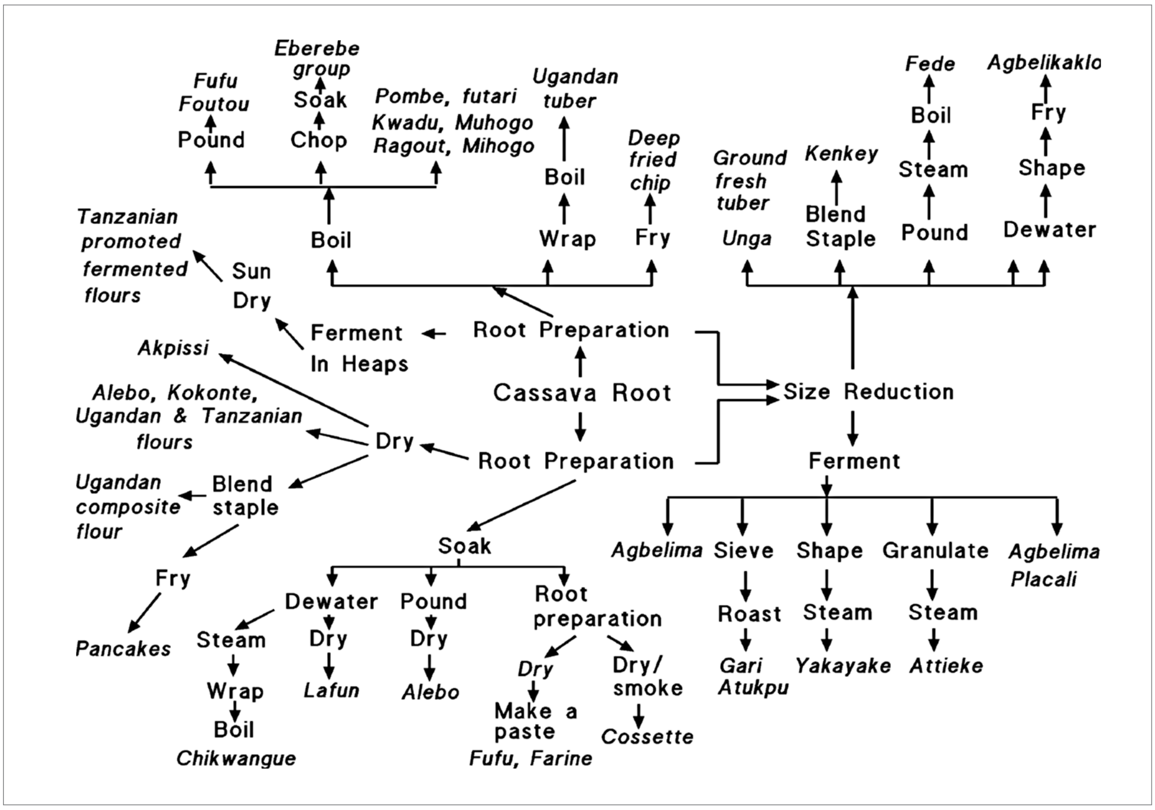

Figure 3: Interrelationships between cassava products based on processing steps
Adopted from Henry, Westby and Collinson, 1998.

According to Guira et al. (2016), the main cassava food products from cassava roots found in Africa are attiéké, tapioca, gari, flour, starch, fufu, fermented flours, akpissi, alebo, eberebe, ragout, kwadu, ground fresh tuber, kenkey, fede, agbelilakia, placali, yakayake, cossette, lafun, chikwangwe.

Filbert et al. (2016) list 22 products that are fermented by region of Africa indicating Ubuswage, Imikembe, Ikivunde, Inyange, Kivunde, Mokopa in east Africa; Chickwangwe, Meduame-Mbong, Fufu and cossette in central Africa and Gari, Attiéké, Placali, Lafun and efubo, Kokondé, Agbelima, Loi-loi, Attoupkou, Dumby and Abacha, Kapok pogari, Bêdêkouma in western Africa. Zannou, Gbaguidi and Ahoussi-Dahouenon[10] list 23 different products in Benin: Cossettes de manioc, Fingnin, Gari, Kuté libo, Galikponnon (pain de manioc), Fufu, Farine de manioc, Goman (amidon), Lafun, Ayan (Purée de manioc), Goman kluiklui (snack), Attiéké, Kuté dida (manioc bouilli), Kponnonvi (biscuit de goma), Agléli mawè, Kuté mime (manioc grillé), Tapioca (amidon granule), Kuté siso (manioc frit), Abloyoki, Kutéta (snack), Kuté founfouin (manioc pile), Agbéli klaklou and Greedy (goma séché au four).

Codex Alimentarius Commission, the international food standards agency mentions Gari, fufu, cassava flour, cassava starch (tapioca), cassava chips, Lafun (an unfermented cassava flour); Attiéké (steamed fermented cassava granules) Chikwangwe, Bikedi (a traditional fermented cassava root food) and Ntobambodi (a semi solid fermented cassava leaves soup) in the international standards (CAC 2013). Codex has development international standards for sweet and bitter fresh cassava and edible cassava flour. This is a recognition of the importance of these products in international trade.

The main unit operations (not in any order or

10 Zannou, Gbaguidi and Ahoussi-Dahouenon (2018)

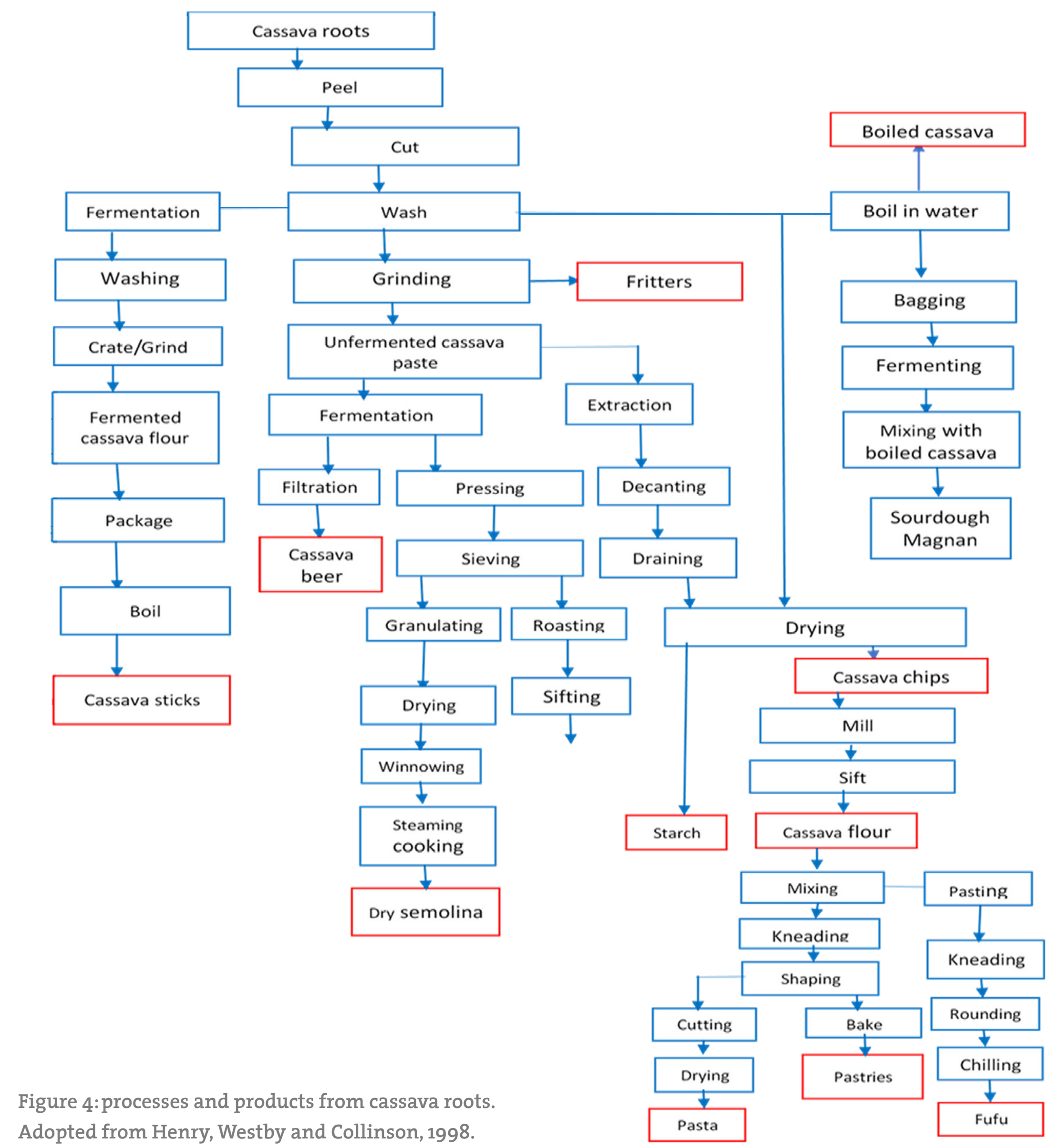

Figure 4: processes and products from cassava roots. Adopted from Henry, Westby and Collinson, 1998.

sequence) in most of the cassava products are Peeling, washing, grating, chipping, soaking, fermenting, Peeling, sifting or sieving, roasting, cooking, cooling, drying, packaging, storage. These operations are described in CAC, 2013.

To illustrate the sequence of the operations we have drawn flow charts for the following products i.e. Dried Cassava Chips, Dried Cassava Pellets, Cassava Flours, High Quality Cassava Flour, Attiéké, Fufu, Cossette, Tapioca, Chikwangwe, Gari and Lafun are described in section 2.3.3.2 to 2.3.3.10 and the product charts with relevant references are illustrated in **Annex B**.

2.3.3.2 Dried Cassava Chips

Dried cassava chips and flour are called cossette in some places. Dried cassava chips are produced fermented or non-fermented.[11] [12] Fermented chips are made by peeling, slicing

11 Kaaya and Eboku, 2010

12 FAO, 2014

and heaping cassava pieces (with or without initial exposure to sunshine for 2–4 h) and allowing to ferment for a step of solid-state fermentation (heap fermentation) before drying (crushed or uncrushed) to produce fermented cassava chips or crumbs. Normally it takes up to four days of sun-drying to make dried chips with about 12 % to 14 % moisture content.

Non fermented cassava chips are produced by peeling, slicing and drying the cassava without fermentation. Both fermented and non-fermented cassava chips or crumps are traditionally milled to produce cassava flour for home consumption.

The ability to reduce bulk and the possibility of deriving many products from dried cassava chips makes this one of the most tradable commodities. Cassava chips can be further processed to animal feeds, cassava pellets, cassava flour, high quality cassava flour (unfermented), starch, and other related industrial tertiary products such as glucose, ethanol and sorbitol.

2.3.3.3 Cassava Pellets

Most of the international feed cassava trade is carried out under the form of pellets and hard pellets, as disintegration of the chips often caused dust problems upon unloading at destination ports. There might therefore be some interest in promoting the pelletizing of cassava for exports.

Processing of cassava pellets can be done in a variety of ways, degrees of mechanization and the quality of the finished product varying in countries or regions[13]. Roots and leaves can be combined in the ratio 4:1 to make composite pellets. The most common process converts milled dried chipped cassava roots (peeled or not) into pellets. The process involves feeding dried and milled flour into a pelleting machine which presses the chips / mash before extrusion through a large die. The heat and moisture in the chips help in the formation of pellet-like shaped product known as soft pellet. Later process development involves milling of chips followed by steam extrusion through a large die to obtain partially gelatinized pellets that become hardened on cooling known as hard pellets. They have been observed to have a longer shelf life when dried to 8 % moisture on wet basis. Cassava pellets are uniform in quality and strength; light weight, have less storage volume and retain quality during shipment.

2.3.3.4 Cassava Flours

Cassava flour is produced by milling dried cassava chips. Cassava flours can be used for direct human consumption or mixed with other grain flours and consumed as household composite flours. In Uganda cassava flour is eaten singly or in combination with millet, sorghum, maize or sweet potato flour and use to make porridge as well as flours for millet bread (Atap) and maize meal (posho) to be consumed by children and adults.

Cassava flour can also be mixed with grain flours to make industrial composite flours that are used in industries such as bakeries and confectioneries. Bread consumption continues to expand in Africa as urbanization increases and road infrastructure enables distribution into rural areas.

The use of composite flours for bread baking in order to use locally available materials is encouraged in many parts of Africa. Fortunately, the FAO of United Nations has had the Composite Flour Program since 1964. Wheat–cassava composite as well as wheat-cassava-maize composite flours have been tested and found acceptable for baking bread, cakes, biscuits and pastries[14].

The light, evenly structured bread made of wheat flour and the characteristic soft crumb are due to the swelling properties of wheat-flour gluten in water. If pure starch from another cereal or a tuber is used, the product is considerably more rigid and its texture is irregular because gases are insufficiently retained in the dough. Therefore, when starches like cassava that do not contain gluten-forming proteins are used, a swelling or binding agent must be added during the preparation of the dough to bind the starch granules (i.e., egg white, gums, glyceryl monostearate).

13 Raji et al., 2008.

14 Eduardo, Svanberg and Ahrne, 2014.

Bread made from steam-leavened dough composed of 60 % wheat flour, 30 % cassava starch and 10 % soybean has quality equivalent to ordinary wheat-flour bread in volume, appearance and eating quality. Other bakery products made from composite flours (cassava / soya bread and cassava / groundnut) and assessed for nutritional value have been found to have a higher protein quality than common wheat bread. In recent years plenty of campaigning to increase the consumption of composite flours in Africa has been done. Public education, the spread of knowledge and application of standards can facilitate the adoption of new products.

2.3.3.5 High Quality Cassava Flour (HQCF)[15]

High quality cassava flour (HQCF) is cassava flour that has not been fermented. High-quality cassava flour is made within a day of harvesting the root. It is very white, has low fat content, is not sour like traditionally fermented cassava flour, does not transfer odour of taste to food products and can mix very well with wheat flour for use in bread or cakes. It can be used as an alternative to wheat flour and other starches in bread and confectionary.

The processing of cassava roots into HQCF involves peeling, washing, grating, pressing, disintegration, sifting, drying, milling, screening, packaging and storage. High quality cassava flour (HQCF) was developed in West Africa as a new product that would be white / light cream in colour, unfermented, low fibre, finely milled and of a generally high quality suited for use in bakeries and industrial applications. The name HQCF was chosen to distinguish the new product from the many traditional flours. HQCF is also produced from crushed roots to ensure sufficient removal of cyanogenic glucosides especially when using bitter varieties of cassava. This type of HQCF has high purity with very low fibre levels and is ideally suited for the production of clear beers and paperboard adhesives but would also be suitable for all food uses. The conversion ratio for HQCF is ~4:1.

2.3.3.6 Starch

Production of starch involves a washing step before peeling apparently to get rid of impurities (mud) which might impart undesirable colour to the final product. Cassava is then peeled and again thoroughly washed. This is followed by grating into fine pulp. The pulp is then washed over a strainer so that coarse particles could be reintroduced into the grater. The process is followed by sedimentation, drying at 55°C, milling and sifting, and packaging.

2.3.3.7 Attiéké

Attiéké is the most widely consumed cassava-based product in Burkina Faso, Côte d'Ivoire Benin, Togo, Senegal and Cameroon. In the production of Attiéké, cassava roots are peeled, placed in water and ground into a paste. The paste is left to ferment for 2 days in a sack and then pressed. The paste is removed from the sack, crumbled, screened, and dried, and then the final cooking is done by steaming the pulp. Attiéké is available in a wet form with a short shelf-life or dried attiéké which is shelf stable.

2.3.3.8 Fufu

Cassava Fufu (or foofoo, fufuo, foufou) is a staple food common in many countries in West and Central Africa such as Benin, Cameroon, Cote D'Ivoire, Democratic Republic of Congo, Gabon. Ghana, Guinea, Liberia, Nigeria, Republic of Congo, Sierra Leone and Togo and The Central African Republic. It is often made in the traditional Ghanaian and Nigerian method by mixing and pounding separate equal portions of cassava and green plantain flour thoroughly with water.

There are different variations in the method of processing. In all cases, the fresh and peeled cassava tubers are soaked in water and allowed to ferment natural microflora. The part-fermented tubers are removed and re-washed before pulping in a mechanized commercial grating machine before sieving in a coarse sieve to remove fibre. The mash is pressed out to remove the juice with a screw press to get fufu.

2.3.3.9 Cossette

Cossette are dried cassava fermented roots. Cossette, Ikivunde and Inyange are similar products and are most popular in Burundi,

15 FAO, 2013.

Democratic Republic of Congo, and Rwanda[16]. Cossette are prepared by soaking or immersing whole or peeled fresh cassava (mainly the bitter one) in a stream or stationary water for three up to six days to eliminate the toxic glycoside in bitter varieties. The fermented roots are then taken out, peeled and sundried. The dried cassava roots, called cossette, are pounded and milled to yield fermented cassava flour which can be used for the manufacture of secondary products, such as donuts and cake, obtained by frying a dough made with flour mixed with wheat flour.

2.3.3.10 Tapioca

Tapioca, is a hard whitish substance, processed from cassava and eaten both as snack or a full meal. Tapioca refers to roasted cassava starch made from partially gelatinized cassava starch through application of heat treatment to moist starch in shallow pans. Tapioca grits appears as flakes or irregularly shaped granules, which is usually soaked and cooked in water and sugar / milk added.

The steps involved in the processing of tapioca grits from cassava involve; harvesting the cassava, peeling and washing and then grinding with a motorized grinder, thereafter the moisture is sieved through a porous sac. This separates the fibrous and other coarse root material from the starch pulp. The starch pulp is allowed to settle before decanting. The thick starch cake at the bottom of the bowl is pressed to remove water. This is passed through a screen to produce coarse-grained moist starch flour. The solid produced after sieving is fried in a big pan. The fried sample is then subjected to either of the drying technique (gas flared or firewood).

2.3.3.11 Chikwangwe

Chikwangwe, a convenient food product which was available in ready-to-serve form[17]. Whole roots are immersed in water (streams, puddles, or in a container) for 3 to 5 days, while they soften and ferment. They are taken out of the water and peeled. Fibres are removed from the pulp by sieving in water using a basket, fibre bag, or perforated metal bowl. The mash is squeezed in a fibre bag to reduce water content; it is ground until fine, wrapped, and steamed. Sometimes peeling is done before soaking, which improves the attractiveness of the end product but makes it more expensive because fresh roots are harder to peel than soaked ones. This product is ready to eat without further cooking. Uncooked paste is made in a similar way to steamed paste but without cooking, and so it must be steamed before it can be eaten.

2.3.3.12 Gari

Gari is a granulated and toasted cereal-like cassava food product which is convenient for consumption in urban environments because it is in a ready-to-eat form and it has an extended shelf life. The production process involves selection of cassava tubers, peeling, washing, grating, dewatering and fermentation, sieving, frying, cooling / drying, sieving and packaging.

2.3.3.13 Lafun

Lafun is a fine powdery fermented product of cassava that is commonly consumed in the Western states of Nigeria. Peeled cassava roots are immersed in water for 3–5 days during which the fresh tubers undergo fermentation and become soft. The softened tubers are mashed manually, the wooden fibre removed and the mash dewatered. The dewatered mash is sun dried on mats, concrete floors, racks or any other appropriate site for 1–3 days depending on the weather. The dried crumbs are milled into flour which is referred to as lafun flour. It is prepared, before eating by reconstituting the flour in boiling water with constant stirring until a smooth thick paste is formed.

2.3.3.14 Cassava Snacks

According to IFAD and FAO (2005), cassava is often not used for food manufacture in Africa because food products made with 100 percent wheat flour are cheaper and preferred by consumers. Sustained investment in research and development on industrial manufacture of African cassava food products such as gari, attiéké and Chikwangwe which have snack values can lead to the increased use of cassava in food manufacturing industries.

16 Flibert, et al., 2016

17 COSCA, 2000

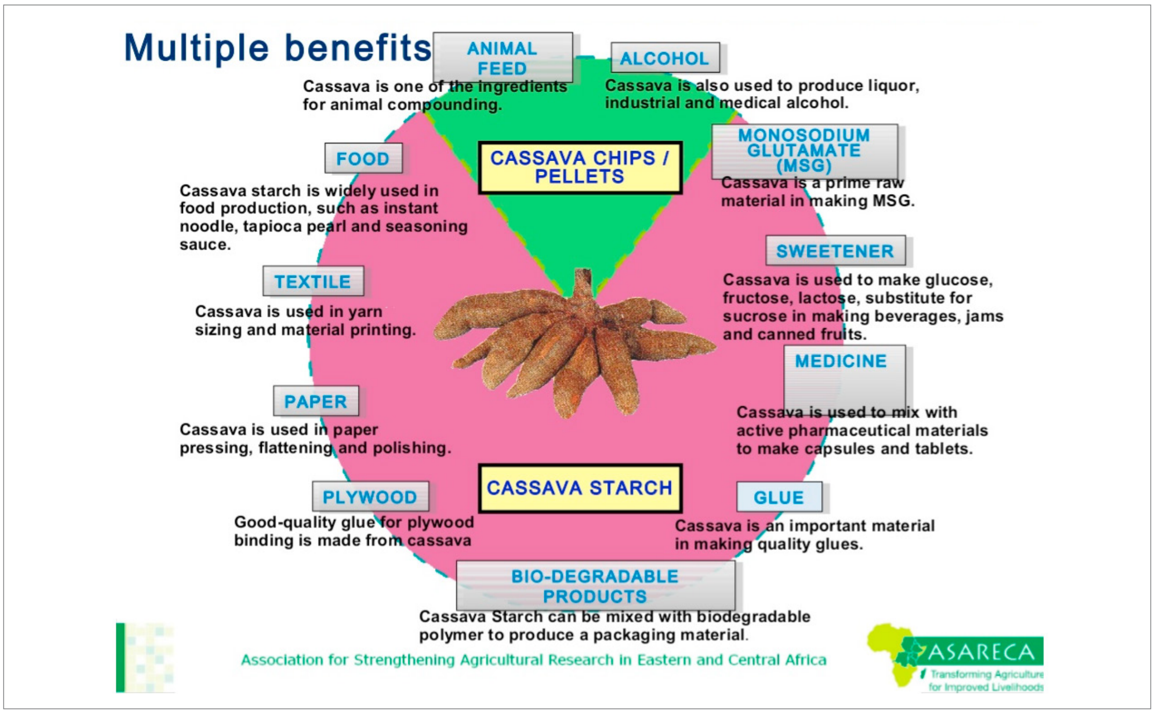

Figure 5: Industrial Uses of Cassava. Adopted from ASARECA (2015)
Adopted from Henry, Westby and Collinson, 1998.

A variety of cassava snacks exist. This may be made by frying or roasting cassava with or without other ingredients to make them tasty and shelf stable. The most common are Cassava crisps and cassava chips.

Cassava crisps are thin slices of peeled and washed cassava roots deep-fried until crunchy and light yellow to golden brown in colour[18]. Fried cassava chips are pieces of fresh cassava roots that are deep fried and may be packaged.

The variety of products from cassava roots is unlimited as different communities use different methods to produce products that have varied properties. Moreover, small scale enterprises always innovate new products.

2.3.4 Tertiary products

2.3.4.1 Cassava-derived Value Added Products

Cassava value added products such as chips and starch can be used to derive tertiary products such as animal feeds, food, glucose, sorbitol and alcohol. Cassava derivatives are used in foods industry (bakery, brewing and distilleries, confectionary), paper, plywood and textiles industries, animal feeding, plastics and packaging industries, pharmaceutical and cosmetics industries, and energy industries for biofuel for motor vehicle and industrial processes. Cassava starch can notably perform most of the functions where maize, rice and wheat starch as well as sugar cane are currently used.[19] Figure 5 shows various industrial uses of cassava products.

A variety of products can be made from cassava. Table 5 shows a summary of cassava derivatives used in food industry.

2.3.4.2 Cassava Ethanol

Cassava ethanol can be produced from fresh cassava roots, dried chips, cassava flour, cassava starch and / or from cassava pulp- by-product of cassava starch production. Cassava is a high potential ethanolic fermentation substrate due

18 EAC , 2010.
19 Tonukari, 2004.

Category	Description & examples
Bakery products	Biscuits, Bread, cakes, buns, cookies and doughnut etc.
Confectioneries	As dextrose and glucose syrup for sweetening confectioneries. As modified starches for manufacturing candies e.g. jellybeans, toffee, hard / soft gums, boiled sweets (hard candy), fondants, Turkish delight. Starch as dusting on sweets to prevent sticking together. Dextrose prevents crystallization in boiled sweets and reduces hygroscopicity in the finished product.
Canned fruits, jams and preserves.	As dextrose or SO2-free glucose syrup to emphasize the natural flavour of processed fruit and reduce crystallization tendency of sugar
Monosodium glutamate (MSG)	MSG is made with cassava starch and molasses for use as a flavouring agent in meats, vegetables, sauces and gravies.
The production of commercial caramel	MSG is made with cassava starch and molasses for use as a flavouring agent in meats, vegetables, sauces and gravies. Glucose as cheaper colouring agent for food, confectionery and liquor instead of sucrose as flavouring.

Table 5: Categories of Food Products Made from Cassava and Its Derivatives
Source: Balagopalan, 2002.

to its high starch level, low ash content and small particle size of the lignocellulosic fibres.

Cassava is one of the richest fermentable substances for the production of absolute alcohol for industrial use and for alcoholic beverages such as wine and beer. The fresh roots contain about 30 % starch and 5 % sugars, and the dried roots contain about 80 % fermentable substances, at par with rice as a raw material. Leading producers of alcohol such as Malaysia and Brazil have factories set up use cassava as the raw material.

2.3.4.3 Polylactic Acid, a novel material

Polylactic acid (PLA) or polylactide is a thermoplastic aliphatic polyester derived from renewable resources, such as corn starch (in the United States), cassava roots, chips or starch (mostly in Asia), or sugarcane (in the rest of the world). PLA can be made from large industrial facilities that make other products such as ethanol. Because of this, it is the cheapest source of bioplastic. PLA is used in:

- Food packaging as it is generally recognized as safe (GRAS). Its commonly used to produce plastic bottles, utensils, and films
- Healthcare and medical industry as it is biocompatible. It's used in the production of biomedical and clinical applications, in bone fixation devices, such as screws, plates, surgical structure and meshes, and drug delivery systems. It is important for PLA for use in this field to have a high standard for purity.
- Structural applications as it is cheap. It is used to in the construction industry as, for example, foam for insulation, fibre used in carpets, and in furnishing.
- Textile industry due to its breathability, lower weight, and recyclability, among others.
- Cosmetics industry due to its impact on environment it is used packaging

Because PLA is a material that is used to make different types of products that cut across different industries, its standardization would be naturally generic to provide industry with minimum requirements for the material. At international level a standard has been issued by ISO i.e. ISO 17088 (Specifications for compostable plastics). As Africa is the largest producer of cassava and has been found to produce the best PLA, it is high time to move the use of this material to a higher level. In this regard, the absence of a standard on the purity of PLA is regarded as a gap.

The use of PLA in 3D printing is possible through the standardization of products that could be made from PLA materials. For example, food packaging[20] [21], bicycle parts[22] and medical devices. PLA is one of the preferred materials for 3D printing of medical applications due its excellent mechanical and biodegradable properties, ready availability and lower cost[23]. These products are evaluated in accordance with standards[24] and regulatory requirements for such products.

The most important industrial utilizations of cassava are cassava chips, high quality cassava flour (HQCF), ethanol, starch, biofuel, flour, biscuits, bread, jelly, thickening agents, gravies, custard powders, babies' food, glucose, and confectioneries.[25] [26]

Cassava chips are often used in production of animal feed or exported, as they are a more stable intermediary product than fresh cassava, which spoils within 24–48 hours after harvest if not dried or processed. High-quality cassava flour (HQCF) can be blended with wheat flour for making bread, biscuits, snacks and pasta. Starch is extensively used in the food & beverage industry, as well as in pharmaceutical, textile, adhesives, paper, plywood, and other industries. Ethanol is commonly used in production of alcoholic spirits, can be used for sterilization in pharmaceutical and industrial use, and can also serve as a fuel for cooking or blending with gasoline in vehicles.

2.4 Cassava Value Chain Product Exploitation

2.4.1 Introduction

A case study of three countries, Nigeria / Ghana, Uganda and Zambia was conducted to examine the extent of exploitation of cassava products.

2.4.2 Nigeria

In Nigeria (Similar to Ghana) cassava is processed and consumed in different ways, in different countries. Below are examples:

- Consumed as fufu – locally called Akpu or fufuoo (Nigeria, Ghana & DRC)
- Consumed as cassava starch, locally called Owo in Delta State, Nigeria
- Consumed as gari- (different qualities and colour. There are some that have sharp sour taste and low moisture and some whose taste is not sour but also with very low moisture. Gari also has different colours majorly Red and White). Gari is consumed in most of West Africa (Nigeria, Cameroon, Sierra Leone, Benin, Togo a Ghana).
- Consumed as cassava snacks (Nigeria and Ghana) as illustrated below;
  - Akara jojo is a snack from gari which is fried and are made into balls.
  - Kpokpo gari is cassava processed by cooking, slicing and drying to a level that it is believed to have very low starch content. The moisture level is also very low which makes it very crunchy.
  - Nsisa / Abacha / Tapioka is sliced cassava that is dried. It can be consumed dry or made into a delicacy by adding some vegetables

20 Ibrahim, Saber and El-Khawas, 2019

21 Jiménez et al., 2019

22 Tanikella et al. 2016

23 Tappa, and Jammalamadaka, 2018

24 www.iso.org

25 Echebiri and Edaba, 2008.

26 Anonymous, 2015.

and pepper sauce. Nsisa is now an acceptable dish for all tribes in Nigeria because it is good for persons that want to maintain balanced eating habits and at a cheap cost. It is prepared with sliced locust bean and served in big hospitality establishments.

2.4.3 Uganda

In Uganda the main cassava and cassava product uses[27] are the following:

- Traditional food (derived from artisanal techniques); cassava root (raw, boiled, roasted), cassava chips, cassava crisps, cassava flour, cassava-cereal mixed flours, cassava leaves and pan cakes (Kabalagala)

- Industrial Food for Human Consumption; High-quality cassava flour (HQCF), cassava beer, biscuits, bread and composite flour

- Animal feeds (incorporated into industrial stock feeds as a substitute for maize; cassava peels, cassava chips and cassava pellets

- Non-food industrial uses; ethanol, textile uses, paper and pulp and plywood uses

2.4.4 Zambia

In Zambia, according to government cassava sector development strategy[28] documents, cassava is processed in four main categories as follows:

Industrial food for human consumption. Fresh cassava, dried chips and flour are used as substitutes of mainly wheat and maize, both in industrial baking and small scale retail business. Main products are biscuits, muffins, processed leaves (for example soups) and cassava flour for home baking (either pure or mixed with wheat).

Animal feeds. Peels, dry leaves, and dried root chips are incorporated into industrial stock feeds. Cassava is used in the animal feed industry as a substitute of mainly maize in mixed feeds formulas.

Industrial uses of non-food based products. Dried root chips and flour are used by different manufactures, such as the paper and card box, glue and wood industry, as a substitute for maize and corn starch.

Artisanal food. Raw and processed cassava (dried chips, flour, grates) of both sweet and bitter varieties offer an alternative to maize and wheat as sources of carbohydrates. In addition to the latter, low starch content products derived from artisanal techniques could be used to explore the nutraceutical industry.

2.5 Gaps in the different Qualities of Cassava

2.5.1 General

This study reviewed the different cassava products production, processing, consumption and other industrial applications and noted concerns on quality to assess the gaps between the expectations of users and the available products.

2.5.2 Production

Limited use of high-quality inputs has been a key impediment to growth of the cassava sector, as the major reason for low yields of between 8 MT–12 MT per hectare compared to trial yields in Ghana of reach 20 MT per hectare and above. This is reported in Ghana, Mozambique and Nigeria[29]. Farmers tend not to use improved inputs because they are expensive, and without strong offtake opportunities they do not see economic incentives to increase productivity. Low productivity is a constraint to commercialization because it drives high costs of sourcing raw material and problems securing sufficient supply. There is also lack of awareness among both input suppliers and of farmers about improved inputs with a notable

27 NARO and NACRI

28 GRZ, 2010

29 Anonymous, 2015

weak link being between research and development, and the inputs and production stages of the chain[30]. Improved production technologies and relevant inputs, appropriate technologies for the mechanization of processing and packaging are needed[31].

2.4.3 Processing

Cassava is mainly traditionally processed. For example, the traditional method of grating and milling cassava is by pounding it in a mortar with a pestle while peeling, cutting and other size reduction techniques are performed using a hand knife. Similarly drying is predominantly by sunshine, dry frying, smoking or roasting while preservation is undertaken using fermentation. Most methods involve the use of kitchen tools for peeling, cutting roots to chunk / chipping, slicing, soaking in water (e.g. Zambia) or heaping fermentation (e.g. Tanzania), sun- or smoke-drying, milling, and sieving. Others are frying, dehydration by pressing, sedimentation, decanting, and or cooking, boiling, or steaming. Due abundance of sunshine, sundrying is done virtually on any surface in the open air such as a large flat rock in the field, on the shoulders of a paved road, on flat roof tops, in a flat basket, or even on bare ground.

The methods have been influenced by the availability of sunlight, water, fuel wood and wage rates. There is regional variation in cassava preparation methods in Africa. Because of variation of the traditional methods, there are challenges with consistency, quality, shelf life and ability to produce large quantities of the products for marketing.

There is a need to identify, develop and diffuse the best practices from one region to other regions within Africa. There is a need to develop technologies and equipment to mechanize production, processing methods to facilitate production of quality products at right quantities. The use of mechanized graters, pressers and ills is relatively common in some countries Benin, Congo, Côte d'Ivoire, Ghana, Nigeria, Tanzania and Uganda and is reported to improve the efficiency of the cassava processing[32].

The traditional processing methods produce poor quality products; thereby pose major challenges to utilization and marketing of cassava[33]. During the wet season and in areas with high rainfall, drying of chips is often inadequate, causing quality deterioration in storage.

Cassava processing, in most of Africa, is plagued with unhygienic processing methods, including a lack of technologies for adequate drying throughout the year, sun-drying on bare earth floors, inefficient storage and lack of packaging, all leading to huge storage losses, poor quality and often unsafe products. Poor quality of cassava products such as dried chips and flour (HQCF)[34] hinder uptake of the same as a raw material into several industrial uses.

Enquiries made from some pharmaceutical companies in Nigeria and Ghana showed that cassava starch produced locally in these countries, does not meet the requirement specified in the British Pharmacopeia, hence they import from China. Information from a technical report from Natural Resources Institute UK and Food Research Institute Ghana prepared from 1996–1999 on starchy agricultural produce including cassava showed that cassava starch from these countries did not meet the high quality specifications in terms of purity and microbiological limits.

Ultimately, production of this high quality cassava product depends on post-harvest handling right from the farm and the subsequent stages that lead to eventual processing of cassava into products. Regulators and industrial users, especially multinationals, demand quality products but little efforts have been made to support smallholder farmers and processors.[35] [36]

30 DIMAT, 2015

31 Abass et al. 2013

32 IFAD and FAO, 2005.

33 Abass, 2008.

34 DIMAT, 2012.

35 GRZ, 2010.

36 Otekunrin and Sawicka, 2109

The marketing systems including transport infrastructure for the cassava commodities are either lacking, insufficient or inefficient at all levels, starting from bulking of harvested cassava to handling, transporting, storage, processing, wholesaling and retailing. The lack of standards for cassava products makes grade-based pricing impossible. Although there exist some standards to ensure quality of cassava products, they are seldom enforced to the detriment of market demand[37].

Between 2003 and 2007, national institutions particularly in Madagascar (FOFIFA), Mozambique (IIAM), Tanzania (TFNC), Uganda (NARO) and Zambia (ZARI) involved in the CFC small-scale cassava processing project coordinated by IITA and worked with the national bureaus of standards to develop standards for example for flour, chips, starch and rale (gari) in the various countries[38].

Major technical constraints still exit in the area of equipment manufacture in the region, particularly regarding availability of cassava dryers, chipping discs, engines and good quality materials for machine construction – all of which are still imported. The limited expertise for the manufacture of these processing machines limits access to them by farmers and processors. In addition, expertise for equipment maintenance is lacking in most localities[39].

The biggest culprit of poor quality is contamination with foreign materials and **Escherichia coli**[40]. Fungal growth and presence of mycotoxins, moisture content, particle size in case of flour and nutritional aspects and generally developing an enhanced 'quality culture' in different sectors are also of concern,[41]. Inconsistent quality and supply or low volumes of end products subsequently discourages end-users from switching their inputs – which are largely imported today – to an alternative product made from cassava[42]. This is one important barrier to overcome in increasing the demand for local starch in improving quality to meet the needs of certain end-users, for example those requiring food-grade and pharmaceutical starch.

An improved operating environment, increased awareness among producers, and an endorsement by a standards body on the benefits of using cassava flour would support growth in demand toward an estimated 6 000 MT by 2020[43]. Ensuring standards are available for the most marketable products will promote adoption and us of such products. In addition, robust quality assurance activities including certification, testing and enforcement will further assure users of commitment by regulators and producers to support them and protect efforts.

2.4.4 Consumer Perspective

According to Abass (2008)[44], cassava still suffers from many myths and half-truths ranging from its being perceived as not nutritious, a poor man's food, and a potentially poisonous food. Other negative perceptions of cassava still prevail in terms of quality, consistency, and impact on product both from technical and marketing perspectives. Many in the milling industry have negative experiences of cassava and those views are quite embedded. These have negative consequences on cassava product and their marketability. However, all these problems are avoidable with a wider dissemination of appropriate cassava processing techniques and quality assurance checks.

Similarly, a report by Kilimo Trust (2020) records that the use of cassava flour in the baking is hampered in Uganda by inefficient market supplies, lack of quality and standards and poor image of cassava especially among urban

37 DIMAT, 2012.
38 Abass, 2008.
39 Abass, 2008.
40 DMAT, 2015
41 Abass, 2008.
42 Anonymous, 2015.
43 Anonymous, 2015.
44 Klein et al.2013.

consumers. This will also require introduction of grading and standards of the flour and the chips from which the flour is milled[45]. In a related study by McNulty and Oparinde (2015)[46] in Nigeria, the authors note, the quality certification system for cassava in Nigeria is weak and poorly enforced. There are Cassava Trade Shows and National Cassava Fair award prizes for quality, but there are no quality labelling systems recognizable by consumers. On the other hand, most of the interested buyers also complain that production areas are far or that price is high due to high transport charges but most importantly that there is not sufficient production at the required volumes, quality and consistency.

In Zambia, a government strategy document[47] indicates that there is a lot of cassava risk aversion in the industry due to the perceived lack of quality, volume and consistency in supply. The aversion to investment in cassava is also related to fact that the whole sector and industry have limited knowledge in cassava processing and product development as well as limited information on market opportunities and on how to reduce costs by substituting maize inputs and starches with cassava.

It is worth noting that consumers have the most important say on both quality and price for cassava products. In a study conducted in Uganda[48] to understand the opportunities for marketing roots with extended shelf-life, the majority of consumers (72 %) reported that having fresh cassava roots with extended shelf life (over seven days) was acceptable to them, while 61 % expressed the interest to learn more about the shelf life extended cassava roots. About 15 % of consumers expressed concerns about the likely higher cost of these roots.

Therefore, the role of quality infrastructure in improving the quality of cassava and cassava products, including promoting the adoption technologies for production, processing and other handling methods and opening markets of these products is well cut out.

45 Kilimo Trust, 2012.

46 McNulty and Oparinde, 2015.

47 GRZ, 2010.

48 Waigumba et al. 2016.

3 ROLE OF QUALITY INFRASTRUCTURE IN THE CASSAVA VALUE CHAIN

3.1 Overview

The cassava value chain takes a variety of inputs and generates a multitude of products. The quality and safety of inputs, outputs and the related services is the subject of regulations and standards to ensure consumer and environment safety and health; and that trade is fair and vibrant. The elements of quality infrastructure i.e. standards, metrology, conformity assessment (activities including testing, certification, calibration, verification, inspection) and accreditation) are discussed in section 3.2. The status of the quality infrastructure in the cassava value chain is discussed in section 3.3. Furthermore, the status of the quality infrastructure is discussed at three levels i.e. national regional and international. Finally, following the value chain sequence, the main factors influencing cassava product quality and safety are briefly discussed and the standards relevant to the section are listed and discussed.

Availability of credible testing, calibration, inspection, verification and certification services for cassava and selected cassava products in three sampled countries was reviewed in detail with a view to identifying existing gaps that may affect the competitiveness of cassava value chains and limit trade within African countries.

3.2 Elements of Quality Infrastructure in Africa

3.2.1 Standards and Technical Regulations

Standards serve several purposes. Standards define safety and quality characterizes of products and information necessary for consumers or users of the products. In the cassava sector standards help define the characteristics of inputs, processes and products. This will ensure that products are safe and protect the safety and health of consumers. Standards for cassava and related production inputs and products will specify limits for undesirable constituents such as contaminants, limits for desirable components such as nutrients and provide packaging and labelling information. Standards and / or technical regulations will facilitate production and distribution of products; enable regulators to protect consumers and open markets for producers. National standards bodies are responsible for formulating standards in countries and represent their countries in regional and international standards developing organisations to harmonize or develop regional or international standards. Regulators / specifiers are responsible for formulating technical regulations, incorporating standards or parts thereof, in their regulations. Harmonization of standards and technical regulations can facilitate trade across borders. Standards and technical regulations facilitates trade across borders. Standards in the cassava sector cover both those that fall under technical barriers to trade (TBT) and Phytosanitary (SPS) measures.

3.2.2 Testing Services

Testing is the determination of a product's characteristics against technical requirements in standard or technical regulations. Testing laboratories help show that a product or process satisfies technical requirements. Manufacturers may need the technical help of independent testing laboratories either for developing new products or at the marketing and export stage. This facilitates innovation by allowing producers to verify products before launching them in the market.

Safety hazards in poor quality products that consumers cannot identify by are exposed through proper testing. This helps protect consumers' safety, health and the environment. Testing laboratories are therefore essential for policy makers as a basis for their policy decisions and for producers to facilitate their activities.

Testing laboratories require competence to conduct tests. This can be attained by acquiring suitable equipment, training of personnel and implementing credible standards. Accreditation to international standards helps laboratories demonstrate their competence so that their test certificates are recognized in and outside their territory.

For the cassava value chain in Africa, access to testing against physical, chemical, and microbiological requirements and the credibility and recognition of test results across the African continent is essential to facilitate free trade in cassava and cassava products across the borders.

3.2.3 Certification

Certification which is an attestation that a product or process meets requirements in standards or regulations is an important element of quality infrastructure. Certification may be undertaken by the customer (first party), the customer representative (second party) or an independent organization (third party). Third-party certification allows buyers on one side to trust the quality of suppliers on the other side. This creates transparency in the market, promotes quality and makes it easier for firms to compete on the basis of quality.

The most common certification schemes in the market include product certification and quality, environment and food a safety management system certification.

Certification bodies (CBs) require competence to conduct certification. This can be attained by operating credible systems including competent personnel. Implementing and getting accreditation to international standards helps CBs demonstrate their competence and gain recognition in and outside their territory.

Cassava production, processing and distribution of inputs and products can benefit from a robust certification infrastructure.

3.2.4 Measurement and Legal Metrology

A national metrology institute (NMI) establishes the national measurement system used to maintain, develop, and diffuse measurement standards for basic units and to diffuse metrological expertise throughout the economy. NMIs also develop and produce higher-order calibration reference materials (CRMs), and coordinate or conduct proficiency testing schemes. NMIs demonstrate competence through ensuring their measurements systems are traceable to international standards and their laboratories implement international standards. Accreditation of the laboratories demonstrates this competence and enable certificates to be recognized internationally. NMIs cooperate at regional and international levels through RTAs, FTAs or MRAs.

Measurement standards and their supportive metrology infrastructure play an important role in industrial competitiveness. An internationally recognized metrology system relies on modern equipment and sound technical skills.

Legal metrology ensures that the quantity one gets in trade are correct. Legal metrology ensures producers use accurate measures to dispense products. Verification a process used to ascertain the accuracy of measures used in trade is an important function of legal metrology. The verification of equipment ensures that both the seller and the buyer are not cheated. This function undertakes verification of measuring equipment such as weighing scales, fuel pumps and water or electricity meters.

3.2.5 Calibration

Calibration, a process through which the high-level measurement standards of NMIs are diffused throughout economies, determines the relationship between an instrument's input and the magnitude of its output. Calibration is important to disseminate the measurement capabilities to industry in support of the work of NMIs.

3.2.6 Market surveillance, Inspection and Enforcement

Market surveillance, inspection and enforcement authorities ensure the implementation of standards and technical regulations aimed to uphold the main role of standards in ensuring safety and health and preventing deceptive practice whether products are imported or locally produced.

Market surveillance, inspection or enforcement is conducted on products that fall within the scope of a technical regulation at the moment of being placed on the market and may include visits to commercial, industrial, and storage premises; work places; and other places where products are put into service or on the market.

There are many approaches to this including formulating technical regulations, incorporating standards or parts thereof, which producers have to comply to. The authorities then conduct inspection and market surveillance to ensure products meet the requirements. Authorities may require conformity assessment including testing, verification and certification of products before marketing. The institutional arrangements for performing these activities also vary worldwide from having a single national authority conducting all activities to a multitude of them each dealing with a specific scope. These activities may also be delegated to conformity assessment bodies supervised by authorities. Such authorities or bodies they delegate to provide conformity assessment activities to require competence to conduct activities. This can be attained by implementing international standards (e.g. ISO / IEC 17029). Accreditation to international standards helps these authorities demonstrate competence so that their results / reports are recognized within and outside their territory.

Market surveillance inspection and enforcement authorities cooperate at regional and international level through equivalence agreements or FTAs, RTAs or MRAs.

For cassava value chains in Africa to benefit from standards, metrology and conformity assessment infrastructure market surveillance, inspection and enforcement will need to be integral to the systems. This means that regulators are an essential group of stakeholders.

3.2.6 Accreditation

Accreditation is the last level of quality control in conformity assessment services because it can provide credibility to conformity assessment services, so that their services are recognized and respected throughout the economy and abroad.

Accreditation bodies provide independent attestation as to the competency of an organization or individual to offer specified conformity assessment services i.e. testing, certification, calibration, verification or inspection bodies. Accreditation bodies may operate within one economy of in multiple economies (multi-economy accreditation bodies).

Accreditation bodies may cooperate at regional level through MRA's to facilitate the acceptance of conformity assessment results; help harmonize, interpret, and implement accreditation standards and guidelines and support their members in capacity building and peer assessment processes linking them to international forums.

Cooperation between accreditation bodies occurs at regional and international level through membership to regional or international accreditation cooperation arrangements i.e. regional or international MRAs.

3.3 Status of Quality Infrastructure for the Cassava Value Chain

3.3.1 General

From the perspective of Intra-Africa trade international under the RTAs, AfCFTA and WTO countries are expected to participate in regional and international quality infrastructure activities and implement regional and international standards. The use of International standards is preferred to national standards. However, where international standards do not exist, countries are expected to develop national standards based on science to avoid unnecessary barriers to trade. When standards are based on science one would expect that standards between countries would aim at the same objective e.g. safety of products and be similar in those provisions relevant to meet the objective.

The above expectations cover standards, technical regulations, metrology, conformity assessment procedures and Sanitary and Phytosanitary measures. Implementing regional and international standards for products and conformity assessment procedures demonstrates commitment to reduce unnecessary barriers to trade.

In the following sections, detailed analysis of the status of standards, technical regulations and conformity assessment in Africa in general with a case study of three countries i.e. Nigeria, Uganda and Zambia was conducted to identify gaps in meeting the above expectations.

3.3.2 Quality Infrastructure at National Level

Each of the countries studied- DRC, Ethiopia, Ghana, Mozambique, Nigeria, Uganda and Zambia has an NSB, conformity assessment bodies and regulatory bodies with different configurations. Regulatory bodies implement compulsory standards and other technical regulations. To illustrate the status, in relation to cassava and cassava products, we enquired into three Countries-Nigeria, Uganda and Zambia, in detail.

In Nigeria, the NSB, SON undertakes the development of standards, conducts conformity assessment activities and undertakes inspection and enforcement of standards. The National Metrology Institute (NMI) in SON is responsible for Scientific Metrology while the Weights and Measures Department (WMD) of the Federal Ministry of Industry, Trade and Investment (FMITI) oversees the formulation and implementation of policies for Legal Metrology. In addition to the three institutions, there is the Nigerian food and drugs administration and control (NFDAC) that is responsible for food control. Under the NFDAC legislation, certain food products are controlled and must be registered before marketing.

In Uganda, the mandate of UNBS covers standards development, metrology including legal metrology and enforcement of standards. Although there is a Food and Drugs law in Uganda, the current implementer, National Drugs Authority (NDA) does not regulate food. Discussion are ongoing to provide for NDA to control food products.

In Zambia, standards development, conformity assessment and metrology are under ZABS; legal metrology is under the Zambia Weights and Measures Agency while enforcement of standards is under the Zambia Compulsory Standards Agency. There is also the Food and Drugs Act with two statutory bodies-the Food and Drugs Board and the National Food and Nutrition Commission operating in the food space.

It is adequate to note that the technical regulatory space for food including cassava and cassava products varies between countries and could be complex considering the whole continent.

3.3.3 Regional Economic Communities (RECS)

African countries cooperate under one or more of the several RECs- CEN-SAD, COMESA, EAC, ECCAS, ECOWAS, IGAD, SADC and UMA.

A majority of the countries in this study, also cooperate at the level of RECs (EAC-Uganda), SADC (DRC, Mozambique and Zambia) and ECOWAS (Nigeria and Ghana). 7 RECs (EAC, SADC, COMESA, UMA, ECCAS, ECOWAS and IGAD) are recognized by the AU.

COMESA, EAC, ECOWAS, IGAD and SADC have quality infrastructure programmes. EAC for example, has harmonized more than 1530 standards including 1079 adopted International Standards. EAC has also harmonized standards for cassava and cassava products.

African countries also run variety of conformity assessment cooperation arrangements under the RECS. For example, EAC also runs a conformity assessment recognition scheme under the SQMT ACT. Under this scheme, laboratories are designated by Partner States and are recognized by other Partners States. Certification marks are also recognized with products certified by any of the NSBs in the region moving freely across borders. This certification may be based on harmonised standards or on national standards where no harmonized standards exist.

Africa NMIs cooperate through the sub regional or regional metrology cooperation e.g. SADCMET[49], SOAMET[50], CEMACMET[51], EAMET[52], MAGMET and NEWMET. This enables members to undertake peer review, participate in proficiency schemes and share resources.

49 SADCMET SADC Co-operation in Measurement Traceability

50 SOAMET – "Secrétariat Ouest-Africain de Métrologie" or the Secretariat of Metrology of UEMOA

51 CEMACMET Organisation de Métrologie de l'Afrique Centrale

52 East African metrology cooperation

3.3.4 Continental Quality Infrastructure

The status of quality infrastructure in Africa is still limited compared to lacking as compared with those in industrialized economies[53]. The level of development of quality infrastructure varies from none or limited to well-developed within the same continent. The process of developing a coherent policy towards quality infrastructure for Africa is under development under the AU.

All Africa countries cooperate at continental level under the AU and aspire to a free trade area under the AfCFTA. The main objectives of the AfCFTA are to create a single continental market for goods and services, with free movement of businesspersons and investments, and thus pave the way for accelerating the establishment of the Customs Union. It will also expand Intra-African trade through better harmonization and coordination of trade liberalization and facilitation and instruments across the RECs and across Africa in general. The AfCFTA is also expected to enhance competitiveness at the industry and enterprise level through exploitation of opportunities for scale production, continental market access and better reallocation of resources.

The PAQI institutions, ARSO, AFSEC AFRIMETs and AFRAC are the quality infrastructure institutions recognized by AU. Membership in PAQI institutions **(Table 6)** is still growing with 39 Member States being members of ARSO, 18 members of AFSEC, 21 members of AFRAC and 46 members of AFRIMETS. Membership to the PAQI institutions need to be addressed to enhance participation of member states quality infrastructure institutions in the activities of the PAQI institutions.

Of the seven countries studied, one is not a member of ARSO or of AFSEC; two are not members of AFRAC. All the seven are member of AFRIMETS.

ARSO has a standards harmonization programme and harmonized more than 500 standards including in cassava value chain. Countries that are members of ARSO contribute to the African Standards harmonisation through being members of the ARSO Joint Advisory Committee (JAG) and ARSO Standards Management Committee (SMC) and participate in technical committee that develop or harmonize African Standards.

Eighteen (18) African countries are members of AFSEC. AFSEC and IEC (International Electrotechnical Commission) have agreed to cooperate in a number of areas, covering, in particular, cross representation and exchange of technical information in the fields of standardization and the development of Electrotechnology. With the assistance of the IEC, AFSEC will develop and harmonize standards based on existing IEC International Standards. Where products are not covered by IEC Standards, AFSEC will work on the development of standards, ensuring they are relevant to African needs, before submitting them for consideration by the IEC. AFSEC has Technical Studies Committees are responsible for identifying and harmonising the standards at the appropriate time in liaison with other international organisations and in accord with the standards market. In addition, AFSEC has Compliance Assessment Committee is the institution in which the practical problems of the methods and tests on the compliance assessment of AFSEC in the fields of electricity, electronics and related technologies are analysed. AFSEC agreement with IEC provides an opportunity to enable African countries have a united front in participating in the activities of IEC including standards development and conformity assessment in the field of Electrotechnology.

ARSO through stakeholders under the ARSO Conformity Assessment Committee (ARSO CACO) has developed the African Conformity Assessment Programme (ACAP) that gives requirements, among others, ACAP 1-1:2017, Regulations – Part 1: General requirements for the certification systems, ACAP 1-2:2017, Regulations – Part 2: Special requirements for the certification systems and standards design, ACAP 1-3:2017, Regulations – Part 3: Requirements for approval of certification bodies and ACAP 1-4:2017, Regulations – Part 4: Requirements for approval of testing and calibration

53 Stephenson, 1997.

laboratories. This program could form basis for regulatory convergence to facilitate approval of products. However, membership to this program, inclusion of regulators and the level of participation in activities and the scope of work may require further examination.

Nineteen (19) African countries are members of AFRAC MRAs through either NAB or multi-economy accreditation body. There are 10 NABs and one multi-economy accreditation body (MEAB) in Africa. In addition, there are two regional accreditation cooperation bodies- West African Accreditation System (SOAC), UEMOA Region: Benin, Burkina Faso, Côte d'Ivoire, Guinea Bissau, Mali, Niger, Senegal, Togo SOAs and CRESAC (Côte d'Ivoire, Benin, Cameroun, Gabon, and Senegal).

Five NABs and one MEAB are signatories to AFRAC MRAS. African Accreditation Cooperation (AFRAC) is recognised by IAF for Calibration and testing (ISO / IEC 17025), Medical Testing (ISO 15189) and inspection: ISO / IEC 17020 and by ILAC for Management Systems Certification (ISO / IEC 17021-1). There is therefore more scope for improved cooperation in accreditation in Africa to offer increased recognition of conformity assessment services for Intra-Africa and international trade.

Forty Six (46) African country NMIs are members of AFRIMENTS. The Principal Members of AFRIMETS are the institutes responsible for scientific and industrial and / or legal metrology that represent their country in one of the sub-regional organizations i.e. SADCMET, SOAMET, CEMACMET, EAMET, MAGMET and NEWMET. AFRIMETS is the official RMO for Africa as recognised by the CIPM. Africa NMIs can participate in the CIPM MRA through AFRIMETS and therefore link themselves through AFRIMETs MRAS to CIPM MRAS / MLA. AFRIMETS have been promoting participation in the CIPM MRA (thus the organs of the Metre Convention CGPM / CIPM / BIPM) since 2006, with great success, taking official participation from six to 15. There is opportunity for more cooperation by African countries under AFRIMETS to promote mutual recognition, including at international level for African measurements standards.

3.3.5 Link to International Quality Infra-structure Organizations

We examined the extent of membership by African countries to international quality infrastructure and related organizations such as the WTO **(Table 6)**.

Fifty four (54) African countries are member of WTO (45 full members and 9 observer members). All 54 have signed AFCFTA. Under the WTO and AFCFTA agreements, these countries are expected to use international standards including in their technical regulation to facilitate trade and not create unnecessary barriers to it. However, in general, the level of participation of these countries in developing international standards is limited due to capacity and financial inadequacies. The most prominent quality infrastructure organization include Codex, IEC, ISO, BIPM, OIML, IAF and ILAC.

Many African Countries as well as RECs, including ARSO adopt International Standards. Countries cooperate under BIPM ILAC and IAF to ensure their measurements and conformity assessment systems gain international recognition.

All Africa countries are members of the CAC by virtue of membership to the UN. CAC is a UN organ being a programme created between the World Health Organization and Food and Agriculture Organization of the United Nations to develop international food standards. 40 countries are members of ISO; 26 full members and 14 correspondent members. This leaves out 15 African countries. ISO has issued more than 23 000 international standards that are used globally. Membership at the IEC is limited to only 10 countries with only four full members and six associate members. Access to IEC standards is very restrictive to members.

In the area of metrology, 25 members are members of OIML, 10 full members and 15 associate members. Similarly, only 15 African country NMI have membership to the International MRAs in measurements through membership to BIPM (10 State Members and 10 Associate Members). This leaves 40 African countries outside the arrangements for linking national to international measurements standards. The BIPM is the primary intergovernmental organization established by the Treaty of the Metre Convention and under the auspices of the CGPM. A committee of CGPM, the CIPM representing 60 Member countries and 42 Associates; is responsible for the International System of Units (SI). It has the responsibility of ensuring that the SI is widely disseminated and modifying it as necessary so that it reflects the latest advances in science and technology. The CIPM Mutual Recognition Arrangement (CIPM MRA) is the framework through which National Metrology Institutes demonstrate the international equivalence of their measurement standards and the calibration and measurement certificates they issue. The outcomes of the Arrangement are the internationally recognized (peer-reviewed and approved) Calibration and Measurement Capabilities (CMCs) of the participating institutes.

The CIPM Mutual Recognition Arrangement (CIPM MRA) is the framework through which National Metrology Institutes demonstrate the international equivalence of their measurement standards and the calibration and measurement certificates they issue.

NMI can join the CIPM MRA directly by becoming state parties to CGPM or by becoming an Associate member of CGPM and joining a regional metrology organisation. This link has enabled addition 10 African countries to join the CIPM through AFRIMETS. This brings the total number of African countries having measurements systems linked to international measurements systems to 15 out 55 countries **(Table 6)**. The gap is still glaring!

On the other hand, regarding conformity assessment, the two bodies responsible for international MRAs for recognition of conformity assessment results are ILAC and IAF. 21 African countries are members to ILAC MRAs while and 32 countries are signatories to IAF MRAs. 14 of the African countries have access to ILAC MRA for a limited scope in through a multi-economy accreditation bodies: SADCAS. 22 in IAF MRAs have access through a multi-economy accreditation bodies (SADCAS and SOAC)[54] although members of SOAC are not yet admitted. These countries have their conformity assessment systems linked to international MRAs hence have international recognition and acceptance of conformity assessment results.

The ILAC MRA links the existing regional MRAs / MLAs of the Recognised Regional Co-operation Bodies such as AFRAC. For the purposes of the ILAC MRA, and based on ILAC's evaluation and recognition of the regional MRAs / MLAs, ILAC delegates authority to its Recognised Regional Cooperation Bodies for the evaluation, surveillance, re-evaluation and associated decision making relating to the signatory status of the accreditation bodies that are ILAC Full Members (ILAC MRA signatories).

Similarly, the IAF MLA relies heavily on the MLAs of Recognised Regional Accreditation Groups such as the European co-operation for Accreditation (EA), the Asia Pacific Accreditation Cooperation Incorporated (APAC) and the African Accreditation Cooperation (AFRAC), as it is these groups that perform the majority of the peer evaluation activity, not the IAF. The role of AFRAC in linking Africa conformity assessment systems to ILAC and IAF is noteworthy.

The membership to international quality infrastructure varies between countries. Some of the challenges to attaining membership are limited financial resources. In addition, limited technical capacity reduces ability to participate in the activities. There is also the challenge of a multitude of organizations to which countries are expected to be members and which comes with the need to pay membership fees. This scenario is still evident at international level and is similar at regional. This scenario calls for better cooperation and coordination among international and regional quality infrastructure organizations. Among those that are members the level of participation is limited. This translates to limited access to international standards, recognitions and capacity building opportunities afforded by such organizations with development partners for example international partners such as STDF program under the WTO.

54 https://www.iaf.nu//articles/IAF_MEMBERS_SIGNATORIES/4

There are areas where international standards have gained global popularity such that countries almost have no option but to adopt and promote the use of such standards. These areas include International Standards such as Food safety management (ISO 22000) and Hazard Analysis Critical Control Point (HACCP) Principles, Environmental Management (ISO 14001) Quality Management System (ISO 9001) and the area of conformity assessment where standards such as 17020, 17025 and 17065 are globally used. In such cases, African countries no longer have options but to cope with the demand for implementation of these standards to demonstrate competence or conformance to requirements.

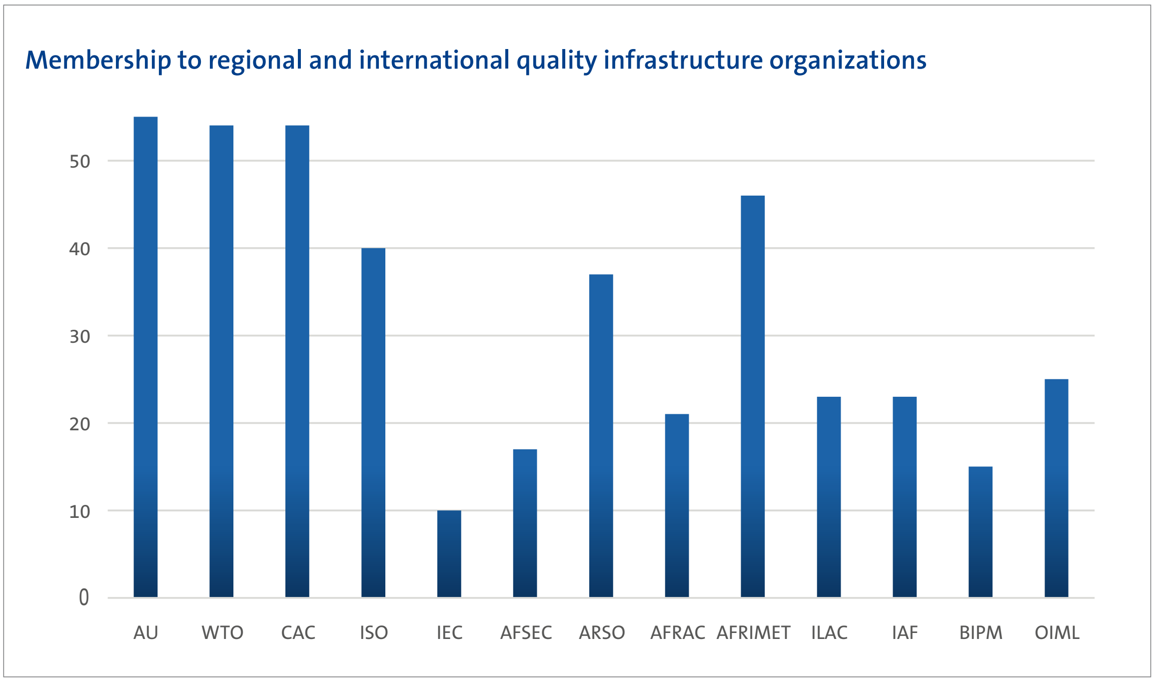

Figure 5a: Representation of Africa countries in regional and international quality infrastructure organizations
Source: Various websites

All the seven countries are members of international standards organizations (Codex, ISO and IEC) **(Table 6)**. However, like is a general situation in Africa, the level of participation of these countries in developing international standards is limited due to capacity and financial inadequacies. This means that these countries have to adopt international standards without having much influence on the content or the suitability of the standards for implementation. Adopting international standards for test methods for example has implications on the kind and cost of equipment and reagents for conducting tests. Countries are however expected to conduct test using such standards as a way to ensure results are accepted in the global market.

Country	Membership / or representation in regional / international organization												
	AU	WTO	CAC	ISO	IEC	AFSEC	ARSO	AFRAC	AFRI-METS	ILAC	IAF	BIPM	OIML
Algeria	x	x	x	x	x		x		x	x			x
Angola	x	x	x	x				x	x	x	x		x
Benin	x	x	x	x			x	x	x	x			
Botswana	x	x	x	x			x	x	x	x	x	x	x
Burkina Faso	x	x	x	x			x	x	x	x			
Burundi	x	x	x	x					x				
Cabo Verde	x	x	x							x			
Cameroon	x	x	x	x			x	x	x				
Central African Republic (CAR)	x	x	x						x				
Chad	x	x	x						x				
Comoros	x	x	x							x	x		
Democratic Republic of the Congo	x	x	x	x		x	x	x	x	x	x		
Republic of the Congo	x	x	x				x		x				
Cote d'Ivoire	x	x	x	x	x	x	x	x	x	x			
Djibouti	x	x	x				x						
Egypt	x	x	x	x	x	x	x	x	x	x	x	x	x
Equatorial Guinea	x	x	x					x	x				
Eritrea	x	x	x	x									
Ethiopia	x	x	x	x		x	x	x	x	x	x	x	
eSwatini	x	x	x	x			x	x	x	x	x		
Gabon	x	x	x	x			x		x	x			
Gambia	x	x	x	x				x	x				
Ghana	x	x	x	x	x	x	x		x	x	x	x	x
Guinea	x	x	x			x	x						x
Guinea-Bissau	x	x	x				x	x	x	x			
Kenya	x	x	x	x	x	x	x	x	x	x	x	x	x
Lesotho	x	x	x					x	x	x	x		
Liberia	x	x	x				x		x				
Libya	x	x	x			x	x		x				
Madagascar	x	x	x	x			x	x	x	x	x		x
Malawi	x	x	x	x			x	x	x	x	x		x
Mali	x	x	x	x				x	x	x			x
Mauritania	x	x	x	x					x				
Mauritius	x	x	x	x			x	x	x	x	x	x	x

Country	Membership / or representation in regional / international organization												
	AU	WTO	CAC	ISO	IEC	AFSEC	ARSO	AFRAC	AFRI-METS	ILAC	IAF	BIPM	OIML
Morocco	x	x	x	x	x		x		x	x	x	x	x
Mozambique	x	x	x	x				x	x	x	x		x
Namibia	x	x	x	x		x	x	x	x	x	x	x	x
Niger	x	x	x	x			x	x	x	x			
Nigeria	x	x	x	x	x	x	x	x	x	x	x		x
Rwanda	x	x	x	x		x	x		x				x
Sao Tome and Principe	x	x	x	x									
Senegal	x	x	x	x		x	x	x	x	x			
Seychelles	x	x	x	x			x	x	x	x	x	x	x
Sierra Leone	x	x	x	x			x		x				x
Somalia	x	x	x										
South Africa	x	x	x	x	x	x	x	x	x	x	x	x	x
South Sudan	x	x	x				x		x				
Sudan	x	x	x	x		x	x	x	x			x	x
Tanzania	x	x	x	x			x	x	x	x	x	x	x
Togo	x	x	x	x			x	x	x	x			
Sahrawi Republic	x												
Tunisia	x	x	x	x	x	x	x	x	x	x	x	x	x
Uganda	x	x	x	x	x	x	x		x				x
Zambia	x	x	x	x		x	x		x	x	x	x	x
Zimbabwe	x	x	x	x		x	x	x	x	x	x	x	x
Total	55	54	54	40	10	18	39	21	46	32	23	15	25

Table 6: Representation of Africa countries in regional and international quality infrastructure organizations
Key: X = Member; X = Associate or correspondent or observer member

3.3.3 Standards along the cassava value chain

3.3.3.1 Scope of Available Standards

We list standards available at national level in case study countries, in the RECs in particular in the EAC and at continental level at ARSO. In addition, we list standards on cassava available at international level CAC and ISO where specific or generally applicable standards exist.

The standards include standards of products and services that are most directly related to the cassava value chain that were found at Africa level and in the countries included in the study. Some standards from other value chains have been included here for the sake of reflecting a gap that exists in the cassava value chain. For example, inclusion of a standards on ground nut Sheller brings to light the gap in the cassava value chain at the step mirrored by shelling operation i.e. peeling.

Some generic standards that do not exclusively apply to cassava have been included where it is known that they are used to apply regulations pertaining to cassava value chain management. Where such a standard is considered to be too generic, this has been pointed out as a gap because some markets require specific standards in order for products to be traded.

3.3.3.2 List of Standards at National Level

In this section different standards along the value chain in three countries Nigeria, Uganda and Zambia are compiled and discussed as a case study. We discuss standards for inputs and field production practices, chain of custody and postharvest management and distribution practices, processing and other value addition operations and for cassava the product including the concerns on cyanide toxicity and nutritional value.

a) Inputs and Field Production Practices

Cassava is easy to grow and requires limited attention when compared with other farm crops but farming practices such as seed selection, land preparation, crop nutrition, weed management, pest and disease management and harvest practices all make a big difference in the yield and marketable output quality. Cassava production is affected by drought and insect pests and diseases that attack cassava plants. Farmers need constant provision of knowledge and skills to understand basic biology behind the spread of these diseases to better manage them at field level.

Breeding programs can provide farmers with new drought tolerant and pest and disease resistant cassava varieties. Cassava is also bred for high starch content and ease of processing e.g. peeling. Starch content is very critical for industrial usage and is a function of varietal selection as well as crop nutrition. The higher the starch content, the more yield to industrial products. Research institutions constantly develop new cassava varieties and field management information that is crucial to the management of the crop for maximum quality and yield.

Crop varieties released by these institutes are distributed among selected farmers who multiply them. Cassava stems are then distributed directly or sold to NGOs and government to distribute. Cassava is planted using stem cuttings.

Cassava varieties are controlled under SPS regulations of the countries. In some countries e.g. Nigeria, information on cassava varieties is available online: https://seedtracker.org/cassava/.

A number of Standards that affect this segment of the value chain exist and are listed in **Annex C1**.

We noted the following observations:

i) A sizeable number of these standards exists within the cases study countries.

ii) Nutrition supplements, essentially formulations of micronutrients, continue to be marketed as fertilizer just because they contain a miniscule amount of NPK, akin to describing a vitamin pill as a meal.

iii) There are no standards relating to planting machinery or mechanized preparation of planting material i.e. chopping cassava stems to a standard length to enable mechanization in large-scale operations.

iv) Most standards are recently introduced, so limited history of enforcing crop nutrition products standards.

v) Substantial volume of fertilizer is imported. Whatever is made on the continent however needs to be supported with standardization at the factory production line where quality control is done. Where large orders are to be placed abroad, AFRICA based importers will be more alert to the specification on the product being quoted.

vi) Experiences from elsewhere or from other commodity groups such as cotton, cocoa, coffee and tea have been commercial commodities for a long time could be looked at.

vii) Sampling methods for production lines are required even for compounds and formulations of micronutrients supplements.

Analysis of the standards for inputs and field production practices shows the following gaps and needs:

i) More detailed and specific standards should be made for products for protecting cassava crop from diseases and pests, including soil borne diseases of the cassava crop.

ii) Standards for herbicides suited to cassava production are missing. It has to be confirmed from research if the cassava crop requires its own formulation of herbicide.

iii) Standards for good agricultural practices for cassava should be put in place such as these available with GlobalGAP. ARSO has taken the initiative to develop GAP standards for cassava. These should be adopted and applied by Member states.

iv) Regulations on pest and disease control should be strengthened and disseminated. Technical reports are available with IITA and various research institutes affiliated to it. Standards and regulations can easily be developed from those documents.

v) Standards and technical regulations on pesticide residues in food and feed specific to cassava and cassava products.

vi) Standards and technical regulations and conformity assessment procedures on soil conditioners and fertilizers. Technical reports are available with IITA and various research institutes affiliated to it.

vii) Enforcement of standards and codes of practice around seed systems remains a challenge in many African economies. Harmonized mechanisms for enforcement are sometimes lacking in due to mandate ambiguity between different institutions.

viii) Standards on managing the seeds are missing. Every release of planting material should be tracked so it does not remain in the planting field for too long. The number of planting cycles recommended by breeders should be specified and enforced to reduce the temptation of farmers over using material whose productivity or disease resistance has dropped over the years.

b) Chain of custody and postharvest management and distribution practices

In the rapid movement of cassava roots from farm to fork or in the distribution of stabilized processed products, many critical points exist where quality could drop drastically. It is therefore appropriate to standardize or codify some practices used throughout the value chain, including those that are followed by custodial actors such as warehousemen, brokers and transporters. Proper hygienic practices such as thorough washing of roots with potable water should be adopted. Machinery and equipment must be washed to avoid cross-contamination during processing. Packaging of fresh produce is also vital in postharvest handling as it determines the shelf life and availability of the processed products. This means that degradation of quality attributes could still occur during storage of the produce depending on the type of packaging materials used, thereby resulting in physicochemical, functional as well as the nutritional losses of the processed products.

Therefore, standardization should focus on preventing or minimizing the following categories of contaminants:

i) Pesticide residues from field sprays as well as any fumigation of warehouses.

ii) Heavy metals contained in soil, irrigation water and other post-harvest treatments.

iii) Oils and greases that may be on transportation trucks both on road and rail as well as boats.

iv) Chemical migrations that may arise because of using inappropriate packaging.

v) Organic foreign matter from animal droppings and from pests that may be in and around warehouses.

vi) Inorganic foreign matter from contact with soil such as during drying and storage

vii) Environmental contaminants that may come from highway traffic and able to penetrate products in nearby warehouses, if they are not well packaged. In his regard, the standards of warehousing for food storage must take into consideration the dangers of such highway traffic and restrict proximity to such traffic.

Additionally, cassava suffers deterioration when exposed to extreme temperatures and solar radiation. These conditions need to be monitored throughout the chain of custody.

Cassava roots are highly perishable, which limits the marketing of the fresh produce. The roots are prone to physical damage. Poor harvest and postharvest handling methods cause the most physical damages to cassava roots. Rodent and pest attack also contribute to physical damages.

Primary deterioration of stored cassava roots is an endogenous physiological process. Secondary deterioration occurs when pathogens penetrate through wounds and bruises inflicted during harvesting and handling. The use of agro-chemicals that can prevent microbial growth is often required with preservation methods that can promote the yield of these cassava roots.

Standards are needed in this area to guide the handling, processing and preservation of fresh cassava roots. **Annex C2** is summary of standards that exist in the countries studied.

Analysis of the standards for post-harvest practices shows the following:

Standards for good general post-harvest practices such as transportation, preservation, storage are available especially at international level. For imports and exports of fresh cassava roots certification to such international standards and private standards for example GlobalGAP and ISO 22000 is required. Ecolabeling can be applied. A number of guidelines have been made by NGOs and extension bodies but have not been formalized as standards or official guidelines for enforcement. In DRC, it was reported that the Office Congolais de Contrôle (OCC), is the only governmental body operating under the Ministry of Commerce in the DRC that has the responsibility to developing and enforce standards and performing conformity assessments on imports and exports. The Codex standards are applied to imports, but not to exports because of lack of adequate equipment in the OCC lab.

Standards for good post-harvest practices-transportation, preservation, storage and packaging of fresh produce are available within international organizations for example, ISO 22000 / ISO TS 22002-5 prerequisite programmes on food safety part 5: transport and storage.

There are no standards for food additives e.g. Thiabendazole for preservation of fresh cassava roots. Fresh cassava, like potato, can be preserved using thiabendazole[55] or bleach as a fungicide, then wrapped in plastic, coated in wax or frozen. Such practices as waxing cassava roots to extend shelf life are not common in Africa. Standards could promote adoption of such technologies.

Although there are standards for primary processing for grains for example ground nut Sheller in Nigeria, there are no equivalent standards for cassava. Machinery for post-harvest processing e.g. chopping, peeling, washing, retting and ratting could be fabricated

55 Directive 90/642/EEC.

and standardized. Additionally, materials and equipment of handling e.g. tarpaulins of plastic sheets for drying could be promoted.

c) Cassava roots processing and other value addition operations

i) Cassava roots perishability

Processing of the roots prolongs the shelf life and increases market value. Processing of the cassava root by peeling, grating, fermentation (at times) and continuous washing of harvested cassava roots

- reduces the weight of the produce,
- facilitates its transportation to markets;
- lessens post-harvest losses arising from breakage of the roots; and
- extends the product's shelf-life.

Processing operations intended to add value to cassava roots may be described in similar terms but resulting in considerably different quality of output. Standards support the adoption of good manufacturing practices and use of cassava products in industry.

Annex C3 shows standards for value added cassava products and gaps therein. The majority of standards found pertain to utilization of cassava for food or feed.

Standards pertaining to many food and non-food products are missing. See section 2.4 for discussion on gaps in the quality infrastructure.

ii) Cyanide Toxicity

Cassava roots contain cyanogenic glycosides that can release hydrogen cyanide (hydrocyanic acid or HCN) and result in cyanide poisoning in humans. The cassava tubers (root) normally require a post-harvest treatment to reduce the concentration of toxic cyanogenic glycosides before safe consumption is possible. Unprocessed cassava tubers are classified as either bitter or sweet based on the concentration of hydrocyanic acid that can be released from the cyanogenic glycosides. Sweet cassava tubers must contain less than 50 mg hydrogen cyanide / kg on a fresh weight basis in accordance with Codex Alimentarius Commission[56]. Bitter varieties are especially fitted for industrial and feed purposes, because of their higher starch content, while sweet varieties are generally preferred if the root is consumed as food.

Bitter cassava can be made safe for direct human consumption if properly treated to remove the cyanide content. Clinical symptoms of cyanide poisoning in patients depending on the amount consumed can include headache, dizziness, mental confusion and stupor in addition to cyanosis, twitching and convulsions. In severe poisoning cases, a fatal coma may result.

Processing of the cassava root by peeling, washing, grating, fermentation and drying reduces the levels of naturally occurring hydro cyanide toxins.

The limits for cyanide in the product destined for human consumption are regulated worldwide and included in almost all product standards such as fresh cassava roots, dried cassava chips and cassava flour. Codex Alimentarius Commission has set limits for cyanide in cassava and countries appear to have adopted the same limits.

Additionally, codex has a Code[57] of practice for the reduction of Hydrogen Cyanide (HCN) in Cassava and cassava products. This standard is adopted in Zambia and in Uganda (Annex C2). The Code outlines measures that have been proven to prevent and / or reduce concentrations of hydrogen cyanide in cassava products. Good Manufacturing Practices (GMP) can be taken to prevent or reduce significantly the concentrations of hydrogen cyanide in cassava products. Soaking allows hydrogen cyanide to diffuse out making the product safer for human consumption. The use of scientific kits such as picrate kits to monitor cyanide concentrations in cassava products at the point of use and urinary thiocyanate concentrations in the population is recommended.

56 CAC/RCP 73-2013

57 CAC/RCP 73-2013

iii) Functional and Nutritional Quality

A typical cassava root is composed of 70% moisture, 24% starch, 2% fibre, 1% protein and 3% other elements. Special breeding program are known to produce cassava with increased micronutrients such as vitamin A and B6. For example, by 2016, HarvestPlus and its partners had successfully developed and delivered vitamin A cassava variety to more than one million farming households in Nigeria and the Democratic Republic of Congo (DRC) and shown that farmers are willing to grow vitamin A cassava varieties and consumers are willing to buy and eat vitamin A cassava product[58].

There are currently no standards for biofortified cassava and cassava products. Setting standards for levels of Vitamin A in cassava products and ability to test for such nutrients will help the success of such biofortification programs.

d) Packaging materials and storage conditions
Packaging and storage of cassava products is essential because it helps to reduce loss, add value, extend shelf life, maintain quality and wholesomeness of products, improve marketability and food safety. The quality and safety of packaging materials is important to enable producers to protect the product. Standards help guide industry and regulators on the use of packaging materials as well as promote local production and availability of materials for industry to use.

Annex C4 shows standards available in Uganda and Zambia that apply to packaging of foods. These standards, a number of them adopted from international standards; apply to packaging of cassava and cassava product too. In addition, product specifications often provide for packaging of all food in food grade materials that protect the product from contamination during handling.

e) Existing Electrotechnical Standards for Processing Equipment
Cassava production and processing can be done by use of different machinery that may be powered by electricity. Electrotechnology standards make provision for the safety, performance and efficiency of such machines. Most of the processing of cassava is currently done using traditional manual methods.

The availability of standards for machines and equipment to help mechanisation of production and processing will enhance the industrialization of cassava.

Annex C5 shows examples of the standard available for processing equipment. These standards are generic in nature and apply to other sectors other than cassava. Careful examination of these standards could promote production of equipment for cassava processing.

f) Test methods for Cassava and Cassava Products
Testing, the process of conducting the tests is one of the conformity assessment processes. Test methods are essential to determine the parameters set in standards.

In practice for every requirement that is set in standards or regulations, a test method is developed or selected from among existing methods and declared in the standard or regulation. This reduces ambiguity and ensures that the results can be comparable.

In discussing gaps, the fact that each product specification already has standards on test methods is taken into account. However, for any group of related standards, some test methods are applicable to more than one product. The practice is to have standalone test methods specified with the knowledge that they will apply to a number of products or processes in the category.

We largely found that the standards that exist for cassava and cassava product have provided test methods for specified requirements. Such methods are either published in the product standard or referenced where an independent test method standard exist. We have found a variety of methods published by Codex, ISO and AOAC in use. There is a practice to adopt international standards where they exist, which is consistent with expectation under the world

58 Ilona, et al., 2017.

trade organization, AfCFTA and other international and regional agreements. In some cases however, countries have standards other than international standards (See Table 7).

Table 7 indicates the test methods published or reference in following case study standards:

- ZS 992: 2016, Dried cassava chips – Specification (Zambia)
- US EAS 739:2010, Dried cassava chips – Specification (Uganda)
- ARS 839:2016(E), Dried cassava chips – Specification (ARSO)
- NIS 344: 2004, Standard for Cassava Chips (Nigeria)

For a majority of the parameters, there are international standards published. This illustrates the extent to which test methods to determine key parameters in cassava and cassava product are available and used.

g) Standards and Standard Related Information
i) National Enquiry Points

Quality infrastructure is not complete without a system to provide information to the public and trading partners. Majority of African countries are members of WTO and are obliged to set up national enquiry points for both the TBT and SPS agreements.

An enquiry was made through the Uganda WTO TBT National Enquiry Point to the selected countries- Nigeria, DRC, Ghana, Mozambique, Uganda, Ethiopia and Zambia, and Thailand and Indonesia in Asia that are major producers and exporters of cassava products. Thailand and Indonesia, among the top global exports of cassava product, were used as bench marks.

Although we received acknowledgements for the enquiry, only one country out of 8 study countries in Africa provided a response on the standards and regulations for cassava. Indonesia and Thailand however, gave responses on the regulations and standards governing cassava sector.

Test methods applicable for common parameters in cassava products

SN	Parameter	Test methods (Annex D)					
		ISO	CODEX	ARSO	Uganda	Zambia	Nigeria
1	Moisture content	ISO 712	ISO 712	ISO 712	ISO 712	ISO 712	In house
2	Total acidity	ISO 750		ISO 750			In house
3	Total ash	ISO 2171	ISO 2171	ISO 2171	ISO 2171	ISO 2171	In house
4	Tin (Sn)	ISO 2447		ISO 2447		AAS	
5	Crude fibre	ISO 5498	ISO 5498	ISO 5498	ISO 5498	ISO 5498	In house
6	Protein, as N	ISO 3188 ISO 5378 ISO 1871				ISO 1871	
7	pH	ISO 1842				In house	
8	Acid insoluble ash	ISO 762 ISO 763	ISO 763	in house	in house	In house	
9	Total viable micro-organisms	ISO 4833-1 ISO 4833-2		ISO 4833	ISO 4833	NA	
10	Hydrogen cyanide	ISO 2164		ARS 844	EAS 744	AOAC-915.03,	In house
11	Fluorine					AAS	
12	Copper	ISO 7952		ISO 7952	ISO 3094	AAS	
13	Lead	ISO 6633	AOAC 972.25	ISO 6633	ISO 6633	AAS	
14	Arsenic	ISO 6634		ISO 6634	ISO 6634	AAS	
15	Mercury	ISO 6637 ISO 11212-2				AAS	
16	Manganese					AAS	
17	Total coliforms	ISO 4831 ISO 4832				NA	
18	Escherichia coli	ISO 7251 ISO 16649-1 ISO 16649-2 ISO 16649-3 ISO 16654		ISO 7251	ISO 7251		
19	Yeast and moulds	ISO 21527-1 ISO 21527-2		ISO 21527-2	ISO 21527-2		
20	Vibrio Cholerae	ISO 21872-1				NA	
21	Staphylo-coccus	ISO 6888-1 ISO 6888-2 ISO 6888-3				NA	
22	Salmonella spp	ISO 6579-1 ISO/TS 6579-2 ISO/TR 6579-3		ISO 6579	ISO 6579	NA	
23	Starch content	ISO 10520		ISO 10520	ISO 10520		In house
24	Iron (Fe)	ISO 5517 ISO 9526		ISO 5517		AAS	

Test methods applicable for common parameters in cassava products							
		Test methods (Annex D)					
SN	Parameter	ISO	CODEX	ARSO	Uganda	Zambia	Nigeria
25	Cadmium	ISO 11212-4 ISO 6561-1					
26	Zinc	ISO 6636-1 ISO 6636-2 ISO 6636-3		ISO 6636-1		AAS	
27	Aflatoxins		ISO 6540	ISO 16050	ISO 16050	NA	
28	Pesticide residues		Codex guidelines				
29	Pirimiphos methyl						
30	Malathion						
31	Hydrogen cyanide						
32	Permethrin						
33	Deltamethrin						
34	Diclorvos						
35	Fenitrothion						
36	Chlorpyrifus						
37	Bromoethane						
38	Hydrogen phosphide (phosphine)						
39	Carbofuran						

Table 7: Test methods applicable for common parameters in cassava products

Thailand responded as follows: "In case Uganda would like to export fresh Cassava (Manihot esculenta) to Thailand such as tapioca chip, tapioca meal, tapioca pellet and tapioca root – we would like to inform that those cassava products are identified as prohibited articles under Plant Quarantine Act of Kingdom of Thailand. We would like to suggest that you start a market-access for new commodities process by Notifying the Department of Agriculture (Re: Specifications, methods and conditions of pest risk analysis) for the importation of prohibited articles and send an official letter from the NPPO (National Plant Protection Organization) of Uganda to the NPPO of Thailand (Department of Agriculture)"

The limited response from countries in Africa shows the need to improve activities of the national enquiry points to support trade in the cassava sector.

ii) Stakeholder Awareness, Knowledge and Skills

Many sector study reports indicate that standards or SPS measures are not adequately enforced. It is also common to hear that standards are being enforced unfairly. A key feature is insufficient awareness, knowledge and skills on the need, the benefits and the impact of standards across all level of society - from policies, laws and regulations to grassroots practices, leadership. Many standards are underutilized because cassava farmers and dealers are not aware that they exist, leave alone how they could impact their businesses and market share.

3.3.3.3 Standards Available at the REC level

One approach to improve the trade environment for food staples that has gained considerable momentum and widespread support in recent years has been to harmonize quality standards across countries and with international ones. The East African Community has been especially active in pursuing harmonization of standards in an effort to facilitate trade between Member States and ensure global markets remain open to EAC exporters. Harmonization of standards is also a practice in COMESA and SADC and as part of an agreement to establish a tripartite free trade area between the three regional blocks (COMESA, EAC and SADC).

So far, EAC has established more than 200 standards in the area of food and agriculture covering agricultural inputs, practices and food products. These standards are implemented as mandatory standards within the region (Burundi, Kenya, Rwanda, South Sudan, Tanzania and Uganda) and intra and international trade in such products is subjected to compliance to those standards.

Annex C6 shows the list of harmonized standards relevant for cassava and cassava products.

There are nine standards on cassava and cassava product in addition to other standards for manufactured products such as bread and beer. There is one test method developed at EAC level for determination of cyanide content and several adopted from ISO, and AOAC. The various standards for cassava and cassava products indicate other test methods. A majority of the test methods covering determination for heavy metals and microbiological contaminants and chemical compositional level such as crude fibre, total ash, starch and toxins (aflatoxins are adopted intentional standards which are endorsed at the REC level. This provides harmonization with international standards.

3.3.3.4 Standards at Continental Level

ARSO, the Africa continental standards body has issued several standards on cassava and cassava products **(Annex C7)**. The standards include nine specific cassava standards and several others on related products. ARSO has also adopted by reference several international standards including Codex standards on food additives, contaminants and toxins and test methods from ISO. This shows that the level of harmonization of standards at continental level is substantive. It also indicated harmonization with international standards.

3.3.3.5 International Standards

The WTO agreements on TBT and SPS measures institute the concepts of use of international standards where they exist in developing regulations by Member States in order to avoid unnecessary barrier to trade. The agreement requires members to ensure that their sanitary or Phytosanitary measures are based on an assessment of the risks to human, animal or plant life or health, taking into account available scientific evidence; relevant processes and production methods; relevant inspection, sampling and testing methods. Where international standards do not exist the agreement, provide for using scientific information to develop standards.

Codex Alimentarius Commission, the international food standards organization has developed three specific standards on cassava and cassava products. In additional Codex has several standards that cover the subject of food, feed and trade. Codex standards relating to food additives, veterinary drug and pesticide residues, contaminants, methods of analysis and sampling, and codes and guidelines of hygienic practices, where available, are referred to under the WTO TBT agreement as the applicable standards for international trade in food. Codex has published and uses guidelines for risk analysis when developing food standards. A list of codex standards relevant for the cassava sector is indicated in **Annex C8**.

The most relevant standards from Codex are those dealing with food safety such as standards setting limits of food additives, contaminants including heavy metals, mycotoxins and pesticide residues. Codex also provides several test methods, codes of practices and guidelines that countries are expected to use in setting national, regional standards or technical regulation. It is remarkable to note that codex does not set limits for microbiological contaminants but provides guidelines on how to set such requirements. Codex also has guidelines ion food safety risk analysis which could guide countries and regions is setting standards based on scientific principles. In the area of pesticide residues, codex has several guidelines including good laboratory practices, portion of commodities to be used, sampling, and performance criteria for methods in pesticide residue analysis.

ISO, is one of the international standards developing organizations that are relevant to the cassava sector. ISO develops standards in various fields. The standards in the fields of food and agriculture, management and conformity assessment are among the most popular standards and are applicable to the cassava sector. Standards in the following fields are closely relevant to the cassava sector:

- Fruits and vegetables and their derived products
- Cereals and pulses
- Spices, culinary herbs and condiments
- Microbiology
- Animal feeding stuffs
- Sensory analysis
- Quality management and quality assurance
- Management systems for food safety, Environmental management
- Chemistry, Laboratory equipment
- Starch (including derivatives and by-products)
- Packaging; packaging machinery, Machinery intended for use with foodstuffs,
- Fertilizers, soil conditioners and beneficial substances
- Foundry machinery and
- Fertilizers, soil conditioners and beneficial substances

In addition to the specific sector standards, ISO has issued standards in conformity assessment including for laboratories, calibration, accreditation and inspection Bodies. A list of ISO standards relevant for cassava sector are in **Annex C9**.

3.4 Analysis of Gaps in Quality Infrastructure

3.4.1 General

To appreciate the nature of gaps in the existing standards, metrology and conformity assessment infrastructure, we conducted a comparison amongst three Countries-Nigeria, Uganda and Zambia. We compared the list of standards available at ARSO with similar lists in the countries to identify standards that are common, those that are only in some countries and those that are missing completely (not yet developed in the four scenarios). We also looked at the text of the standards to compare parameters indicated in the standards and the limits that are set for these parameters to see if the standards need harmonization.

We then looked at the test methods for cassava and cassava products to identify any gaps in availability of test methods for key parameters of concern for cassava products. In this case, we used dried cassava chips are representative of cassava products. The main characteristics of concern in cassava products are notable in cassava chips. Test methods for tertiary products such as bread, ethanol and glucose are not necessarily restricted to cassava but apply across industry.

We then look at gaps inconformity assessment, measurements and accreditation to understand the availability of recognized test and measurements laboratories, in particular if there are accredited laboratories for the relevant tests in cassava products.

3.4.2 Gaps in Existing Cassava Product Standards

Analysis of the existing standards indicates the following types of gaps:

- Difference is number of products standards between countries.
- Lack of standards for certain common products across all countries and at regional and international levels.
- Differences in number of parameters that are provided for in different standards at different levels.
- Differences between the limits for similar parameters in different standards at national, regional and international levels.

This kind of gaps could be an indicator on the different levels of importance the products are given in the different countries, different approach to standards and differences in level of competence among the standards developers.

a) Standards for Cassava Products
The different organizations have a different number of standards for primary and processed products (Table 8). This ranges from only one standard in Angola to 13 in Uganda (East Africa community). Similarly, there is only one draft standard at ISO and four standards at the level at the Codex.

Organization	No. of Standards for primary and processed cassava products
International (Codex)	4
International (ISO)	1 (draft)
Africa (ARSO)	12
EAC	10
Angola (IANORQ)	1
Ethiopia (ESA)	8
Ghana (GSA)	8
Nigeria (SON)	5
Uganda (UNBS)	9
Zambia (ZABS)	13

Table 8: Variation in number of standards for cassava between countries, the RECs and international organizations

Among the most common products in Africa, there are standards for fresh cassava roots, Gari, dried cassava chips, cassava starch, cassava crisps, cassava flour, composite flours, and cassava leaves at national, regional (EAC and ARSO) and international (Codex). Standards for dried chips are available only at national and regional level, even though this is the most internationally traded product.

Under the current framework of harmonized standards and with a view to demonstrate the role of certification in promoting trade, the products that have standards could be certified using the existing mechanism i.e. national standards bodies offering certification, ARSO certification mechanism or independent accredited certification bodies.

Basing on existence of standards for these products in many of the countries in Africa, assign of progress in commercialising those products, the following products could be certified against available standards:

a) Cassava chips

b) Cassava flour

c) High quality cassava flour

d) Cassava starch

e) Gari

Certification could be certified using the following ARSO standards. This may require a review of the standards to ensure acceptability among the intended training countries in Africa.

a) ARS 839:2016(E), Dried cassava chips – Specification

b) ARS 838:2016(E), Cassava flour – Specification

c) ARS 840:2016(E), High quality cassava flour – Specification

d) ARS 846:2016(E), Food grade cassava starch – Specification

e) ARS 854:2016, Gari – Specification

There is a need to promote the development of standards for similar products in all countries, harmonize the standards at regional level and promote the development of international standards to facilitate trade.

b) Products for which no standards exist

There are no standards for about 75 common cassava products named by Henry, Westby and Collinson (1998); Kauakou et al., (2016); Alamu et al., (2020), Guira et al. (2016), Filbert et al., (2016) and Gbaguidi and Ahoussi-Dahouenon (2018) as follows:

Abacha, Abloyoki, Agbéli klaklou, agbelilakia, Greedy (goma séché au four), Agbelima, Agelikaklo, Agléli mawè, Akpissi, Alebo, Attiéké, Attoupkou, Autkpu, Ayan (Purée de manioc), Bêdêkouma, cassava beer, cassava sticks, Chickwangwe, Cossette, Cossettes de manioc, dry semolina, Dumby, Eberebe, Farine de manioc, Fede, fermented flours, Fingnin, flour, foufou, Foutou, fritters, Fufu, Galikponnon (pain de manioc), garba, Goman (amidon), Goman kluiklui (snack), ground fresh tuber, Ikivunde, Imikembe, Inyange, Kabalagala (Uganda), Kapok pogari, Kenkey, Kivunde, Kokondé, Kokonte, Kponnonvi (biscuit de goma), Kuté dida (manioc bouilli), Kuté founfouin (manioc pile), Kuté libo, Kuté mime (manioc grillé), Kuté siso (manioc frit), Kutéta (snack), Kwadu, Lafun, Efubo, Loi-loi, Meduame-Mbong, Mihogo, Mokopa, Pasta, pastries, Placali, Pombe (cassava beer), ragout, sourdough, tapioca (amidon granule), Ubuswage and Yakayake.

One of the most notable gaps during the study, for standards for secondary cassava products is the lack of standards Brewers' cassava flour. Breweries have been reported to have expressed interest in using HQCF for beer production as a substitute for milled grains with a note on challenges on quantities and the quality of the cassava flour[59] [60]. Beer consumption is reported to grow at nearly 10 % per year.[61] A

59 Kilimo Trust 2012

60 DH 2015

61 Kilimo Trust 2012

sustained market for cassava flour therefore requires ability to supply large quantities.

Using ordinary cassava flours requires brewers to deploy additional technology to clarify the extra fine flour milled for direct human consumption and baking. This puts off some brewers from cassava flour as raw material. Milling for brewing need to be manipulated carefully to find a balance between a grind that is too fine and one that is too coarse. Fine grind leads to a mash that will clump and become sticky while coarse grind would reduce the surface area of the grist that is exposed to the brewing enzymes and affect the brewers yield.

The multiplicity of cassava products in Africa points to a need for a standard on terminologies in the cassava sector. There has been an indication that a name may be used for different products yet at the same time many products may be called by the same name in different countries or communities. For example, according to Sang Ki Hahn (1997), **fufu in DRC**, Congo, Cameroon and Gabon **is the same as amala** in Nigeria, **toh** in Guinea, and **kuon** or **atap** in Uganda, **ugali** in Tanzania, **nchima** in Mozambique, **nsima** in Malawi, **ubugali** in Rwanda and **funge** in Angola. Similarly, cossette (s) appears to be the same as fermented cassava chips and flour, which are produced using different methods in different communities.

c) Number of parameters for which standards are set

A look into the standards for dried cassava chips **(Table 9)** as an example, reveals a difference in the number of parameters and the limits for given parameters among the countries.

We compared the standards issued by ARSO and those issued by the three case study countries on dried cassava chips. Dried cassava chips are a minimum secondary value added products that can be produced with traditional processing techniques and easily improved to provide additional cassava products of different levels of quality. Dried cassava chips are a commonly trade product worldwide and represent an opportunity for trade within Africa and for exports.

	Concern / issue	Regulations/standards requirements (limits)				No. Accredited test laboratoriesa		
		ARSO (ARS 839)	Nigeria (NIS 344)	Uganda (US EAS 739)	Zambia (ZS 700)	Nigeria	Uganda	Zambia
1	Basic characteristics for quality of the products							
	Moisture content, %, m/m, max	12	10	12	10- 13	1)	2	1
	Total Ash	3.0	3	3.0	3.0	12	2	1
	Fat content	na	na	na	na	9	1	
	Protein, %, min.	na	na	na	1.0	8	1	
	Crude fibre	3.0	3	2.0	2.5	5	1	
	Carbohydrate (starch), %, Min.	75	75		60	5		
	Energy	na	na	na	na	2		
	Total acidity, % m/m, max	1.0	1	na	na			
	pH	na	na	na	5.0-7-.0			
	Mineral elements (nutrients)							
	Calcium (Ca)	na	na	na	na		1	1
	Iron (Fe), mg/kg, max	22	na	na	10	5		1
	Potassium (K)	na	na	na	na	2	1	1
	Magnesium (Mg)	na	na	na	na	2	1	1
	Manganese (Mn)	na	na	na	7.0	2		1
	Sodium (Na)	na	na	na	na	2	1	1
	Zinc (Zn), mg/kg, max	50	na	na	50	5		1
	Copper (Cu), mg/kg, max	20	na	na	20	5	1	1
	Nickel (Ni)	na	na	na	na	1	1	
	Cobalt (Co)	na	na	na	na	2		
	Tin (Sn), mg/kg, max.	15	na	na	250			
	Fluorine, mg/kg, max.	na	na	na	10			
	Vitamin A	na	na	na	na	1	1	
2	Natural material toxins							
	Hydrocyanic acid, mg/kg, max.	10	10	10	na			

	Concern / issue	Regulations/standards requirements (limits)				No. Accredited test laboratoriesa		
		ARSO (ARS 839)	Nigeria (NIS 344)	Uganda (USEAS739)	Zambia (ZS 700)	Nigeria	Uganda	Zambia
3	Contaminants							
3.1	Microbiological contamination							
	Total Plate Count, cfu/g, max.	10^5	10^5	na	10^5	5	2	
	Total coliforms, cfu/g, max.	absent	absent	na	102	4	2	
	Escherichia coli, cfu/g, max.	absent	absent	absent	absent	3	2	
	Yeast and Moulds, cfu/g, max.	10^3	10^3	10^3	10^3	4	1	
	Vibrio cholera	na	absent	na	absent		2	
	Salmonella, 25g, max	absent	absent	absent	absent	2	2	
	Staphylococcus aureus	na	absent	na	absent	3	2	
	Vibrio parahaemolyticus	na	absent	na	na		1	
	Sulphite Reducing Anaerobes	na	absent	na	na		1	
	Intestinal Enterococci	na	absent	na	na		1	
	Listeria monocytogenes	na	absent	na	na	1	1	
	Enterobacteriaceae	na	absent	na	na	1	1	
	Listeria mono-cytogenes	na	absent	na	na		1	
3.2	Mycotoxins							
	Aflatoxins, Total, µg/kg, max.	10	na	10	10		1	1
	Aflatoxins, B1µg/kg, max.	5						
3.3	Inorganic chemicals (heavy metals)							
	Lead	1.0	1.0	1.0		3	2	
	Arsenic	0.1	0.1	0.1				
	Mercury		0.1				1	
	Cadmium	0.1		0.1		4	2	
	Chromium					2		
3.4	Physical contaminants (dust)							
	Acid insoluble ash, on dry matter basis, %, max	0.15		0.15	0.15			

	Concern / issue	Regulations/standards requirements (limits)				No. Accredited test laboratoriesa		
		ARSO (ARS 839)	Nigeria (NIS 344)	Uganda (US EAS 739)	Zambia (ZS 700)	Nigeria	Uganda	Zambia
4	Residues							
4.1	Pesticide Residues	Codex +		Codex	TR[b]			
	Poly Chlorinated Biphenyls (PCBs)					1		
	Organochlorine Pesticides (OCPs)					1		
	Poly Brominated Di-phenyl Ethers (PBDEs)					1		
	Poly Aromatic Hydrocarbons (PAHs)					1		
	N- Alkanes[62]					1		
	Pirimiphos Methyl	0.10	0.10					
	Malathion	0.10	0.10					
	Hydrogen Cyanide	0.05	0.05					
	Permethrin	2.00	2.0					
	Deltamethrin	2.00	2.0					
	Dichlorvos	2.00	2.0					
	Fenitrothion	10.00	10.0					
	Chlorpyrifus	10.00	10.0					
	Bromoethane	5.00	5.0					
	Hydrogen Phosphide (Phosphine)	0.10	0.1					
	Carbon furan	0.20	0.2					
4.2	Radioactive residues							
4.3	Food additive residues	Codex						
5	Sanitary and Phytosanitary measures (SPS)							

Table 9: Parameters in standards and available accredited test laboratories for dried cassava chips for ARSO, Nigeria, Uganda and Zambia.

Key: = Gaps n = Number of accredited labs na = not requirement set

a: Source: https://ninas.ng/; https://www.sadcas.org/accredited-organizations; https://www.sanas.co.za/Pages/index.aspx; www.a2la.org;

b: Food and drugs regulations 2001

62 Used in studying feeds and feeding stuffs.

Between Nigeria, Uganda and Zambia the standard for dried cassava chips are different (Table 9). The standards also differ with those issued by ARSO although each of these countries are ARSO members. None of the Countries has adopted the ARSO standard for cassava chips. The number of parameters set are not the same. Without including limits for pesticide residues, the ARSO standard (ARS 839) specifies limits for 21 parameters; the Nigerian Standard (NIS 344) provides for 22 parameters; the Uganda Standard (East African Standard, US EAS 739) provides for 12 parameters while the Zambian Standard (ZS 700) sets limits for 21 parameters.

Another notable discrepancy includes the limits for some contaminants that are higher in local standards than those set by Codex and limits for mineral salts otherwise considered nutrients that are even added to food e.g. Zinc and Iron. Zinc and Iron are often added to food e.g. maize flour / meal at rate of minimum 33 mg / kg for Zinc and 21 mg / kg for iron because they are essential nutrients. Other limits in cassava product standards such as Tin, Manganese, Copper and Calcium are not set for common foods. Codex for example limits Tin only in foods that are a canned due the risk of transfer from the cans.

A large number of parameters for a given product implies an increased need for tests and difficulties getting credible test houses for all of them. Differences in parameters of concern creates trade barriers between countries as producers in one country will have to take additional tests for products to be traded in an export country. Where the approach to standards is the same, the number of parameters should be close or the same.

On pesticides, the different standards make varied provisions. The ARSO Standard (ARS 839) refers to Codex and adds a list of 11 compounds: Nigeria has a list of 11 compounds; Uganda Standard refers to codex while the Zambia Standard refers to a Zambian technical regulation[63]. Codex has set limits for 20 pesticides for root and tuber vegetables and one specific limit (Spiromesifen, 0.02 mg / kg) for cassava. Such variation can be complex and different users can interpret and apply differently.

We also compared the standards issued by Codex, ARSO and EAC (Uganda) for cassava flour **(Table 10)**. We observed a high level of harmonization within the three standards. The only exception in this case are limits for aflatoxins and microbiological contamination, where codex has not concluded standards for cassava.

One observation is that the standards for cassava chips and the standards for cassava flour are not aligned. The requirements for cassava chips in ARSO standard and a couple of national standards include limits for Zinc, Copper and Iron. These requirements are not in cassava flour. In normal circumstances, the rationale for limits should be the same in similar situations or for similar products. Similarly, the requirement for acid insoluble ash in chips and in flour are not coordinated with high standards set for chips that for flour.

d) Variation in limits for same parameters in similar standards

We observed that even where the parameters of concern are the same in different countries, the limits for requirements set are different. For example, **(Table 9)**, the maximum limits for crude fibre in cassava chips in Nigeria is 3.0 %, in Uganda it is 2.0 % and 2.5 % in Zambia. In such a scenario, a product that is accepted in one country cannot be accepted in other even if the concerns or objectives of the standard are the same. Incidentally, many countries base their standards on the same text of codex standards. However, limited participation in Codex work could lead to differences in interpretation of the text. Moreover, limited application of scientific principles such as risk analysis could exacerbate the problem.

63 Food and Drugs Regulations of 2001.

	Parameter	Limits set in standards			Remarks
		ARSO (ARS 839)	Codex CX 176	EAC EAS 740	
1	Basic characteristics for quality of the products				
	Particle size	90 % through 600 µm Sieve (fine flour) 90 % through 1600 µm (course flour) 90 % through 250 µm sieve (Baking flour)	90 % through 600 µm Sieve (fine flour) 90 % through 1600 µm (course flour)	90 % through 600 µm Sieve (fine flour) 90 % through 1600 µm (course flour) 90 % through 250 µm sieve (Baking flour)	
	Moisture content, %, m/m, max	13	13	12	
	Total Ash	3.0	3.0	3.0	
	Crude fibre	2.0	2.0	2.0	
	Carbohydrate (starch), %, Min.	60	na	60	
	Total acidity, % m/m, max	1.0	na	1.0	
	Mineral elements (nutrients)	na	na	na	
2	Natural material toxins				
	Hydrocyanic acid, mg/kg, max.	10	10	10	
3	Contaminants				
3.1	Microbiological contamination				
	Total Plate Count, cfu/g, max.	105	na	na	
	Escherichia coli, cfu/g, max.	absent	na	absent	
	Yeast and Moulds, cfu/g, max.	103	na	103	
	Salmonella, 25g, max	absent	na	absent	
3.2	Mycotoxins				
	Aflatoxins, Total B1, B2, G1 and G2, Total, µg/kg, max.	10	na		
	Aflatoxins, B1µg/kg, max.	5	na		
3.3	Inorganic chemicals (heavy metals)	Codex	Codex	Codex	
	Lead	0.1	0.1	0.1	Roots and tubers
	Arsenic	0.1	0.1	0.1	Roots and tubers
	Cadmium	0.1	0.1	0.1	
3.4	Physical contaminants (dust)				
	Acid insoluble ash, on dry matter basis, %, max	0.6	na	0.35	
4	Residues				
4.1	Pesticide Residues	Codex	Codex	Codex	
4.2	Food additive residues	Codex	Conform With Legislation of the Country in Which the Product is Sold	Codex	

Table 10: Comparison of Codex, ARSO and EAC standards for Cassava flour

Such are the many discrepancies in standards in Africa! These types of discrepancies risk two ways:

1) The risk of failure to protect the consumers from hazardous substances; and

2) The risk of increasing the cost of business.

Both risks get worse when enforcement agencies lack capacity to undertake adequate conformity assessment.

When standards for the same product, vary between countries or organizations whose objectives would be the same, it could be an indication of the differences in approaches used, knowledge and skills among the standards writers. A useful first step would be a review to determine the extent to which the standards meet public health and market demands, especially with regard to protecting consumers' safety and health; and maintaining the economic viability of small-scale producers. Training of standards professionals in concepts of risk assessment and regulatory impact assessment may be good starting points that could help alleviate these anomalies.

3.4.3 Gaps in Cassava Test Methods

Analysis of existing testing methods shows that there are test methods specified in the product standards **(Table 7 and Annex D)**. This is the practice since for every parameter set a test method has to be declared. The majority of the test methods indicated in the three case study standards (ARSO, Uganda and Zambia) are adopted from international standards in particular ISO. These are accepted test methods worldwide. The question is whether the laboratories in the countries in Africa can conduct tests according to these methods. We return to this subject in section 5 under testing capacity.

Most of the methods for testing for common parameters in cassava products such as moisture starch content in dried products, heavy metal contaminants such as lead and arsenic and mycotoxins such as aflatoxins are available at international level. Codex Alimentarius commission also recommend ISO standards in some cases for example for ISO 5498 crude fibre in edible cassava flour, ISO 2591-1 for granularity in cassava flour and ISO 712 for moisture content in cassava flour.

We note the use of in-house test methods for the following: Acid insoluble ash and Hydrogen cyanide even when there is similar international standards. This could lead to variation in results and a cause of discrepancy. Acid insoluble ash test is used to determine the physical contamination of dried cassava products with inorganic mineral content such as sand and stones. Due to artisanal processing methods, this is a common concern on dried cassava products. We note that there are international standards that could apply to both the two scenarios. This presents an area for harmonization, adoption or the development of international standards.

3.4.4 Gaps in Competence in Conformity Assessment

3.4.4.1 General

Credibility in conformity assessment services is necessary for recognition of certificates issued by conformity assessment bodies. Credibility is a measure of competence, access to effective equipment and good conformity assessment environment.

Accreditation is the highest level of demonstrated competence through the implementation of relevant international standards that is recognized internationally. A case study of three countries was conducted to assess the level of competence in testing for cassava and cassava product requirements by using cassava chips. To assess credibility basing on good practices an environment requires physical visit to laboratories and agencies. We used available accreditation information.

3.4.4.2 Testing

Table 9 shows that gaps exist in accreditation with some test laboratories accredited in some countries and not in others while some are not accredited at all.

For Hydrocyanic acid, a common concern in cassava there is no accredited laboratory in the case study countries. Similarly, only two out of the three countries shave accredited laboratories for aflatoxins which are a concern in dried cassava products.

On basic proximate analysis for moisture content, and total ash all three countries have accredited laboratories but only two have accredited laboratories for protein and crude fibre. For microbiological test, Escherichia coli and Salmonella, only two of the three countries have accredited laboratories. Only one of the three countries has accredited laboratories for pesticide residues analysis.

Even when laboratories are accredited in all the three countries, the number of such laboratories is not the same. For example, to determine total ash in dried cassava products, there are 12 accredited laboratories in Nigeria, two in Uganda and one in Zambia. This implies that the access to such laboratories varies between countries. One may be tempted think that because the sizes of the countries vary, these discrepancies may not matter but the need to reduce turnaround time from laboratories is a known challenge to cost of doing business and speed of decision aiming. In Uganda, government is supporting UNBS to install state of the art machinery which will enable analysis of many parameters concurrently hence reducing turnaround time and cost of doing business. This will further enable the Bureau to absorb the current pressures created by policy requirements compliance across the industry sector.

3.4.4.3 Calibration

Calibration is necessary for measurement of such as weight, length pressure, temperature and volume. For trade purposes, measuring equipment such as weighing scales must be calibrated to national standards that are traceable international standards. Similarly, test laboratories need their equipment to be calibrated.

We noted **(Table 11)** gaps in level of competence in calibration in the case study countries. For example, whereas Zambia and Nigeria have mass, volume and length accredited calibration laboratories Uganda has none. This creates a gap in trust between the different countries. This situation is likely to be representative of the many countries in Africa. Efforts to upgrade calibration laboratories to gain international r recognition is necessary.

		Nigeria	Uganda	Zambia
1	Accredited Certification Body (Number of accredited bodies)			
	ISO 9001	10[64]	4[65]	
	ISO 22000	10	4	
	ISO 14000	10	3	
	Product certification	6[66]	1[67]	1
	Metrology-Accredited laboratory			
	Pressure gauge, Bar 0–20 (1)	x		
	Pressure gauge, Bar 0–100 (1)	x		
	Pressure gauge, Bar 0–700 (1)	x		
	Temperature, 0.0 °C–100 °C;	x		x
	Temperature, –30 °C to 140 °C	x		x
	Temperature, –40 °C to 600 °C			x
	Low voltage electrical (ClampMeter) 1000 V max; 10 A max; 1000A max	x		
	Calibration of liquid in glass Thermometers, 0–100 °C	x		x
	Liquid in glass thermometer, –40 °C to 200 °C	x		x
	Calibration of weights Class M1; 1 g to 5 kg	x		x
	Mass Pieces, 1 mg to 20 kg	x		x
	Calibration of balances, 1 mg to 2000 kg	x		x
	Volumetric, 1µl to 1 l			x
	Length; 1 mm to 1500 mm			x

Table 11: Available accredited measurement laboratories[68] in Nigeria, Uganda and Zambia

Key: X = Accredited laboratory n = No. of certification agencies No. of accredited laboratory

64 1.SGS, 2. BV 3. BSI. 4. SON-MSC. 5.NECA. 6.BQC. 7.DNV. 8.DQS. 9. G-certi. 10.PECB

65 1.SGS 2. BV 3. Nemko. 4.Intertek

66 1.SGS. 2.BV. 3.Cotecna. 4.Intertek.5.CIS

67 1.UNBS.

68 Source: https://ninas.ng/; https://www.sadcas.org/accredited-organizations; https://www.sanas.co.za/Pages/index.aspx; www.a2la.org;

3.4.4.4 Certification

Certification is necessary to build confidence among consumers on the safety and quality of products and commitment of companies to meet regulatory requirements. Certification also builds trust between businesses. Certification services should be accredited to international standards as a means to demonstrate competence. This study found that the availability of accredited certification for quality, environment and food safety management systems based on popular ISO standards varies within case study countries. This is also a gap.

The demand for certification has risen in recent times. This is due to increase in consumer awareness and demand for safe and quality products and protection of the environment and other social aspects of life. This has led to increased demand by enterprises for certification. In Africa the current approach still emphasizes individual product certification based on a specification and often a compulsory standard (technical regulation). This system relies on mandatory inspections and unique national (rather than regional or international) standards and testing; and, occasional heavy government involvement in all dimensions of the standards system.

This approach is a challenge because it is not possible to certify all products, the process is slow, increase the cost of business and still not provide the desired assurance of safety. For international markets, the requirements for accredited or approved certification has made the situation worse. In such cases, the certification agency that is approved may have to come from abroad. In other cases, a local certification agency will have to seek accreditation from abroad. Such are the constraints that the producers have to face. Moreover, the entrance of private standards has introduced evermore changing environment driving cost beyond the reach of SMES. Cassava value chains have not been spared from the challenges.

We examined the availability of certification services in the three case study countries **(Table 11)**. The availability of certification services is a limiting factor. For example, in Uganda only UNBS conducts product certification to national standards. These services are highly demanded especially after mandatory certification was established in 2016. On the other hand, most certification agencies in Africa are foreign companies whose headquarters is often Europe. This arises from inadequate local investment into these services, the high costs of getting accreditation and low demand for such services. The low demand creating low investment and supply leads to an egg and chicken dilemma.

Any program to promote standards and conformity assessment for cassava value chains will do well to explore new approaches. For the international market, this only requires a government to government MRA supported by an accreditation regime. A regional approach to recognize product certification could be explored. Further studies on this deserves additional considerations. We return to this subject in section 5.

3.4.4.5 Verification

Verification a process used to ascertain the accuracy of measures used in trade is an important function of legal metrology. Verification in legal metrology and in conformity assessment in general, pertains to the examination and marking and / or issuing of a verification certificate for a measuring system. Verification has two elements, the traceability of the measurements to international standards and verification that measures used in trade are verified. The former has a link to calibration and the linkage of that calibration to international measurements standards. The latter is an inspection function which requires demonstration of competence by the verification laboratories or bodies. Majority of Africa countries need to create these linkages.

4 CASSAVA INDUSTRY STAKEHOLDERS

4.1 Major stakeholders along the cassava value chain

The major stakeholders along the cassava value chain include: National Standards Bodies; National agricultural research agencies; Trade and export promotion departments; Departments responsible for transportation; National farmer organizations; National chambers of commerce; Departments responsible for infrastructure planning, development and maintenance; Agencies responsible for aviation and national ports and harbours; In-country Liaison offices for RECs e.g. the EAC, SADC and the COMESA; In-country office for WFP, and UNHCR; Private sector trades organizations; Farmers; Processors; Warehouse and Logistics Actors; National Quality Infrastructure Institutions; and Government Departments and Agencies Responsible for Trade Development.

The sections below discuss how the above stakeholders can be engaged to build better quality infrastructure, along the cassava value chain.

4.2 Role of different stakeholders in standards and conformity assessment

4.2.1 General

Standard setting process is based on consensus between the various industry players and other interested stakeholders. From a practical perspective, cooperation is needed between a broad range of stakeholders, including NSBs, public authorities, industry and societal stakeholders and other interested stakeholders. These organizations contribute to standards quality by providing additional expertise in the technical work (specifically related to the interest they represent), bring additional legitimacy and provide resources to the process.

In addition, it is the stakeholders usually outside the standards setting organizations that implement the standards. This can be for regulation, conformity assessment, production and distribution of products. It is the stakeholders who drive the sustainability of standardization by bringing resources and using the products of standardization

4.2.2 Quality infrastructure institutions

NSBs play an important role in developing standards at national, regional and international levels. They enable the interested parties (industry and other stakeholders) to participate in the elaboration and harmonization of standards.

NSBs act as a platform composed of two main parts: a secretariat and a network responsible for handling all administrative and practical matters of the network and for ensuring that the standards are developed according to agreed-upon (open, transparent, inclusive) processes.

Many NSBs under take conformity assessment activities including certification, testing, calibration and inspection (market surveillance).

Other quality infrastructure institutions outside NSBs including accreditation, certification, testing, validation, verification, laboratories complement the role of NSBs.

4.2.3 Industry

Standards are initiated, developed and used by industry. Industry can participate in the development and harmonization of standards through direct membership in technical committees or and industry associations. SMEs or organisations representing SMES have a specific role and challenges in standardization.

Industry usually provides the majority of the experts that contribute to the development of standards. In some countries Industry also finances the costs of developing standards, through the supply of voluntary experts to participate in the technical committees. They also contribute through the purchase of published standards, certification and other conformity assessment services.

Industry plays a particularly useful role in providing information and data on products and processes; and research and innovations that take place in specific industry sectors.

Industry actors may also invest into conformity assessment infrastructure including laboratories, certification and calibration services.

4.2.4 Government Authorities and Regulators

Government authorities and regulators have a direct interest in standardization due to the role in protecting health, safety of citizens (consumers, workers and other interest groups e.g. people with disabilities) and environment, promoting industry competitiveness, and controlling access to internal and foreign markets. Government also has oversight roles of the NSBs, market surveillance, accreditation and related sectors. Government authorities and regulators have a permanent role which is essential in the context of their statutory objectives. They bring in policy, legislative and regulatory information, data and perspective to the standard development and harmonization process. They ensure that standards serve the role of supporting the achievement of policy legislative and regulatory objectives.

The roles of accreditation and market surveillance are largely regulatory functions. Some of such functions may be liberalized or subcontracted while government retains the oversight role.

4.2.5 Societal Interest Groups

Interest groups such as those presenting consumers, environment, and other social groups have no financial interest in participating in standardization. They bring in value that serves society as whole through highlighting issues of health, safety and environment in standards.

4.2.6 Other Interest Groups

There are several other stakeholders that have interest in standardization. These include research institutes, academics, professional associations, innovation agencies, legal experts (e.g. on intellectual property rights (IPR, patents), insurers, trade / labour unions, NGOs and other groups representing specific sectorial activities e.g. projects and independent experts.

4.3 Engaging stakeholders

The WTO principles for the development of standards of transparency, inclusiveness, openness, impartiality and consensus speak directly to the level of involvement of stakeholders. Stakeholder engagement helps to safeguard the outcomes of the standards development and harmonization systems, promote the value, strength and authority of standards and the processes by which they are produced.

Engagement with stakeholders creates opportunities to build relationships, understand concerns, resolve / manage issues, minimize risks and involve those with an interest in the standard being developed and prevents problems occurring later. Engaging stakeholders in any programs to improve competitiveness of cassava and cassava products is essential to realize the benefits.

All stakeholders should be aware of activities in any given sectors. Moreover, standardization is a subject for all stakeholders since most of the people will be consumers in the least. Because resources are limited it is neve possible to engage all stakeholders.

It is anticipated that development in the cassava value chain will engage many stakeholders- at least 200 in each country. Stakeholder selection will benefit from tools such as Power-Interest grid, Willingness-Expertise diagram **(Figure 6 a and b).** In section 2.3.2 criteria for selecting stakeholders are illustrated.

Using a power / interest or expertize willingness grid plot, different stakeholders can be grouped into categories that determine the level of engagement required.

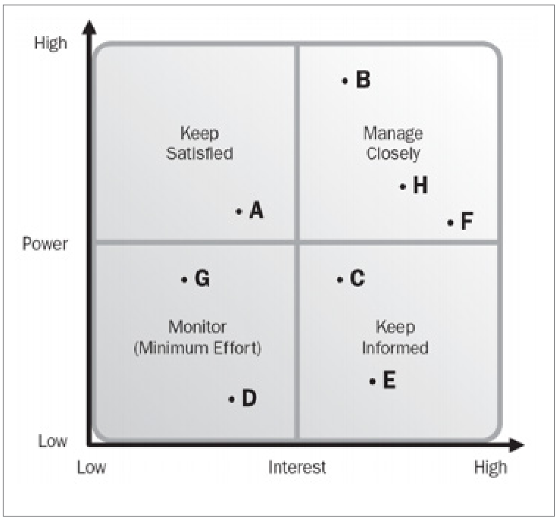

Figure 6a: Power/interest grid plot
Adopted from Jonathan Morris, 2012.

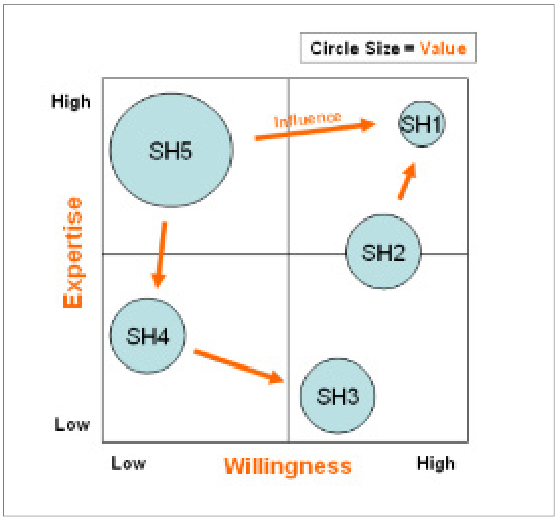

Figure 6b: Expertise/willingness grid plot
Adopted from Jonathan Morris, 2012.

4.4 Criteria for identification and selection of 200 value chain actors

4.4.1 General

To plan for the development of the cassava sector in Africa a number of suggested pre-conditions should be met. Stakeholders should be selected from all the relevant groups including National Standards bodies, accreditation bodies conformity assessment bodies (certification, inspection, testing facilities), regulators, inputs providers (cuttings, fertilizers, pesticides), transporters, exporters and collection centres.

The stakeholder should be selected based on tools such as illustrated in 4.3 by plotting a desired characteristic against counter characteristics e.g. power against interest in a power interest grid.

4.4.2 Primary Target stakeholders

The primary stakeholders in the cassava value chain are farmers and processors.

To successfully provide intervention that can ensure adequate food security in targeted countries, more emphases should be put on medium scale operations. Small-scale operators should be encouraged to form cooperatives for more effective and efficient value chain management. Cassava farmers in many countries are members of cooperatives that are relevant to their areas of farming. This approach has proved to be very successful and it is commonly used by governments and research institutes to introduce different agricultural development programs.

a) Farmers (medium and Large scale farmers)

- Farmers with cassava farms up to 5 acres and who have successfully farmed cassava for over 4 years.
- Level of mechanization on the farm. These farmers should be able to rent tractors for clearing and cultivation.
- They should have primary knowledge on codes of practice; available national standards for their produce certification; herbicide and pesticide application techniques;

Training / certification needs for farmers are as follows: Global GAP, sustainability management system, food safety management system ISO 22000 / TS 2002-3 farming etc.

b) Processors (medium and large scale processors, packaging firms, collecting centres)

- Semi-automated processing plant
- Improved processing area hygiene practices
- Improved cassava storage facility
- Improved finished goods storage facility
- Economic importance of products. Whether they produce primary, secondary and tertiary products. Example, cassava starch has wider industrial usage than gari or fufu and will earn better income.
- Number of employees and farmers that they engage

c) Quality infrastructure institutions and other business support agencies

- Linkages to markets
- Linkages to international recognition arrangements
- Provision of testing services for cassava products
- Provision of certification for cassava products and systmes
- Provision of training services – Training / certification needs for processors are as follows: Hazard Analysis Critical Control Points HACCP, food safety management system ISO 22000 / TS 2002-2 Manufacturing, Current good warehousing practices / services on cold rooms, rodent / pest management(fumigation) etc.
- Provision of innovation and incubation centres

4.5 Criteria for Eligibility

The following items illustrate the kind of criteria that can be used to select participants in any program. These criteria may be used following the methods indicated in section 4.3 to select among the key actors in section 4.1 to be involved at different level of interventions in the cassava chain. Emphasis should be made to ensure quality infrastructure institutions are engaged through out any program to enhance the use of quality infrastructure to promote trade.

1. Legally registered for-profit entity or consortium such as other commercial businesses, farmer cooperatives, consulting firms, and / or business / member associations.
2. Have sufficient funds of their own.
3. Availability of well qualified persons at the firm that could be trained to become proficient in what they do.
4. Have a demonstrable multiplier effect downstream in terms of products and services that they are able to produce.
5. Potential multiplier effect of producing specific products and services should be examined before resources are spent on developing standards for them. This is already standard practice anyway so it only needs to be applied specifically to cassava.
6. Applicants should demonstrate investment opportunities, existing and potential synergies at industry level. They should propose technologies, technology systems, or services that promote farmers' capacities to manage emerging threats and must combine short term benefits of improving cassava market opportunities exposed by the lead firm with opportunities for systemic transformation in the longer term.
7. Successful applicants must demonstrate how their proposed improved capacity and certification project will contribute to food security, as well as applicants' business growth through market change and innovation.
8. Risk Management – the measures taken to transfer risk and / or 1) cope with, 2) protect against (mitigate the impacts of), and 3) reduce the frequency and severity of shocks.
9. Resilience of cassava value chain actors i.e. their ability to mitigate, adapt to, and recover from shocks as well as environmen-

tal, technological and market stresses so as to remain relevant to the value chain.

10. Articulate the market opportunity, including any market constraints faced by the business and how swiftly the product or service can be distributed to the target market and how the product or service will continue to grow / increase in that market.

11. How standardization will impact their business.

12. Sufficient business and management credentials in regards to scaling products or services in their chosen markets.

13. Demonstrate potential for growth of the product or service in the market.

14. Identify any potential capacity gaps in systems or management, and provide solutions for filling those gaps.

15. Budget and Leverage Ratio equal to or better than one-to-one. The budget and leverage ratio should not be included in an applicant's technical evaluation but should be reviewed separately after the technical review of applications is complete. Descending order of preference for leveraged funds includes: cash, contribution in-kind and other sources.

16. Able to meet their ongoing business expenses such as the procurement of commodities from farmers or normal processing and operations expenses

17. Cost effectiveness will be measured as the degree to which the application demonstrates viable resources for in-kind and / or cash contributions; the degree of efficient use of funding resources towards direct costs with direct correlations to the delivery of results; and the ratio of dollar to results.

Cost realism being an assessment of accuracy with which proposed costs represent the most probable cost of performance within the Applicant's technical and management approach. Cost realism to be used to:

a) verify the Applicant's understanding of the requirements;

b) assess the degree to which the cost / price proposal accurately reflects the approaches and / or risk assessments made in the technical and management approach as well as the risk that the Applicant will provide the supplies or services for the offered prices / cost; and

c) assess the degree to which the cost included in the cost / price proposal accurately represents the work effort included in the technical proposal.

5 FRAMEWORK FOR INTRA AFRICA ACCEPTANCE OF CONFORMITY ASSESSMENT AND MEASUREMENT RESULTS FOR THE CASSAVA SECTOR

5.1 General approach

Intra-Africa and international acceptance of conformity assessment and measurement results are necessary for trade. Conformity assessment and measurement results indicate that the requirements set in standards or regulations have been met.

To facilitate trade in the products, Member States could agree that

- Every government has a principal role to protect its territory and citizens. The objectives of protecting the life, safety and health and the environment in their territories is a shared responsibility as citizens move across the continent. A common regulatory framework will facilitate the achievement of such objectives. Formal demonstration of a certification, verification, inspection or laboratories competence to carry out specific tasks provides the required trust for protection of safety, security and environment.
- They have common commitment to the WTO TBT&SPS Agreements that establish the cardinal principles for addressing technical barriers to trade through standards and technical regulations and conformity assessment including sanitary and Phytosanitary measures. The AfCFTA Agreement and the Annexes 6 and 7 on TBT and SPS reaffirm State Parties' commitment to comply with the WTO agreements.
- The level of development amongst the institutions, public and private in the different countries is not the same. Therefore, in the short / medium term, shared resources might address the quality infrastructure challenge.

The benefits of increased trade will drive economic growth and provide the needed income for reinvesting into developing the systems. Such income also contributes to tax and budget of the countries which can be invested to improve the overall economy.

A sector approach with the aim to promote trade of a given sector products within the continent, could act as a stepping stone. The following steps may be considered and are illustrated for the cassava sector in the sections that follow:

a) Harmonize or ensure equivalence of product requirements across the continent

b) Develop conformity assessment capacity to test, certify and inspect against those requirements within the continent

c) Develop capacity to undertake measurements traceability and verification for the sector within the continent

This approach can be scaled up from Member State to RECs and then to the continent. This will enable sharing of resources e.g. through centres of excellence and within the REC.

The next sections describe how this sector approach can be scaled up starting with seeking harmonization or equivalence of regulations (5.2), harmonization of standards (5.3), ways to enable the acceptance of conformity assessment results (5.4), ways to promote acceptance of measurements standard (5.5) and capacity building arrangement (5.6) to support Intra-Africa acceptance of conformity assessments and measurement's results and link the cassava sector with regional and international recognition arrangements.

5.2 Equivalence of Technical Regulations

Regulations establish requirements for products and services and set mandate for institutions to implement them. There are not enough resources to build a multitude of institutions that are necessary to carry out the several mandates.

African governments could focus on a minimum number of essential institutions to ensure the safety of the people and the environment. For example, having a single national metrology (measurements) institute to advance issues of metrology could concentrate resources and advance capacity. This of course will vary the level of development of the economy as some economies may be able to sustain different systems. In some cases, it is also feasible to include the private sector accredited labs in the measurement system, with the NMI mostly providing traceability. The next step is to focus on one sector at time.

Countries could each designate, where necessary, a single institution to deal with cassava value chains. This institution should spearhead all developments that support cassava value chain from production to marketing and help coordinate all other related institutions.

The designated institutions should examine the equivalence of their regulations and work together to improve and facilitate the development of the sector. Collaboration under the RECS and African Union offers a new opportunity for regulatory cooperation and convergence. A common regulatory framework could be an opportunity to streamline and develop single approach to regulations. This can be through establishing equivalence of technical regulations, approximation of regulations or harmonization of standards. This is then followed by a mechanism to mutually recognize conformity assessment and measurements systems.

A common approach is to take advantage of harmonised standards and to encourage regulators to build their technical regulations by adopting / adapting harmonised (voluntary) standards enabling collaborating countries to achieve regulatory objectives using common standards. This promotes transparency since all stakeholder sill know the market requirements and facilitates trade and development.

5.3 Harmonization of Standards

At regional level, harmonization is required to preserve indigenous technologies, production methods and processes, to promote Intra-Africa trade and to advocate for the preparation of international standards concerning products of special interest to African countries. Development of international standards for products of African interest will promote the adoption of these products in the international market and provide market for African products. There are many Africa nationals that live in the diaspora who could well be the first market for such products.

While harmonization of standards can continue at REC level, a sector approach to leapfrog some standards to the continent and international arenas is feasible.

In the cassava value chain, there are few international standards. Africa has multitude of cassava products that could gain market within the continent and beyond. Standards are needed for this products to be produced and promoted. Harmonization of cassava and cassava products standards within the continent and the adoption of these by regulators as a basis for technical regulations, is therefore instructive. The work done at the EAC on cassava could be ceded to the continent ARSO level so that the whole Africa now uses the same standards for the cassava sector. Additionally, Electrotechnology and other standards for equipment necessary for the cassava sector should be identified and harmonized at AFSEC continental level. This will promote mechanization of cassava production and processing.

Once standards are harmonized the challenges in conformity assessment and measurements will be known throughout the continent. It will be possible then to focus resources to develop the infrastructure needed to support conformity assessment against those standards.

ARSO has already undertaken harmonization of more than 20 standards for the cassava value chains. These standards are yet to be adopted even among the countries that participated in their harmonization. Why? This question remains to be answered but by and large it could be because there is more than one regulator for the sector in the countries and not all have bought the idea of the standards. The other reason submitted by some countries is that they are required under the RTA to adopt the REC standards. The case in point here is the arrangement at the EAC where East Africa Standards are de facto mandatory for trading within the region. The lack of adoption of ARSO standards will likely persist as ARSO develops voluntary standards and only the regulator / government can decide to adopt a voluntary standard to make it compulsory. Thus the AUC needs to play a role and this matter should be taken up by the regulatory committee of the AU.

The following approaches could be used to increase up take of harmonized standards:

- Increase awareness on the value of standards, how to implement them through reference in regulations and how to support producers in putting the standards to use.

- Advocate for increased participation of African countries in the activities of ARSO and AFSEC to enhance harmonization of standards at continental level.

- ARSO / AFSEC standards should be promoted including addressing challenges why they are not adopted immediately. Currently, ARSO produces voluntary standards. It can only be adopted if made mandatory in whole or in part. Unless there is an agreement at AU level to adopt a particular standard or part of it, adoption of a voluntary standard cannot be made mandatory. One approach is to seek a mandate from AU to require countries to use those standards to assess all products for trade purposes through a directive. Such a directive could further be used to modify the mandate at the REC level.

- Improve the processes for the harmonization of standards by increasing engagement of stakeholders especially regulators who make decision on market access and public policy decisions to recognize the benefits of using standards.

To gain entry into the international arena and open Africa products to international markets, continental standards should be promoted to international standards. The continental standards organizations ARSO and AFSEC could seek agreements with international organizations such as ISO, IEC and Codex to promote international standards of interest to Africa at international level. An agreement similar to the Vienna Agreement between CEN and ISO where international standards are sponsored or coordinated by CEN and issued as ISO standards and CEN standards concurrently could be explored.

5.4 Cassava sector conformity assessment

5.4.1 General

In the area of conformity assessment generally, the work by ISO and IEC under the Conformity assessment committee (CASCO) has taken prominence at international level. All conformity assessment policies and standards, for example for ISO 17025, ISO 17020 and ISO 17021, are developed by CASCO. Africa countries currently have limited representation a situation that could be a disadvantage. The capacity for local trainers in the continent is still limited partly because few experts from Africa participate in the development of these standards. African countries should up their participation as a way to provide input and also develop expertize in such standards.

ARSO through stakeholders under the ARSO Conformity Assessment Committee (ARSO CACO) has developed the African Conformity Assessment Programme (ACAP). There are however questions as to whether this scheme if feasible in particular its cost implications, the mode of governance and whether it can be adopted as model for Africa.

It is necessary to build capacity in conformity assessment services in the continent to facilitate acceptance of results of conformity assessment. Beyond having capacity in the RECs, a framework for MRAs at continental level will go a long way in enhancing acceptance of conformity assessment results. Such framework already exists and is the core responsibility of AFRAC. AFRAC run an internationally recognised MRA for the acceptance of conformity assessment results. What needs to happen is that this framework needs to be adopted in regulatory space.

5.4.2 Intra-Africa mutual acceptance of conformity assessment results for the cassava sector

The entry point to Intra-Africa acceptance could be recognition of product and system certification. Products certified to an international or continentally accepted standard in one country could freely circulate in the African market. Certification could then be the centre of focus to ensure minimum requirements are met. Such minimum requirements will cover the testing and calibration capacity plus market surveillance ability. This reduces focus to three institutions that can then collaborate to support each other through mutual benefiting programs for common advantage.

All countries need to be able to access credible analysis for analytes or parameters of concern in cassava and cassava products, for example, cyanide which is of concern for safety of cassava products. Once such an analyte or parameters are identified all resources should be used to ensure

- adequate equipment
- laboratory consumable
- certified reference materials and
- competence of personnel to deliver that analysis.

Once minimum capacity is built for the cassava sector laboratories will also be able to undertake proficiency testing schemes, training and even personnel exchange with minimum difficulties.

Countries will also need to be able to access recognized certification, calibration and inspection services.

At the REC level some recognition is already taken place. For example, in the EAC laboratories are designated by Partner States while certification is mutually recognized. The gains in RECs could be upgraded to continental level using the RECs systems as building blocks.

Continental MRAs under AFRAC will facilitate Intra-Africa acceptance of conformity assessment. This should be based on minimum capacity to undertake conformity assessment including testing, certification and inspection.

5.4.3 International recognition of conformity assessment results

The internationally recognized system for conformity assessment recognition worldwide is to achieve accreditation to international standards developed under the ISO / IEC CASCO. Africa may aspire for a national accreditation body in each country in the long run. In the short to medium run, using the services of other countries national and multi-economy accreditation bodies that currently exist in the continent can still bring accreditation closer to economic actors in different economies of African countries. The AfCFTA agreement provides a framework for MRAs. We propose a relationship as illustrated in **Figure 7.**

Conformity assessment institutions should have, at continental level, a common forum (Africa conformity assessment forum (s)) similar to laboratory associations, certification body association or cooperation of inspection authorities. These associations could build from similar associations at national level or the cooperation at REC level. The common forum can oversee capacity building, supervise the various conformity assessment recognition schemes and link the specific conformity assessment component to the continental accreditation cooperation.

The entry point to internationally recognized mutual acceptance of conformity assessment results in countries can only be through accreditation. Institutions that provide conformity assessment services to the economy, namely; certification, inspection, testing, verification and calibration bodies commonly referred to as CABs, should be able to access accreditation services from national or multi-economy (regional) accreditation bodies. These accreditation bodies could cooperate at continental level under MRAs supervised by AFRAC. In turn, AFRAC could link all the CABs in the continent to ILAC / IAF MRAS hence affording the Africa conformity assessment system a link to international recognition.

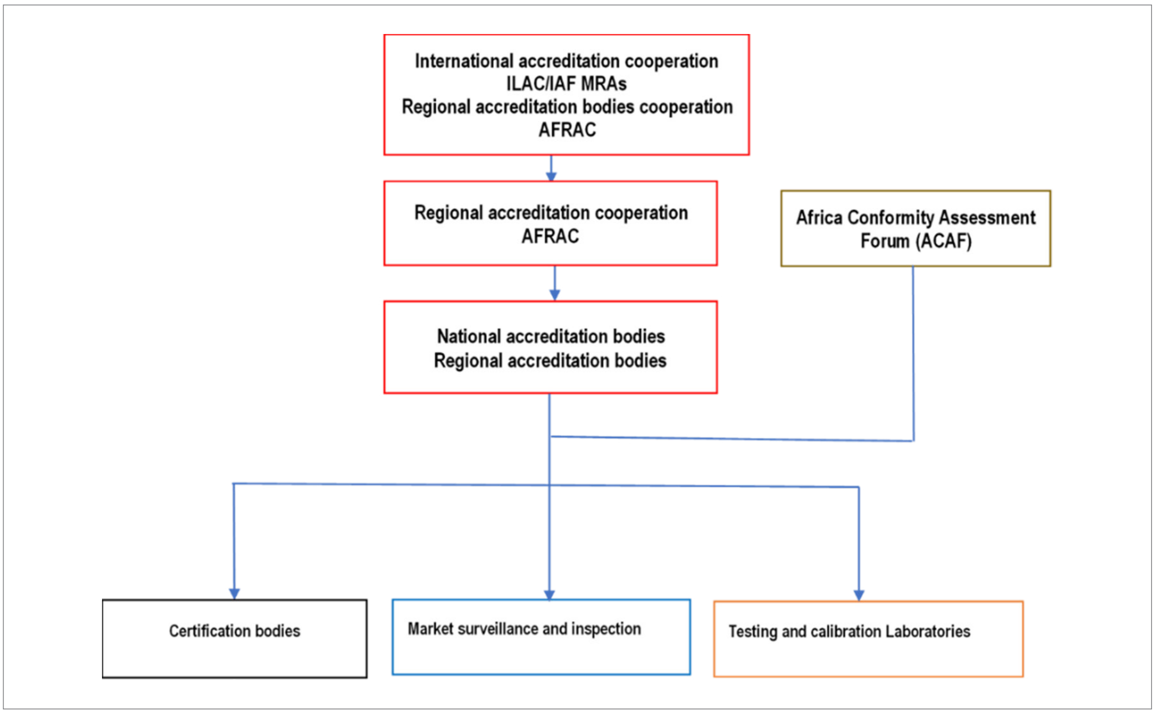

Figure 7: An illustration of cooperation and MRAs for Africa conformity assessment system

5.5 Cassava sector measurement standards

5.5.1 General

African countries will achieve much by working within the principles established at international level, while taking into consideration the fundamental climatic and geographical factors, technological problems and financial and trade needs. African countries should work under the international principles to introduce the continent-specific issues.

Development at international level continues to change. Coping with new international requirement for standards, measurements and conformity assessment has become an unending game. One approach is to ensure that Africa countries participate in developing international standards so that international measurement and conformity assessment standards consider Africa's specific conditions. A progressive sector focused approach could provide an entry point to link Africa's systems to international systems. A regional MRA framework for Intra-Africa acceptance should be the starting point and could link by linking measurements in cassava processing to the international measurement system. We propose a relationship as presented in 5.5.2 and 5.5 3 and illustrated in Fig. 8.

5.5.2 Intra-Africa acceptance

Africa NMIs should build on the cooperation established under AFRIMETS with its sub regional metrology organizations SADCMET, SOAMET, CEMACMET , EAMET , MAGMET and NEWMET, to build capacity on measurements. This enables members to compare their national measurement standards, undertake peer review, participate in proficiency schemes and share resources.

Africa NMIs can participate in AFRIMETS comparative studies and proficiency testing schemes. Those that participate in the Metre Convention can also participate in international comparative studies and the results of both these and the official AFRIMETS studies can be published internationally in the BIPM calibration and measurement capability database – KCDB (currently 15 countries in Africa). Although the capabilities of the others are not eligible for publication in the KCDB and therefore are not internationally recognised, their capabilities could at least be recognised regionally amongst the members of AFRIMETS.

Through the AFRIMETS activities a database of regionally acceptable capabilities can be built. Members State NMIs can then recognize those capabilities for intra-trade. This can continue to grow as capacity building continues.

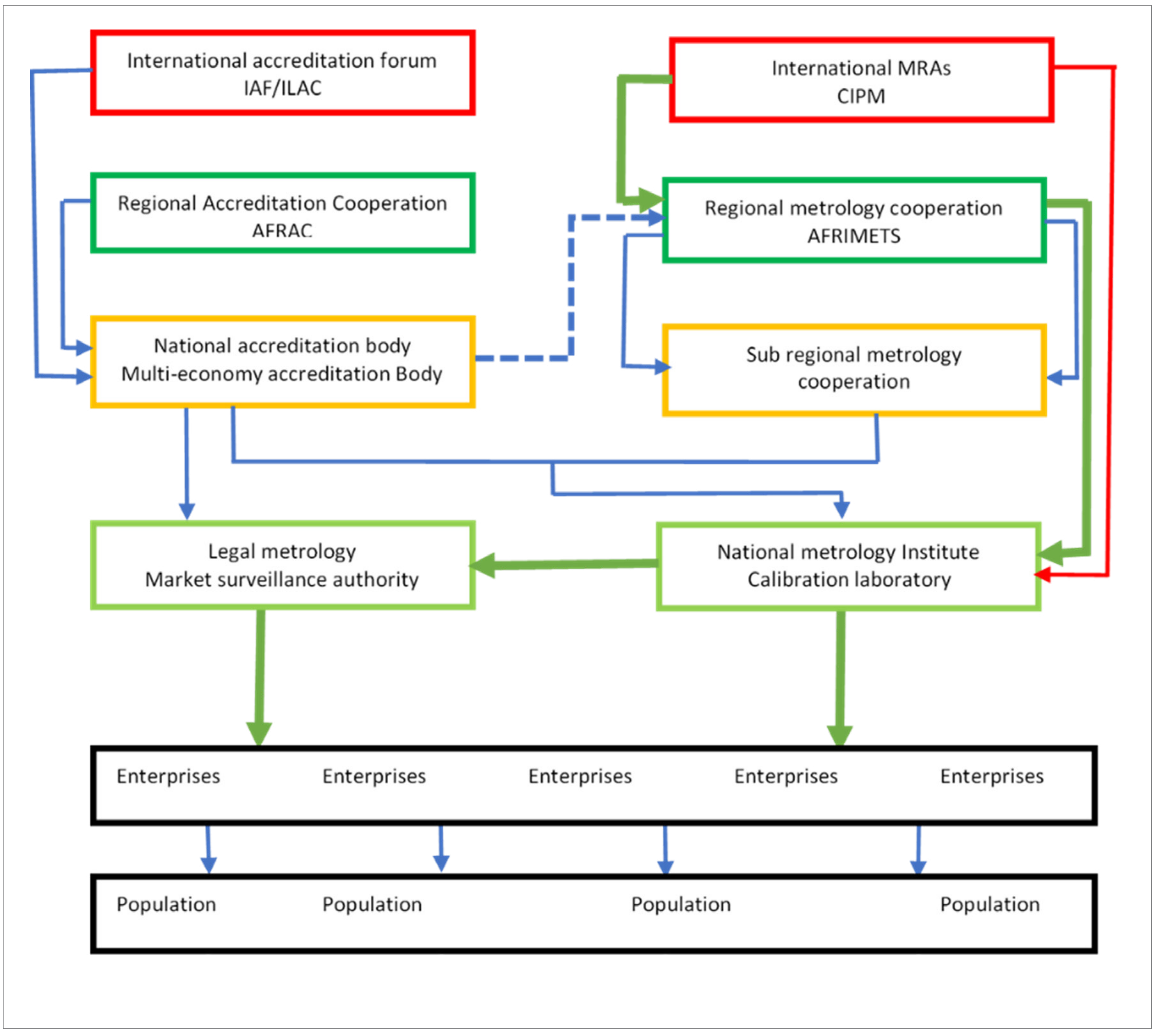

Figure 8: Regional framework for linking cassava processing to international measurement systems (Authors' Proposal)

5.5.3 Linking Africa to international measurement system

Using the traditional accreditation approach to demonstrate competence of the national measurement system is represented on the left. NMIs and national weights and measures systems (measurement verification bodies) seek accreditation. This can be provided by a national or multi-economy accreditation body. Through this accreditation body a link is made to international accreditation forum and the international laboratory cooperation (ILAC) where MLAs and MRAs create a global inter linkages. This system facilitates the mutual acceptance of conformity assessment results. This link can be made through AFRAC in the same manner as conformity assessment recognitions mechanism.

On the right (Fig. 8) is an alternate system that links NMIs to CIPM ensuring that their national measurements standards are internationally recognized. This link can be made directly by the NMI. Currently only five Africa countries are able to use this direct link through being a State Party to the Metre Convention, also called a Member of BIPM. The next option is to link through a regional metrology organization (RMO). This link has been made possible since 1999 by allowing countries to be associate members of the General Conference on Weights and Measures (CGPM). The status of Associate State implies the intention to accede to the Metre Convention and become a Member State at an appropriate time in the future. The NMIs of Associates participate in the MRA through their local regional metrology organization as specified in the text of the CIPM MRA. AFRIMETS has been able to make this link possible for an additional 10 economies in Africa.

The RMOs are responsible for carrying out comparisons and other actions within their regions to support mutual confidence in the validity of the calibration and measurement certificates of their member NMIs. AFRIMETS can therefore facilitate mutual recognition arrangement for African measurements systems. The accreditation bodies could also agree with AFRIMETS on acceptable measurements capabilities within the continent.

The process requires a few steps; 1) become a member of AFRIMETS and participate in the AFRIMETS activities. 2) become an associate member of CGPM or better a State Party to the Metre Convention (Member) and participate in the BIPM and Consultative Committees of the CIPM activities 3) AFRIMETS introduces an intra-regional recognition system for the capabilities of countries that are not a State party or Associate.

This would then mean that the capabilities of the countries that are internationally recognised is by default acceptable for intra-regional trade, and the capabilities of the other members of AFRIMETS are recognised for intra-regional trade. Care will have to be taken that the regional recognition is not confused with the international recognition.

5.6 Capacity building

Mutual support to build capacity of members to fulfil the minimum requirements for their measurement including for traceability to international measurement standards, technical regulations, accreditation and calibration will involve capacity building including training, building of institutions including shared institutions at regional level and common Centres of Excellence within the Regional Economic Communities (RECs).

African countries could together

- seek and share support for specific sector or scope
- advocate for exemptions
- ask for time to comply with given international requirements without being excluded from the market
- make proposals for new unique solutions to developing country challenges and
- related matters.

6 RECOMMENDATIONS

Cassava is a unique product for Africa because of its significance for food security, and potential to transform into an industrial crop. Intra-Africa trade is an important element to facilitate market access and support industrialization. Quality infrastructure is essential for both industrialization and trade. African countries should therefore develop the following to enhance its competitiveness:

1) Harmonized requirements for cassava products to promote trade of cassava products within the region.

2) Advocate for mandate to adopt ARSO standards to partner states from AU and or RECS to enhance the benefits of ARSO standards

3) Enhance cooperation with SPS institution to exploit synergy and improve consistency in standards development and implementation within the continent

4) Enhance collaboration to build capacity of NSBs and experts to develop coherent standards and related requirements to support effective technical regulations on product safety and quality requirements.

5) Promote standardization of cassava products to enhance technology adoption and increase commercialization of cassava

6) Promote proficiency schemes to build capacity of national measurement systems towards mutual recognition arrangements

7) Basing on existence of standards for the products in many of the countries in Africa, assign of progress in commercialising those products, the following products could be certified as a pilot scheme to promote movement of products in the continent: cassava chips, cassava flour, cassava starch and gari

8) Promote participation of NMIs in CGPM of BIPM to facilitate linking of national measurements standards and calibration to international measurements systems through AFRIMETS and for the acceptance of a regional recognition system for those countries Members of AFRIMETS that are not linked to the BIPM or CGPM.

9) A joint capacity building program for cassava quality infrastructure, especially conformity assessment; testing, certification and calibration that are immediately necessary to provide assurance that cassava and cassava products meet requirements.

10) Regional market information systems to benchmark suppliers and buyers of cassava products, sources, prices to support intra-regional trade within the tripartite region.

11) ICT-enabled raw material information tracking system to determine stocks at local level to enable buyers to know the quality and quantity of stocks available, their location, and price and facilitate the cassava purchasing process

12) Raw material testing facilities (linkages between collection centres and existing quality infrastructure and programmes to support compliance with basic quality standards

13) Regional Centres of Excellence showcasing best practices and complementing the actions being implemented at national level.

14) Support supplier-buyer meetings between producers and exporters from the tripartite region.

15) Advocate for MRAs amongst African country CABs-testing, certification, calibration and inspection (surveillance authorities) who are actors for the cassava sector and linking them to international recognition through AFRAC MRAS.

7 AREAS OF RESEARCH COLLABORATION

The areas below require constant generation of information and knowledge. What is applicable for this particular report may not be in a few years' time, considering the dynamic economic environment on the continent.

1. Investment Opportunities, Existing and Potential Synergies at Industry Level

2. Quality and Standardization Competence Development is a costly affair. There needs to be a concerted effort to innovate on how to deliver this service with minimum resources. Globally, there are many researchers in the area of competence development for study and part of the agenda is how to lower the cost of competence development for industry. The same should apply to standardization as an area of endeavour in the commercial world.

3. Effectiveness of the current standards to support industry and meet consumers and environment safety and health objectives. Are standards implemented and facilitating business? Are standards actually having potential multiplier effect of producing specific products? What is the cost-benefit impacts of implementing standards?

4. The area of test methods is an area for detailed examination with a view to increasing harmonization, competence and mutual recognition to facilitate trade.

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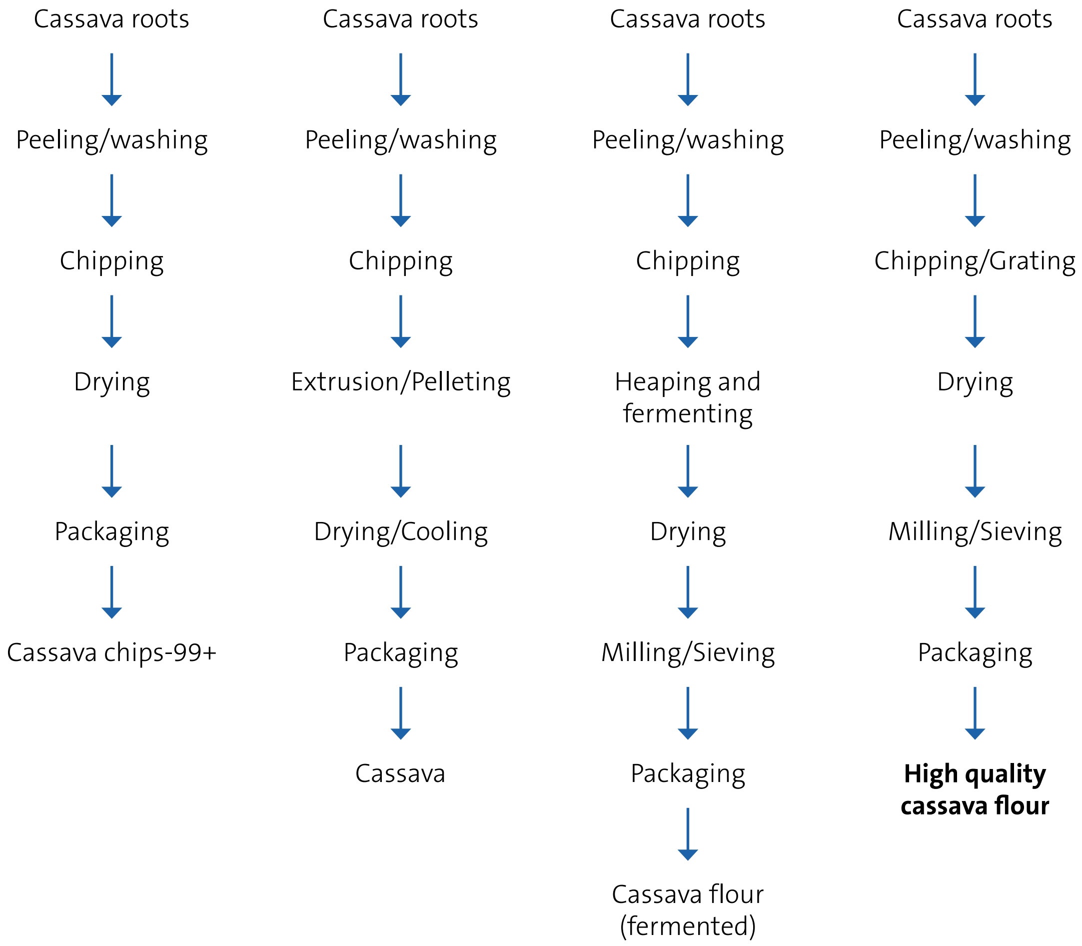
ANNEX A

S/N	A	B	C	D	E	F
	Stages of along the Value Chain	Common technical inputs	Procedures, materials (grey rows); Instrumentation and mechanisms (orange rows)	Current standards (grey rows); Gaps (orange rows)	Current infrastructure (grey rows); Gaps (orange rows)	Existing competencies (grey rows); Gaps (orange rows)
1	Production – field production	Land preparation; Genetic resources; pest, disease and weed control; soil improvements; plant nutrition; crop health surveillance; weather data; crop water management; farm equipment; farm infrastructure e.g. irrigation systems	Bush clearing; cultivation; planting; weeding, rationing, pesticide application and other husbandry operations; field demarcations; variety multiplication; irrigation;	Standards, regulations and conformity assessment procedures for good agricultural practices, use of pesticides, pesticide residues in food and feed, soil conditioners and fertilizers, agriculture water, planting materials	Irrigation infrastructure Roads Transport systems including cold chain for fresh produce;	Competences in regulations, standards, metrology and conformity assessment processes Capacity to undertake recognised conformity assessment activities e.g. testing, certification and accreditation for services to facilitate production of cassava and related products
4	Production – harvesting and post-harvest practices					
6	Field Production, harvesting and post-harvest OSH					
7						
22	Compliance, Conformity assessment	Surveillance, Inspection, Metrology,				
30	Cassava competitiveness with other staples at the level of energy provision from starch					
31	What are the key starch sources in industry food					

ANNEX A: FRAMEWORK (TOOL) USED TO COLLECT DATA ON STATUS AND GAPS ALONG THE VALUE CHAIN

ANNEX B

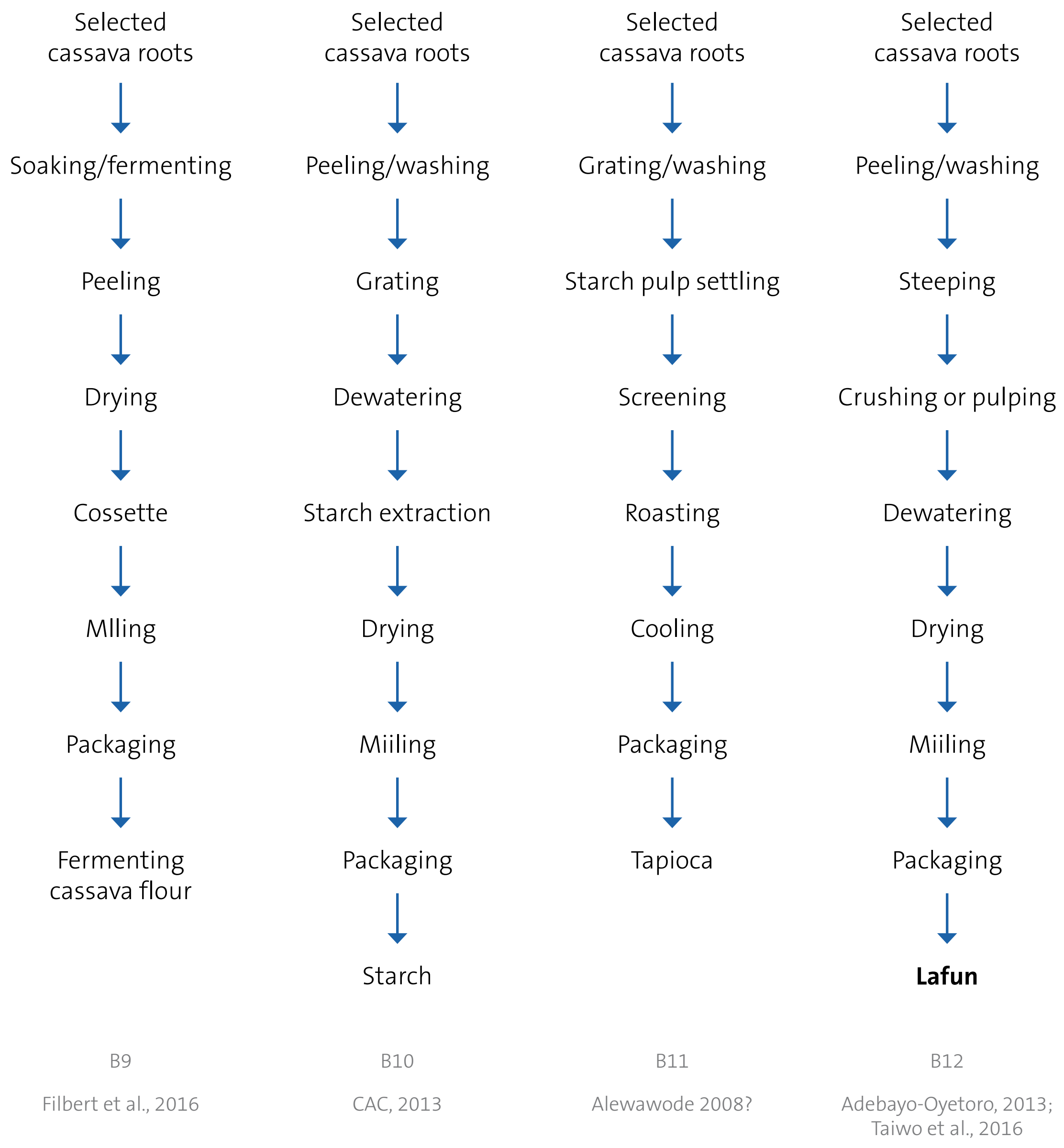


B1	B2	B3	B4
Wilhemina et al., 2009	Adopted from Raji, et al. 2008	Kaaya and Eboku, 2010	Wilhemina et al., 2009

ANNEX B: FLOWCHARTS FOR SELECTED CASSAVA PRODUCTS (2.3.3)

B5	B6	B7	B8
Selected cassava roots	Selected cassava roots	Selected cassava roots	Selected cassava roots
↓	↓	↓	↓
Peeling/washing	Peeling/washing	Peeling/washing	Peeling/washing
↓	↓	↓	↓
Grating	Retting	Grating	Cutting
↓	↓	↓	↓
Dewatering	Pulping	Dewatering and fermenting	Fermenting
↓	↓	↓	↓
Sieving	Pounding	Sieving	Mashing/Pounding
↓	↓	↓	↓
Roasting	Forming/wrapping	Steaming	Dewatering
↓	↓	↓	↓
Packaging	Boiling	Packaging	Fufu
↓	↓	↓	↓
Gari	Packaging	Attiéké	Dring
	↓		↓
	Chikwangwe		**Instant Fufu**
B5	B6	B7	B8
CAC, 2013	COSCA, 2000, CAC, 2013	CAC, 2013, Balagopalan, 2002.	CAC, 2013, Achi and Akomas, 2006

ANNEX B: FLOWCHARTS FOR SELECTED CASSAVA PRODUCTS (2.3.3)



ANNEX B: FLOWCHARTS FOR SELECTED CASSAVA PRODUCTS (2.3.3)

ANNEX C

C1: Standards for inputs and field practices
Nigeria
Seed
• Plant variety and Seeds Regulation, PVSR (2016) Ministry of Agriculture, (Seed Control and Certification Institute, sealing report, pp 89) (TR)
Land preparation
Terminology
• NIS317:1997 Standard for agricultural engineering Machinery: Terminology for tillage and tillage equipment.
Test methods
• NIS318:1997 Standard agricultural engineering machinery: Test code for Agricultural Tillage Disc,
General Crop Nutrition
• NIS 106–10:2018 Standard for Fertilizers; Part 10 – Methods of Sampling of Fertilizer, TM • NIS 967:2017 Standard for Bio–Fertilizer • NIS 582:2009 Standard for solid fertilizers • NIS 106–11:2018 Standard for Fertilizers; Part 11 – Requirements for Packaging and Labelling of Fertilizers • NIS 106–8: 2018 Standard for Fertilizers Part 8 – Solid Organic Fertilizer • NIS 106–7: 2018 Standard for Fertilizers Part 7 – Solid NPK Compound Fertilizer • NIS 106–6:2018 Standard for Fertilizers Part 6 – Solid Inorganic Potash Fertilizer • NIS 106–5: 2018 Standard for Fertilizers Part 5 – Solid Inorganic Phosphate–Potash Fertilizers • NIS 106–1: 2018 Standard for Fertilizers Part 1 – Solid Inorganic Nitrogenous Fertilizer • NIS 106–2: 2018 Standard for Fertilizers Part 2 – Solid Inorganic Nitrogenous–Phosphate Fertilizer, PS • NIS 135:1981 Method of analysis of fertilizers (See NIS 106:2009), TM • NIS 97:2009 Glossary of terms used in fertilizer trade and industry, TD • NIS 80:1980 Method of sampling solid and liquid fertilizers, MS • NIS 106–10:2018 Standard for Fertilizers; Part 10 – Methods of Sampling of Fertilizer, MS • NCP 10: 2009 Code of practice of practice for handling storage fertilizers, CoP • NCP 25: 2009 Code of practice for matching dry fertilizers for bulk blend ingredient
Crop protection
• NIS 969:2017 Standard for Bio-Pesticides • NIS OIMLR 112 Subject: Mech. PP: PG: Status: FD ICS 17.120 High performance liquid chromatographs for measurement of pesticides and other toxic substances
Management standards
• ISO 22000:2018 – Food safety management • Hazard Analysis Critical Control Point (HACCP) Principles • ISO 14001: 2015 – Environmental Management • ISO 9001:2015 – Quality Management System • Certifications to FSSC ISO 22000, GLOBALGAP are required in export markets but are expensive too expensive for small-scale farmers.

Uganda
Seed
• The fertilizer control regulations 2012 • The seeds and plant regulations, 2010
Land preparation
Crop Nutrition
Specifications
• US 1576:2015, Biofertilizer – Specifications • US 1584:2017, Organic fertilizer – Specifications • US 1660:2017, Inorganic foliar fertilizer – Specifications • US 1661:2017, Magnesium sulphate fertilizer – Specifications • US 2038:2019, Blended fertilizer Specifications • US 2078:2019, Organic–inorganic compound fertilizer Specifications • US 2081:2019, Compound microbial fertilizer Specifications • US 756:2017, Urea fertilizer – Specifications • US 757:2017, Ammonium sulphate nitrate fertilizer – Specifications • US 758:2017, Calcium ammonium nitrate fertilizer – Specifications • US 759:2017, Monoammonium phosphate (MAP) and Diammonium phosphate (DAP) fertilizer – Specifications • US 760:2017, Potassium chloride (muriate of potash) fertilizer – Specifications • US EAS 904:2019, Fertilizers – Phosphate rock powder – Specifications • US EAS 905:2019, Fertilizers – Granulated phosphate rock – Specifications • US EAS 906:2019, Fertilizers – Triple superphosphate – Specifications • US EAS 907:2019, Fertilizers – Potassium sulphate (sulphate of potash) – Specifications • US EAS 908:2019, Fertilizers – Potassium chloride (muriate of potash) – Specifications • US EAS 909:2019, Fertilizers – Calcium ammonium nitrate (CAN) – Specifications • US EAS 910:2019, Fertilizers – Urea – Specifications • US EAS 911:2019, Fertilizers – Ammonium sulphate (sulphate of ammonia) – Specifications • US EAS 912:2019, Fertilizers – Nitrogen, Phosphorus, Potassium (NPK) compound – Specifications
Test methods
• US ISO 10084:1992, Soil fertilizers – Determination of mineral–acid–soluble sulfate content – Gravimetric method • US ISO 10249:1996, Fluid fertilizers – Preliminary visual examination and preparation of samples for physical testing • US ISO 15604:2016, Fertilizers – Determination of different forms of nitrogen in the same sample, containing nitrogen as nitric, ammoniacal, urea and cyanamide nitrogen • US ISO 17318:2015, Fertilizers and soil conditioners – Determination of arsenic, cadmium, chromium, lead and mercury contents • US ISO 17319:2015, Fertilizers and soil conditioners – Determination of water–soluble potassium content – Potassium tetraphenylborate gravimetric method • US ISO 17322:2015, Fertilizers and soil conditioners – Analytical methods for Sulfur Coated Urea (SCU) • US ISO 17323:2015, Fertilizers and soil conditioners – Sulphur Coated Urea (SCU) – General requirements • US ISO 18643:2016, Fertilizers and soil conditioners – Determination of biuret content of urea–based fertilizers – HPLC method • US ISO 18644:2016, Fertilizers and soil conditioners – Controlled–release fertilizer – General requirements • US ISO 18645:2016, Fertilizers and soil conditioners – Water soluble fertilizer – General requirements • US ISO 19746:2017, Determination of urea content in urea-based fertilizers by high performance liquid chromatography (HPLC) • US ISO 21263:2017, Slow release fertilizers Determination of the release of the nutrients Method for coated fertilizers • US ISO 25475:2016, Fertilizers – Determination of ammoniacal nitrogen

Uganda
Test methods
• US ISO 3944:1992, Fertilizers – Determination of bulk density (loose) • US ISO 5311:1992, Fertilizers – Determination of bulk density (tapped) • US ISO 5314:1981, Fertilizers – Determination of ammoniacal nitrogen content - Titrimetric method after distillation • US ISO 5315:1984, Fertilizers – Determination of total nitrogen content - Titrimetric method after distillation • US ISO 5316:1977, Fertilizers – Extraction of water-soluble phosphates • US ISO 5317:1983, Fertilizers – Determination of water-soluble potassium content - Preparation of the test solution • US ISO 6598:1985, Fertilizers – Determination of phosphorus content - Quinoline phosphomolybdate gravimetric method • US ISO 7407:1983, Fertilizers – Determination of acid-soluble potassium content - Preparation of the test solution • US ISO 7408:1983, Fertilizers - Determination of ammoniacal nitrogen content in the presence of other substances which release ammonia when treated with sodium hydroxide - Titrimetric method • US ISO 7409:1984, Fertilizers – Marking - Presentation and declarations • US ISO 7497:1984, Fertilizers – Extraction of phosphates soluble in mineral acids • US ISO 7742:1988, Solid fertilizers – Reduction of samples • US ISO 7837:1992, Fertilizers – Determination of bulk density (loose) of fine-grained fertilizers • US ISO 7851:1983, Fertilizers and soil conditioners – Classification • US ISO 8157:2015, Fertilizers and soil conditioners Vocabulary • US ISO 8397:1988, Solid fertilizers and soil conditioners – Test sieving • US ISO 8633:1992, Solid fertilizers – Simple sampling method for small lots US ISO 8634:1991, Solid fertilizers – Sampling plan for the evaluation of a large delivery
Crop Protection Terminology
• US ISO 257:2004, Pesticides and other agrochemicals – Principles for the selection of common names • US 1792-1:2017, Classification of pesticides and stock remedies – Part 1: Pesticides for sale and handling • US 1792-2:2017, Classification of pesticides and stock remedies – Part 2: Stock remedies for sale and handling • Code of practice • US 1793:2018, The handling, storage and disposal of pesticides • US ISO 765:2016, Pesticides considered not to require common names • US ISO 27065:2011, Protective clothing – Performance requirements for protective clothing worn by operators applying liquid pesticides • US 1945:2019, Standard Practice for Conformity Assessment of Protective Clothing Worn by Operators Applying Pesticides
Specifications
• US 1577:2015, Biopesticides – Specifications

Zambia
Seed
• Seed crop register. Seed Control and Certification Institute, SCCI (2016) Chilanga
Land preparation
• ZS 905 2016, Agricultural Hand Hoes – Specifications • ZS 909: 2015, Agricultural Machinery – Mouldboard Plough – Specifications • ZS 966: 2016, Agricultural Machinery – Method of Sampling • ZS 967: 2016, Engineering Materials – Bolts and Nuts for Agricultural Machines – Specifications • ZS 968: 2016, Engineering Materials – Screws for Agricultural Machines – Specifications and Applications • ZS 969: 2016, Engineering Materials – Washers for Agricultural Machines – Specifications and Applications
Crop Nutrition
Specifications
• ZS 431: 2014, Compound Fertilizers • ZS 605:2014, Fertilizers – Urea – Specifications • ZS 606: 2014, Fertilizers – Ammonium nitrate – Specifications • ZS 607: 2014, Fertilizers – Calcium ammonium nitrate (C.A.N.) – Specifications • ZS 608:2014, Fertilizers – Ammonium sulphate – Specifications • ZS 609:2004, Fertilizers – Sulphate of potash – Specifications • ZS 610:2004, Fertilizers – Potassium chloride – Specifications • ZS 611: 2010, Cooked Cured Chopped Meat – Specifications • ZS 612:2004, Fertilizers – Magnesium nitrate – Specifications • ZS 613: 2004, Fertilizers – Single super phosphate – Specifications • ZS 614: 2004, Fertilizers – Triple super phosphate – Specifications • ZS 615:2004, Fertilizers – Calcium nitrate – Specifications • ZS 383-2:2013, Lime-Part 2: Lime for Agricultural Purposes – Specifications
Sampling and test methods
• ZS 399: 2013, Sampling of lime – Specifications • ZS 324 Part 1 2004, Fertilizers – Test Methods Part 1: Determination of Total Phosphorous: Spectrophotometric Method. • ZS 324 Part 2 2004, Fertilizers – Test Methods Part 2: Determination of Total Phosphorous: Quinolinium Phosphomolybdate Method • ZS 324 Part 3 2004, Fertilizers – Test Methods Part 3: Determination of Total Nitrogen: Kjeldahl Method specifies the determination of total nitrogen in fertilizers using the Kjeldahl method. • ZS 324 Part 4 2004, Fertilizers – Test Methods Part 4: Determination of Zinc by Atomic Absorption Spectrophotometry Specifies the determination of Zinc in fertilizers by Atomic Absorption Spectrophotometry. • ZS 324 Part 5 2004, Fertilizers –Test Methods Part 5: Determination of Boron: Spectrophotometric Method • ZS 324 Part 6 2004, Fertilizers – Test Methods Part 6: Determination of Ammoniacal nitrogen content – Titrimetric Method after distillation • ZS 324 Part 7 2004, Fertilizers – Test Methods Part 7: Determination of Sulphur by Gravimetry • ZS 324 Part 8 2004, Fertilizers – Test Methods Part 8: Determination of Citrate Insoluble Phosphorous by Spectrophoto-metric Method • ZS 324 Part 9 2004, Fertilizers – Test Methods Part 9: Determination of Total Water • ZS 324 Part 10 2004, Fertilizers – Test Methods Part 10: Determination of Potassium: Per chloric Acid Method • ZS 324 Part 11 2004, Fertilizers – Test Methods Determination of Bulk density (Tapped • ZS 324 Part 12 2004, Fertilizers – Test Methods Part 12: Determination of Total Nitrogen Content – Titrimetric method after distillation

Zambia
Sampling and test methods
• ZS 324 Part 13 2004, Fertilizers – Test Methods Part 13: Determination of Nitrate nitrogen content – Nitron gravimetric method • ZS 324 Part 14 2004, Fertilizers – Test Methods Part 14: Extraction of water – soluble phosphates • ZS 324 Part 15 2004, Fertilizers – Test Methods Part 15: Determination of water – soluble potassium content – Preparation of test solution • ZS 324 Part 16 2004, Fertilizers – Test methods, Part 16: Determination of available phosphorous content – Spectrophotometric molybdovandophosphate method • ZS 324 Part 17 2004, Fertilizers – Test Methods Part 17: Determination of potassium content – Titrimetric method • ZS 325 2004, Fertilizers and Soil conditioners – vocabulary Defines terms, relating to fertilizers and soil conditioners. • ZS 326 2004, Fertilizers: Marking – Presentation and Declaration Specifies the procedure for marking containers or labels for fertilizers. • ZS 356 2004, Fertilizers – Sampling Part 1: Sampling of Solid Fertilizers
Code of practices
• ZS 666:2008, Code of practice – Handling and storage of bagged and bulk fertilizers Gives guidance for handling and storage of bagged and bulk fertilizers.
Crop Protection
• ZS ASTM F 1355-06, Standard guide for irradiation of fresh agricultural produce as a Phytosanitary treatment.

C2: Standards for Post-Harvest Handling (Nigeria, Uganda and Zambia)

Nigeria

Machinery

- NIS 321:1997 Standards for agricultural engineering machinery: Test code for groundnut Sheller
- NIS 320:1997 Standard for agricultural engineering machinery: Test code for grain and seed cleaner
- NIS 321:1997 Standards for agricultural engineering machinery: Test code for groundnut Sheller (none for peeling of harvested cassava roots)

Gaps

- No equivalent found for cassava primary crop processing stages Machinery for peeling, grating or chipping of harvested cassava roots

Uganda

Machinery

- US ISO 14159:2002, Safety of machinery – Hygienic requirements for design of machinery
- US ISO 21469:2006,
- Safety of machinery - Lubricants with incidental product contact – Hygiene requirements

Code of practices

- US CAC/RCP 73:2013, Code of practice for reduction of Hydrocyanic Acid (HCN) in cassava and cassava products, Cop
- US EAS 776:2012, Production and handling of fresh cassava - Code of practice

Products

- US EAS 738:2010, Fresh Sweet Cassava – Specifications
- US EAS 778:2012, Fresh bitter cassava – Specifications
- US EAS 780:2012, Fresh cassava leaves – Specifications

Zambia

Machinery

- ZS 963: 2016, Agricultural Machinery – Hammer Mill – Specifications
- ZS 964: 2016, Agricultural Machinery – Hammer Mill – Test Methods
- ZS 965: 2016, Agricultural Machinery – Operators Manual – Content and Presentation
- ZSASTM D4397-10, Standard Specifications for polyethylene sheeting for Construction, Industrial and Agricultural Applicants

Code of practices

- ZS 915: 2016, Code of practice for the reduction of Hydrogen Cyanide (HCN) in Cassava and cassava products
- ZS ASTM F 1355-06, Standard guide for irradiation of fresh agricultural produce as a Phytosanitary treatment.
- ZS 997: 2016, Determination of cyanogen in cassava products
- ZS 998: 2016, Production and handling of fresh cassava – code of practice

Products

- ZS 989: 2016, Fresh sweet Cassava – Specifications
- ZS 990: 2016, Fresh bitter Cassava – Specifications

C3: Standard s for Value Added Cassava Products

Angola

Specifications

- NA 7:2007, Farinha de mandioca comestível (Fuba de bombo)) (Edible manioc flour (Fuba de bombo))

Ghana

Specifications

- GS 237: 2017 Specifications for Gari
- GS 300: 2017 Specifications for Edible Cassava Chips
- GS 676: 2004 Specifications for Cassava Starch (General Purposes)
- GS 560: 2015 Specifications for Fresh Sweet Cassava
- GS 762: 2019 Specifications for Edible Cassava Flour
- GS 868: 2019 Specifications for Fufu Flours
- GS 1057: 2013 Specifications for Composite Flour
- GS 584: 2003 Specifications for Cassava Starch for Industrial use

Ethiopia

Specifications

- ES 3328:2007: Specifications for Dextrins for Textile Industry (Including British Gum),
- ES 3428:2008: Specifications Prescribes the Requirements for Industrial Cassava Starch
- ES 980:2004: Dextrose Monohydrate – Specifications
- ES 982:2004: Glucose Syrup – Specifications
- ES 615:2001: Ethanol – Specifications

Nigeria

Specifications

- NIS 459: 2004 – Standard for Cassava Roots
- NIS 386: 2004 – Standard for Cassava Starch (Food and Industrial Grade)
- NIS 344: 2004 – Standard for Edible Cassava Flour
- NIS 344: 2004 – Standard for Cassava Chips
- NIS 181: 2004 – Standard for Gari

Uganda

Specifications

- US EAS 778:2012, Fresh bitter cassava – Specifications
- US EAS 738:2010, Fresh sweet cassava – Specifications
- US EAS 780:2012, Fresh cassava leaves – Specifications
- US EAS 739:2010, Dried cassava chips – Specifications
- US CODEX STAN 151:1985, Standard for gari
- US EAS 740:2010, Cassava flour – Specifications
- US EAS 741:2010, Cassava composite wheat flour – Specifications
- US EAS 742:2010, Food grade cassava starch – Specifications
- US EAS 743:2010, Cassava crisps – Specifications
- US EAS 779:2012, High quality cassava flour – Specifications

Zambia
Specifications
• ZS 989: 2016, Fresh sweet cassava – Specifications • ZS 990: 2016, Fresh bitter cassava – Specifications • ZS 991: 2016, Cassava flour – Specifications • ZS 992: 2016, Dried cassava chips – Specifications • ZS 993: 2016, High quality cassava flour PS • ZS 994: 2016, Composite flour – Specifications • ZS 995: 2016, Cassava wheat composite flour – Specifications • ZS 996: 2016, Cassava crisps – Specifications • ZS 999: 2016, Food grade cassava starch – Specifications • ZS 700: 2008, Edible Cassava Chips – Specifications • ZS 701: 2008, Edible Cassava Flour – Specifications • ZS 1000: 2016, Cassava bread – Specifications • ZS 1001: 2016, Gari – Specifications

C4: Standards for Packaging of Cassava and Cassava Products
Uganda
• US 28 EAS 39:2002 Code of practice for hygiene in the food and drink manufacturing industry • US 130: 2017, Hazard Analysis Critical Control Point (HACCP) based Food Safety Systems – Requirements (2nd Edition) • US 568: 2005, Packaging for the international transport of fresh fruits or refrigerated fruits and vegetables – Recommendations • US EAS 776:2012, Production and handling of fresh cassava – Code of practice • US 1659:2017, Materials in contact with food – Requirements for packaging materials • US ISO 21067-1:2016, Packaging – Vocabulary – Part 1: General terms • US ISO 21067-2:2015, Packaging and environment • US ISO 21469:2006, Safety of machinery – Lubricants with incidental product contact – Hygiene requirements
Zambia
• ZS 672:2012, Woven polypropylene sacks for bulk packaging of foodstuffs – Specifications • ZS 833:2014, Code of practice for packaging and transport of fresh fruit and vegetables • ZS 891:2015, Corrugated fibreboard boxes – Specifications • ZS 892:2015, Corrugated fibreboard boxes for export of horticultural produce – Specifications • ZS 894: 2015, Paper boards packaging – Specifications • ZS 998: 2016, Production and handling of fresh cassava – code of practice • ZSISO 6590-1, Packaging- sacks- vocabulary and types – part 1: paper sacks • ZSISO 6591-1, Packaging- sacks- description and method of measurement – part 1: empty paper sacks • ZSISO 7023, Packaging- sacks- method of sampling empty sacks for testing. • ZSISO 22002-4, Prerequisite programmes on food safety – Part 4: Food packaging manufacturing

C5: Standards for Electrotechnology
Refrigeration systems
• ZS 840:2014 Refrigeration systems and heat pumps: Flexible pipe elements, vibration isolators Expansion joints and non-metallic tubes – Requirements and classification • ZS 841:2014 Refrigerating systems and heat pumps – Qualification of tightness of components and joints • ZS 842-1:2014 Refrigerating systems and heat pumps – Safety and environmental requirements Part 1: Definitions, classification and selection criteria • ZS 842-2:2014 Refrigerating systems and heat pumps – Safety and environmental requirements – Part 2: Design, construction, testing, marking and documentation • ZS 842-3:2014 Refrigerating systems and heat pumps – Safety and environmental requirements – Part 3: Installation site. • ZS 842-4:2014 Refrigerating systems and heat pumps – Safety and environmental requirements – Part 4: Operation, maintenance, repair and recovery • ZS 843:2014 Mechanical refrigerating systems used for cooling and heating – Safety requirements
Trailers and mills
• ZS 916-:2015, Semi - Trailer – Specifications • ZS 964: 2016 Agricultural Machinery – Hammer Mill – Test Methods • ZSEN 13570 Food processing machinery – mixing machines – safety and hygiene requirements. • ZSEN 13885 Food processing machinery – clipping machines – safety and hygiene requirements • ZSIEC 60204-1 Safety of machinery: Electrical equipment of machines – Part 1: General requirements
Rotating electrical machines
• Rotating electrical machines • ZSCOMESA 282-1:2010 Part 1: Rating and performance • ZSCOMESA 282-3:2010 Rotating electrical machines Part 3: Specific requirements for turbine-type synchronous machines • ZSCOMESA 282-4:2010 Rotating electrical machines Part 4: Methods for determining synchronous machine quantities from tests • ZSCOMESA 282-5:2010 Rotating electrical machines Part 5: Degrees of protection provided by the integral design of rotating electrical machines (IP code) – Classification • ZSCOMESA 282-6:2010 Rotating electrical machines Part 6: Methods of cooling (IC Code) • ZSCOMESA 282-7:2010 Rotating electrical machines Part 7: Classification of types of construction, mounting arrangements and terminal box position (IM Code) • ZSCOMESA 282-8:2010 Rotating electrical machines Part 8: Terminal markings and direction of rotation • ZSCOMESA 282-11:2010 Rotating electrical machine Part 11: Thermal protection • ZSCOMESA 282-22:2010 Rotating electrical machines Part 22: AC generators for reciprocating internal combustion (RIC) engine driven generating sets • ZSCOMESA 282-23:2010 Rotating electrical machines Part 23: Specifications for the refurbishing of rotating electrical machines

C6: List of cassava related standards harmonized in the East African Community (EAC).
Cassava and cassava products
• EAS 738: 2010, Fresh sweet cassava – Specifications • EAS 739: 2010, Dried cassava chips – Specifications • EAS 740: 2010, Cassava flour – Specifications • EAS 742: 2010, Food grade cassava starch – Specifications • EAS 743: 2010, Cassava crisps – Specifications • EAS 744: 2010, Cassava and cassava products – Determination of total cyanogens – Enzymatic assay method • EAS 776:2012, Production and handling of fresh cassava – Code of practice • EAS 778:2012, Fresh bitter cassava – Specifications • EAS 779: 2012, High quality cassava flour – Specifications • 1EAS 780:2012, Fresh cassava leaves – Specifications
Manufactured product that may contain cassava
• EAS 43: 2013, Bread – Specifications (2nd edition) • EAS 63: 2019 Beer – Specifications (3rd edition) • EAS 741: 2010, Cassava composite wheat flour – Specifications • EAS 782: 2019, Composite flour –Specifications (2nd Edition)
Tertiary product
• EAS 349: 2014, Liquid glucose (glucose syrup) – Specifications (2nd edition) • EAS 820: 2014, Dextrose monohydrate (glucose powder) – Specifications
Agriculture inputs
• EAS 904: 2019, Fertilizers – Phosphate rock powder – Specifications (1st Edition) • EAS 905: 2019, Fertilizers – Granulated phosphate rock – Specifications (1st Edition) • EAS 906: 2019, Fertilizers – Triple Superphosphate – Specifications (1st Edition) • EAS 907: 2019, Fertilizers – Potassium sulphate (sulphate of potash) – Specifications (1st Edition) • EAS 908: 2019, Fertilizers – Potassium chloride (muriate of potash) – Specifications (1st Edition) • EAS 909: 2019, Fertilizers – Calcium ammonium nitrate (CAN) – Specifications (1st Edition) • EAS 910: 2019, Fertilizers – Urea – Specifications (1st Edition) • EAS 911: 2019, Fertilizers – Ammonium sulphate (sulphate of ammonia) – Specifications (1st Edition) • EAS 912: 2019, Fertilizers – Nitrogen, Phosphorus, Potassium (NPK) Compound – • EAS 913: 2019, Solid Fertilizers – Methods of sampling (1st Edition)
Animal feeds
• EAS 230: 2001, Maize bran as animal feed – Specifications • EAS 231: 2001, Bone meal for compounding animal feeds – Specifications • EAS 233: 2001, Ostrich feed – Specifications • EAS 55:2019, Compounded pig feeds – Specifications (2nd Edition) • EAS 58: 2000, Dog feeds – Specifications • EAS 75:2019, Compounded Cattle feed – Specifications (2nd Edition) • EAS 90:2019, Compounded poultry feeds – Specifications (2nd Edition) • EAS 973:2019, Compounded fish feeds – Specifications (1st Edition) • EAS 974:2018, Compounded dairy goat feeds – Specifications (1st edition)

Food safety management
• EAS 151: 2000, Hazard analysis critical control points (HACCP) • EAS 39: 2000, Hygiene in the food and drink manufacturing industry – Code of practice
Food labelling
• EAS 803: 2014, Nutrition labelling – Requirements • EAS 804: 2014, Claims on foods – Requirements • EAS 805: 2014, Use of nutritional and health claims – Requirement • EAS 38:2014, Labelling of pre-packaged foods – Specifications; 2nd Edition
International standards endorsed at the EAC for testing cassava products
• ISO 712, Cereals and cereal products – Determination of moisture content – Routine reference method • ISO 874 Fresh fruits and vegetables – sampling • EAS 744, Cassava and cassava products – Determination of total cyanogens – Enzymatic assay method • ISO 3094, Fruit and vegetable products – Determination of copper • ISO 6633, Fruit and vegetable products – Determination of lead content – Flameless AAS method • ISO 6634, Fruit and vegetable Products – Determination of arsenic content – Silver diethyldithocarbamate spectrophotometric method • ISO 6637 Fruit and vegetable products – Determination of mercury content – Flameless atomic absorption method • ISO 5498, Agricultural food products – Determination of Crude Fibre Content – Modified Scharrer Method • ISO 2171, Cereals, pulses, and derived products – Determination of total ash • EAS 82, Milled cereal products – Methods of Test (General methods) • ISO 7251 Microbiology of food and animal feeding stuffs – Horizontal method for the detection and enumeration of presumptive Escherichia coli – Most probable number technique • ISO 10520, Native starch – Determination of starch content – Ewers polarimetric method • ISO 16050, Food stuffs – Determination of aflatoxins B1 and total content of aflatoxins B1, B2, G1 and G2 in cereals, nuts, and derived products – High performance liquid chromatographic method • Codex General Standard for Contaminants and Toxins in Food and Feed (CODEX STAN 193)

C7: List of standards available at ARSO

Product standards

- ARS 835:2016(E), Fresh sweet cassava – Specifications
- ARS 836:2016(E), Fresh bitter cassava – Specifications
- ARS 837:2016(E), Fresh cassava leaves – Specifications
- ARS 838:2016(E), Cassava flour – Specifications
- ARS 839:2016(E), Dried cassava chips – Specifications
- ARS 840:2016(E), High quality cassava flour – Specifications
- ARS 841:2016(E), Composite flour – Specifications
- ARS 842:2016(E), Cassava wheat composite flour – Specifications
- ARS 843:2016(E), Cassava crisps – Specifications
- ARS 844:2016(E) Cassava and cassava products – Determination of total cyanogens – Enzymatic assay method
- ARS 845:2016(E), Production and handling of fresh cassava – Code of practice
- ARS 846:2016(E), Food grade cassava starch – Specifications
- ARS 853:2016(E), Cassava bread – Specifications
- ARS 854:2016, Gari – Specifications
- ARS 1103:2018, Production and handling of cassava – Good agricultural practices

List of international standards adopted by ARSO

- CODEX STAN 192, General standard for food additives
- CODEX STAN 193, Codex general standard for contaminants and toxins in food and feed
- ISO 712, Cereals and cereal products – Determination of moisture content – Reference method
- ISO 2171, Cereals, pulses and by-products – Determination of ash yield by incineration
- ISO 2447, Fruit and vegetable products – Determination of tin content
- ISO 4833, Microbiology of food and animal feeding stuffs – Horizontal method for the enumeration of microorganisms – Colony-count technique at 30 degrees C
- ISO 5498, Agricultural food products – Determination of crude fibre content – General method
- ISO 5517, Fruits, vegetables and derived products – Determination of iron content – 1,10- Phenanthroline photometric method
- ISO 6561-1, Fruits, vegetables and derived products – Determination of cadmium content – Part 1: Method using graphite furnace atomic absorption spectrometry
- ISO 6561-2, Fruits, vegetables and derived products – Determination of cadmium content – Part 2: Method using flame atomic absorption spectrometry
- ISO 6579, Microbiology of food and animal feeding stuffs – Horizontal method for the detection of Salmonella spp.
- ISO 6633, Fruits, vegetables and derived products – Determination of lead content – Flameless atomic absorption spectrometric method
- ISO 6634, Fruits, vegetables and derived products – Determination of arsenic content – Silver diethyldithiocarbamate spectrophotometric method
- ISO 6636-1, Fruits, vegetables and derived products – Determination of zinc content – Part 1: Polarographic method
- ISO 7251, Microbiology of food and animal feeding stuffs – Horizontal method for the detection and enumeration of presumptive Escherichia coli – Most probable number technique
- ISO 7952, Fruits, vegetables and derived products – Determination of copper content – Method using flame atomic absorption spectrometry
- ISO 10520, Native starch – Determination of starch content – Ewers polarimetric method
- ISO 16050, Foodstuffs – Determination of aflatoxin B1, and the total content of aflatoxin B1, B2, G1 and G2 in cereals, nuts and derived products – High performance liquid chromatographic method
- ISO 21527-2 Microbiology of food and animal feeding stuffs – Horizontal method for the enumeration of yeasts and moulds – Part 2: Colony count technique in products with water activity less than or equal to 0.95
- ISO 24333, Cereals and cereal products – Sampling

C8: List of standards available at Codex
Specific cassava standards
• CXS 176-1989 – Standard for Edible Cassava Flour • CXS 238-2003 – Standard for Sweet Cassava • CXS 300-2010 – Standard for Bitter Cassava • CXS 151-1985 – Standard for Gari • CXC 73-2013 – Code of Practice for the Reduction of Hydrocyanic Acid (HCN) in Cassava and Cassava Products
Food labelling
• CXS 1-1985 – General Standard for the Labelling of Pre-packaged Foods • CXS 146-1985 – General Standard for the Labelling of and Claims for Pre-packaged Foods for Special Dietary Uses
General standards on food safety
• CXS 192-1995 – General Standard for Food Additives • CXS 193-1995 – General Standard for Contaminants and Toxins in Food and Feed • CXG 14-1991 – Guide for the Microbiological Quality of Spices and Herbs Used in Processed Meat and Poultry Products • CXG 21-1997 – Principles and Guidelines for the Establishment and Application of Microbiological Criteria Related to Foods • CXG 30-1999 – Principles and Guidelines for the Conduct of Microbiological Risk Assessment • CXG 63-2007 – Principles and Guidelines for the Conduct of Microbiological Risk Management (MRM)
Sampling and analysis
• CXS 228-2001 – General Methods of Analysis for Contaminants • CXS 234-1999 – Recommended Methods of Analysis and Sampling • CXS 239-2003 – General Methods of Analysis for Food Additives • CXG 33-1999 – Recommended Methods of Sampling for the Determination of Pesticide Residues for Compliance with MRLs • CXG 40-1993 – Guidelines on Good Laboratory Practice in Pesticide Residue Analysis • CXG 41-1993 – Portion of Commodities to which Maximum Residues Limits Apply and which is Analyzed • CXG 56-2005 – Guidelines on the Use of Mass Spectrometry (MS) for Identification, Confirmation and Quantitative Determination of Residues • CXG 84-2012 – Principles and Guidance on the Selection of Representative Commodities for the Extrapolation of Maximum Residue Limits for Pesticides to Commodity Groups • CXG 90-2017 – Guidelines on Performance Criteria for Methods of Analysis for the Determination of Pesticide Residues in Food and Feed
Codes of practices
• CXC 1-1969 – General Principles of Food Hygiene • CXC 2-1969 – Code of Hygienic Practice for Canned Fruit and Vegetable Products • CXC 44-1995 – Code of Practice for Packaging and Transport of Fresh Fruit and Vegetables • CXC 46-1999 – Code of Hygienic Practice for Refrigerated Packaged Foods with Extended Shelf Life • CXC 47-2001 – Code of Hygienic Practice for the Transport of Food in Bulk and Semi-Packed Food • CXC 49-2001 – Code of Practice Concerning Source Directed Measures to Reduce Contamination of Foods with Chemicals • CXC 53-2003 – Code of Hygienic Practice for Fresh Fruits and Vegetables • CXC 56-2004 – Code of Practice for the Prevention and Reduction of Lead Contamination in Foods

C9: List of ISO standards may be applicable to cassava and cassava products
Management
• ISO 14001:2015, Environmental management systems – Requirements with guidance for use • ISO 9001:2015, Quality management systems – Requirements
Specifications
• ISO/WD 24683, High fructose syrup- Specifications and test methods • ISO/DIS 24081, Ground cassava leaves (ISOMBE) – Specifications
Test methods
• A list of standards on starch is here. • ISO 1666:1996, Starch – Determination of moisture content – Oven-drying method • ISO 1741:1980, Dextrose – Determination of loss in mass on drying – Vacuum oven method • ISO 1742:1980, Glucose syrups – Determination of dry matter – Vacuum oven method • ISO 1743:1982, Glucose syrup – Determination of dry matter content – Refractive index method • ISO 3188:1978, Starches and derived products – Determination of nitrogen content by the Kjeldahl method – Titrimetric method • ISO 3593:1981, Starch – Determination of ash • ISO 3946:1982, Starches and derived products – Determination of total phosphorus content – Spectrophotometric method • ISO 3947:1977, Starches, native or modified – Determination of total fat content • ISO 5377:1981, Starch hydrolysis products – Determination of reducing power and dextrose equivalent – Lane and Eynon constant titre method • ISO 5378:1978, Starches and derived products – Determination of nitrogen content by the Kjeldahl method – Spectrophotometric method • ISO 5379:2013, Starches and derived products – Determination of sulfur dioxide content – Acidimetric method and nephelometric method • ISO 5381:1983, Starch hydrolysis products – Determination of water content – Modified Karl Fischer method • ISO 5809:1982, Starches and derived products – Determination of sulphated ash • ISO 5810:1982, Starches and derived products – Determination of chloride content – Potentiometric method • ISO 10504:2013, Starch derivatives – Determination of the composition of glucose syrups, fructose syrups and hydrogenated glucose syrups – Method using high-performance liquid chromatography • ISO 10520:1997, Native starch – Determination of starch content – Ewers polarimetric method • ISO 11212-1:1997, Starch and derived products – Heavy metals content – Part 1: Determination of arsenic content by atomic absorption spectrometry • ISO 11212-2:1997, Starch and derived products – Heavy metals content – Part 2: Determination of mercury content by atomic absorption spectrometry • ISO 11212-3:1997, Starch and derived products – Heavy metals content – Part 3: Determination of lead content by atomic absorption spectrometry with electrothermal atomization • ISO 11212-4:1997, Starch and derived products – Heavy metals content – Part 4: Determination of cadmium content by atomic absorption spectrometry with electrothermal atomization • ISO 11212-4:1997/COR 1:1997, Starch and derived products – Heavy metals content – Part 4: Determination of cadmium content by atomic absorption spectrometry with electrothermal atomization – Technical Corrigendum 1 • ISO 11213:1995, Modified starch – Determination of acetyl content – Enzymatic method • ISO 11214:1996, Modified starch – Determination of carboxyl group content of oxidized starch • ISO 11215:1998, Modified starch – Determination of adipic acid content of acetylated di-starch adipates – Gas chromatographic method • ISO 11216:1998, Modified starch – Determination of content of carboxymethyl groups in carboxymethyl starch • ISO 11543:2000, Modified starch – Determination of hydroxypropyl content – Method using proton nuclear magnetic resonance (NMR) spectrometry

Ethanol
A list of standards for [industrial ethanol is here.]

- ISO 1388-1:1981, Ethanol for industrial use – Methods of test – Part 1: General
- ISO 1388-2:1981, Ethanol for industrial use – Methods of test – Part 2: Detection of alkalinity or determination of acidity to phenolphthalein
- ISO 1388-3:1981, Ethanol for industrial use – Methods of test – Part 3: Estimation of content of carbonyl compounds present in small amounts – Photometric method
- ISO 1388-4:1981, Ethanol for industrial use – Methods of test – Part 4: Estimation of content of carbonyl compounds present in moderate amounts – Titrimetric method
- ISO 1388-5:1981, Ethanol for industrial use – Methods of test – Part 5: Determination of aldehydes content – Visual colorimetric method
- ISO 1388-6:1981, Ethanol for industrial use – Methods of test – Part 6: Test for miscibility with water
- ISO 1388-7:1981, Ethanol for industrial use – Methods of test – Part 7: Determination of methanol content (methanol contents between 0,01 and 0,20 % (V/V)) – Photometric method
- ISO 1388-8:1981, Ethanol for industrial use – Methods of test – Part 8: Determination of methanol content (methanol contents between 0,10 and 1,50 % (V/V)) – Visual colorimetric method
- ISO 1388-9:1981, Ethanol for industrial use – Methods of test – Part 9: Determination of esters content – Titrimetric method after saponification
- ISO 1388-10:1981, Ethanol for industrial use – Methods of test – Part 10: Estimation of hydrocarbons content – Distillation method
- ISO 1388-11:1981, Ethanol for industrial use – Methods of test – Part 11: Test for detection of furfural
- ISO 1388-12:1981, Ethanol for industrial use – Methods of test – Part 12: Determination of permanganate time

Fruit and vegetables
A list of ISO standards for [fruits and vegetables that may apply to cassava are here.]

- ISO 750:1998, Fruit and vegetable products – Determination of titratable acidity
- ISO 751:1998, Fruit and vegetable products – Determination of water-insoluble solids
- ISO 762:2003, Fruit and vegetable products – Determination of mineral impurities content
- ISO 763:2003, Fruit and vegetable products – Determination of ash insoluble in hydrochloric acid
- ISO 874:1980, Fresh fruits and vegetables – Sampling ISO 1026:1982, Fruit and vegetable products – Determination of dry matter content by drying under reduced pressure and of water content by azeotropic distillation
- ISO 1842:1991, Fruit and vegetable products – Determination of pH ISO 1956-1:1982, Fruits and vegetables – Morphological and structural terminology
- ISO 1956-2:1989, Fruits and vegetables – Morphological and structural terminology
- ISO 2169:1981, Fruits and vegetables – Physical conditions in cold stores – Definitions and measurement
- ISO 2447:1998, Fruit and vegetable products – Determination of tin content ISO 2448:1998, Fruit and vegetable products – Determination of ethanol content
- ISO 3634:1979, Vegetable products – Determination of chloride content ISO 3659:1977, Fruits and vegetables – Ripening after cold storage ISO 5515:1979, Fruits, vegetables and derived products – Decomposition of organic matter prior to analysis – Wet method
- ISO 5516:1978, Fruits, vegetables and derived products – Decomposition of organic matter prior to analysis – Ashing method
- ISO 5517:1978, Fruits, vegetables and derived products – Determination of iron content – 1,10- Phenanthroline photometric method
- ISO 5518:2007, Fruits, vegetables and derived products – Determination of benzoic acid content – Spectrophotometric method
- ISO 5519:2008, Fruits, vegetables and derived products – Determination of sorbic acid content
- ISO 5520:1981, Fruits, vegetables and derived products – Determination of alkalinity of total ash and of water-soluble ash
- ISO 5522:1981, Fruits, vegetables and derived products – Determination of total sulphur dioxide content
- ISO 6557-1:1986, Fruits, vegetables and derived products – Determination of ascorbic acid – Part 1: Reference method
- ISO 6557-2:1984, Fruits, vegetables and derived products – Determination of ascorbic acid content – Part 2: Routine methods

Fruit and vegetables
• ISO 6558-2:1992, Fruits, vegetables and derived products – Determination of carotene content – Part 2: Routine methods • ISO 6560:1983, Fruit and vegetable products – Determination of benzoic acid content (benzoic acid contents greater than 200 mg per litre or per kilogram) – Molecular absorption spectrometric method • ISO 6561-1:2005, Fruits, vegetables and derived products – Determination of cadmium content – Part 1: Method using graphite furnace atomic absorption spectrometry • ISO 6561-2:2005, Fruits, vegetables and derived products – Determination of cadmium content – Part 2: Method using flame atomic absorption spectrometry • ISO 6632:1981, Fruits, vegetables and derived products – Determination of volatile acidity • ISO 6633:1984, Fruits, vegetables and derived products – Determination of lead content – Flameless atomic absorption spectrometric method • ISO 6634:1982, Fruits, vegetables and derived products – Determination of arsenic content – Silver diethyldithiocarbamate spectrophotometric method • ISO 6635:1984, Fruits, vegetables and derived products – Determination of nitrite and nitrate content – Molecular absorption spectrometric method • ISO 6636-1:1986, Fruits, vegetables and derived products – Determination of zinc content – Part 1: Polarographic method • ISO 6636-2:1981, Fruits, vegetables and derived products – Determination of zinc content – Part 2: Atomic absorption spectrometric method • ISO 6636-3:1983, Fruit and vegetable products – Determination of zinc content – Part 3: Dithizone spectrometric method • ISO 6637:1984, Fruits, vegetables and derived products – Determination of mercury content – Flameless atomic absorption method • ISO 6822:1984, Potatoes, root vegetables and round-headed cabbages – Guide to storage in silos using forced ventilation • ISO 6949:1988, Fruits and vegetables – Principles and techniques of the controlled atmosphere method of storage • ISO 7466:1986, Fruit and vegetable products – Determination of 5-hydroxymethylfurfural (5-HMF) content • ISO 7558:1988, Guide to the prepacking of fruits and vegetables • ISO 7563:1998, Fresh fruits and vegetables – Vocabulary • ISO 7952:1994, Fruits, vegetables and derived products – Determination of copper content – Method using flame atomic absorption spectrometry • ISO 9526:1990, Fruits, vegetables and derived products – Determination of iron content by flame atomic absorption spectrometry • ISO 9719: 1995, Root vegetables – Cold storage and refrigerated transport • ISO 17239:2004, Fruits, vegetables and derived products – Determination of arsenic content – Method using hydride generation atomic absorption spectrometry • ISO 17240:2004, Fruit and vegetable products – Determination of tin content – Method using flame atomic absorption spectrometry
Cereals and pulses
• ISO 712:2009, Cereals and cereal products — Determination of moisture content — Reference method • ISO 2164:1975, Pulses — Determination of glycosidic hydrocyanic acid • ISO 2171:2007, Cereals, pulses and by-products — Determination of ash yield by incineration
Microbiological methods
The list of ISO standards for microbiological analyses of foodstuffs are here. • IISO 4831:2006, Microbiology of food and animal feeding stuffs – Horizontal method for the detection and enumeration of coliforms – Most probable number technique • ISO 4832:2006, Microbiology of food and animal feeding stuffs – Horizontal method for the enumeration of coliforms – Colony-count technique • ISO 4833-1:2013, Microbiology of the food chain – Horizontal method for the enumeration of microorganisms – Part 1: Colony count at 30 °C by the pour plate technique • ISO 4833-1:2013/DAMD 1, Microbiology of the food chain – Horizontal method for the enumeration of microorganisms – Part 1: Colony count at 30 °C by the pour plate technique – Amendment 1: Clarification of scope • ISO 4833-2:2013, Microbiology of the food chain – Horizontal method for the enumeration of microorganisms – Part 2: Colony count at 30 °C by the surface plating technique

Microbiological methods

- ISO 4833-2:2013/COR 1:2014, Microbiology of the food chain – Horizontal method for the enumeration of microorganisms – Part 2: Colony count at 30 °C by the surface plating technique – Technical Corrigendum 1
- ISO 4833-2:2013/DAMD 1, Microbiology of the food chain – Horizontal method for the enumeration of microorganisms – Part 2: Colony count at 30 °C by the surface plating technique – Amendment 1: Clarification of scope
- ISO 6579-1:2017, Microbiology of the food chain – Horizontal method for the detection, enumeration and serotyping of Salmonella – Part 1: Detection of Salmonella spp.
- ISO 6579-1:2017/AMD 1:2020, Microbiology of the food chain – Horizontal method for the detection, enumeration and serotyping of Salmonella – Part 1: Detection of Salmonella spp. – Amendment 1: Broader range of incubation temperatures, amendment to the status of Annex D, and correction of the composition of MSRV and SC
- ISO/TS 6579-2:2012, Microbiology of food and animal feed – Horizontal method for the detection, enumeration and serotyping of Salmonella – Part 2: Enumeration by a miniaturized most probable number technique
- ISO/TR 6579-3:2014, Microbiology of the food chain – Horizontal method for the detection, enumeration and serotyping of Salmonella – Part 3: Guidelines for serotyping of Salmonella spp.
- ISO 6887-1:2017, Microbiology of the food chain – Preparation of test samples, initial suspension and decimal dilutions for microbiological examination – Part 1: General rules for the preparation of the initial suspension and decimal dilutions
- ISO 6887-2:2017, Microbiology of the food chain – Preparation of test samples, initial suspension and decimal dilutions for microbiological examination – Part 2: Specific rules for the preparation of meat and meat products
- ISO 6887-3:2017, Microbiology of the food chain – Preparation of test samples, initial suspension and decimal dilutions for microbiological examination – Part 3: Specific rules for the preparation of fish and fishery products
- ISO 6887-3:2017/AMD 1:2020, Microbiology of the food chain – Preparation of test samples, initial suspension and decimal dilutions for microbiological examination – Part 3: Specific rules for the preparation of fish and fishery products – Amendment 1: Sample preparation for raw marine gastropods
- ISO 6887-4:2017, Microbiology of the food chain – Preparation of test samples, initial suspension and decimal dilutions for microbiological examination – Part 4: Specific rules for the preparation of miscellaneous products
- ISO 6887-5:2020, Microbiology of the food chain – Preparation of test samples, initial suspension and decimal dilutions for microbiological examination – Part 5: Specific rules for the preparation of milk and milk products
- ISO 6887-6:2013, Microbiology of food and animal feed – Preparation of test samples, initial suspension and decimal dilutions for microbiological examination – Part 6: Specific rules for the preparation of samples taken at the primary production stage
- ISO 6888-1:1999, Microbiology of food and animal feeding stuffs – Horizontal method for the enumeration of coagulase-positive staphylococci (Staphylococcus aureus and other species) – Part 1: Technique using Baird-Parker agar medium
- ISO 6887-5:2020, Microbiology of the food chain – Preparation of test samples, initial suspension and decimal dilutions for microbiological examination – Part 5: Specific rules for the preparation of milk and milk products
- ISO 6887-6:2013, Microbiology of food and animal feed – Preparation of test samples, initial suspension and decimal dilutions for microbiological examination – Part 6: Specific rules for the preparation of samples taken at the primary production stage
- ISO 6888-1:1999, Microbiology of food and animal feeding stuffs – Horizontal method for the enumeration of coagulase-positive staphylococci (Staphylococcus aureus and other species) – Part 1: Technique using Baird-Parker agar medium
- ISO 6888-1:1999/AMD 1:2003, Microbiology of food and animal feeding stuffs – Horizontal method for the enumeration of coagulase-positive staphylococci (Staphylococcus aureus and other species) – Part 1: Technique using Baird-Parker agar medium – Amendment 1: Inclusion of precision data
- ISO 6888-1:1999/AMD 2:2018, Microbiology of food and animal feeding stuffs – Horizontal method for the enumeration of coagulase-positive staphylococci (Staphylococcus aureus and other species) – Part 1: Technique using Baird-Parker agar medium – Amendment 2: Inclusion of an alternative confirmation test using RPFA stab method
- ISO/DIS 6888-1, Microbiology of the food chain – Horizontal method for the enumeration of coagulase-positive staphylococci (Staphylococcus aureus and other species) – Part 1: Technique using Baird-Parker agar medium
- ISO 6888-2:1999, Microbiology of food and animal feeding stuffs – Horizontal method for the enumeration of coagulase-positive staphylococci (Staphylococcus aureus and other species) – Part 2: Technique using rabbit plasma fibrinogen agar medium
- ISO 6888-2:1999/AMD 1:2003, Microbiology of food and animal feeding stuffs – Horizontal method for the enumeration of coagulase-positive staphylococci (Staphylococcus aureus and other species) – Part 2: Technique using rabbit plasma fibrinogen agar medium – Amendment 1: Inclusion of precision data
- ISO/DIS 6888-2, Microbiology of the food chain – Horizontal method for the enumeration of coagulase-positive staphylococci (Staphylococcus aureus and other species) – Part 2: Technique using rabbit plasma fibrinogen agar medium

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• ISO 6888-3:2003, Microbiology of food and animal feeding stuffs – Horizontal method for the enumeration of coagulase-positive staphylococci (Staphylococcus aureus and other species) – Part 3: Detection and MPN technique for low numbers • ISO/CD 6888-3, Microbiology of food and animal feeding stuffs – Horizontal method for the enumeration of coagulase-positive staphylococci (Staphylococcus aureus and other species) – Part 3: Detection and MPN technique for low numbers • ISO 7218:2007, Microbiology of food and animal feeding stuffs – General requirements and guidance for microbiological examinations • ISO 7218:2007/AMD 1:2013, Microbiology of food and animal feeding stuffs – General requirements and guidance for microbiological examinations – Amendment 1 • ISO/WD 7218, Microbiology of the food chain – General requirements and guidance for microbiological examinations • ISO 7251:2005, Microbiology of food and animal feeding stuffs – Horizontal method for the detection and enumeration of presumptive Escherichia coli – Most probable number technique • ISO 7932:2004, Microbiology of food and animal feeding stuffs – Horizontal method for the enumeration of presumptive Bacillus cereus – Colony-count technique at 30 degrees C • ISO 7932:2004/AMD 1:2020, Microbiology of food and animal feeding stuffs – Horizontal method for the enumeration of presumptive Bacillus cereus – Colony-count technique at 30 degrees C – Amendment 1: Inclusion of optional tests • ISO 7937:2004, Microbiology of food and animal feeding stuffs – Horizontal method for the enumeration of Clostridium perfringens – Colony-count technique • ISO 10272-1:2017, Microbiology of the food chain – Horizontal method for detection and enumeration of Campylobacter spp. – Part 1: Detection method • ISO 10272-1:2017/CD AMD 1, Microbiology of the food chain – Horizontal method for detection and enumeration of Campylobacter spp. – Part 1: Detection method – Amendment 1 • ISO 10272-2:2017, Microbiology of the food chain – Horizontal method for detection and enumeration of Campylobacter spp. – Part 2: Colony-count technique • ISO 10272-2:2017/CD AMD 1, Microbiology of the food chain – Horizontal method for detection and enumeration of Campylobacter spp. – Part 2: Colony-count technique – Amendment 1 • ISO 10273:2017, Microbiology of the food chain – Horizontal method for the detection of pathogenic Yersinia enterocolitica • ISO 11133:2014, Microbiology of food, animal feed and water – Preparation, production, storage and performance testing of culture media • ISO 11133:2014/AMD 1:2018, Microbiology of food, animal feed and water – Preparation, production, storage and performance testing of culture media – Amendment 1 • ISO 11133:2014/AMD 2:2020, Microbiology of food, animal feed and water – Preparation, production, storage and performance testing of culture media – Amendment 2 • ISO 11289:1993, Heat-processed foods in hermetically sealed containers – Determination of pH • ISO 11290-1:2017, Microbiology of the food chain – Horizontal method for the detection and enumeration of Listeria monocytogenes and of Listeria spp. – Part 1: Detection method • ISO 11290-2:2017, Microbiology of the food chain – Horizontal method for the detection and enumeration of Listeria monocytogenes and of Listeria spp. – Part 2: Enumeration method • ISO/TS 13136:2012, Microbiology of food and animal feed – Real-time polymerase chain reaction (PCR)-based method for the detection of food-borne pathogens – Horizontal method for the detection of Shiga toxin-producing Escherichia coli (STEC) and the determination of O157, O111, O26, O103 and O145 serogroups • ISO 13307:2013, Microbiology of food and animal feed – Primary production stage – Sampling techniques • ISO 13720:2010, Meat and meat products – Enumeration of presumptive Pseudomonas spp. • ISO 13722:2017, Microbiology of the food chain – Enumeration of Brochothrix spp. – Colony-count technique • ISO/CD 15213-1, Microbiology of the food chain – Horizontal method for the detection and enumeration of Clostridium spp. – Part 1: Enumeration of sulfite-reducing Clostridium spp. by colony-count technique • ISO/CD 15213-2, Microbiology of the food chain – Horizontal method for the detection and enumeration of Clostridium spp. – Part 2: Enumeration of Clostridium perfringens by colony-count technique • ISO/CD 15213-3, Microbiology of the food chain – Horizontal method for the detection and enumeration of Clostridium spp. – Part 3: Detection of Clostridium perfringens • ISO 15213:2003, Microbiology of food and animal feeding stuffs – Horizontal method for the enumeration of sulfite-reducing bacteria growing under anaerobic conditions • ISO 15214:1998, Microbiology of food and animal feeding stuffs – Horizontal method for the enumeration of mesophilic lactic acid bacteria – Colony-count technique at 30 degrees C

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• ISO 15216-1:2017, Microbiology of the food chain – Horizontal method for determination of hepatitis A virus and norovirus using real-time RT-PCR – Part 1: Method for quantification • ISO 15216-1:2017/DAMD 1, Microbiology of the food chain – Horizontal method for determination of hepatitis A virus and norovirus using real-time RT-PCR – Part 1: Method for quantification – Amendment 1 • ISO 15216-2:2019, Microbiology of the food chain – Horizontal method for determination of hepatitis A virus and norovirus using real-time RT-PCR – Part 2: Method for detection • ISO 16140-1:2016, Microbiology of the food chain – Method validation – Part 1: Vocabulary • ISO 16140-2:2016, Microbiology of the food chain – Method validation – Part 2: Protocol for the validation of alternative (proprietary) methods against a reference method • ISO/FDIS 16140-3, Microbiology of the food chain – Method validation – Part 3: Protocol for the verification of reference methods and validated alternative methods in a single laboratory • ISO 16140-4:2020, Microbiology of the food chain – Method validation – Part 4: Protocol for method validation in a single laboratory • ISO 16140-5:2020, Microbiology of the food chain – Method validation – Part 5: Protocol for factorial interlaboratory validation for non-proprietary methods • ISO 16140-6:2019, Microbiology of the food chain – Method validation – Part 6: Protocol for the validation of alternative (proprietary) methods for microbiological confirmation and typing procedures • ISO 16649-1:2018, Microbiology of the food chain – Horizontal method for the enumeration of beta-glucuronidase-positive Escherichia coli – Part 1: Colony-count technique at 44 degrees C using membranes and 5-bromo-4-chloro-3-indolyl beta-D-glucuronide • ISO 16649-2:2001, Microbiology of food and animal feeding stuffs – Horizontal method for the enumeration of beta-glucuronidase-positive Escherichia coli – Part 2: Colony-count technique at 44 degrees C using 5-bromo-4-chloro-3-indolyl beta-D-glucuronide • ISO 16649-3:2015, Microbiology of the food chain – Horizontal method for the enumeration of beta-glucuronidase-positive Escherichia coli – Part 3: Detection and most probable number technique using 5-bromo-4-chloro-3-indolyl-ß-D-glucuronide • ISO 16654:2001, Microbiology of food and animal feeding stuffs – Horizontal method for the detection of Escherichia coli O157 • ISO 16654:2001/AMD 1:2017, Microbiology of food and animal feeding stuffs – Horizontal method for the detection of Escherichia coli O157 – Amendment 1: Annex B: Result of interlaboratory studies • ISO 17410:2019, Microbiology of the food chain – Horizontal method for the enumeration of psychrotrophic microorganisms • ISO 17468:2016, Microbiology of the food chain – Technical requirements and guidance on establishment or revision of a standardized reference method • ISO 17604:2015, Microbiology of the food chain – Carcass sampling for microbiological analysis • ISO/TS 17728:2015, Microbiology of the food chain – Sampling techniques for microbiological analysis of food and feed samples • ISO/TS 17919:2013, Microbiology of the food chain – Polymerase chain reaction (PCR) for the detection of food-borne pathogens – Detection of botulinum type A, B, E and F neurotoxin-producing clostridia • ISO 18465:2017, Microbiology of the food chain – Quantitative determination of emetic toxin (cereulide) using LC-MS/MS • ISO 18593:2018, Microbiology of the food chain – Horizontal methods for surface sampling • ISO 18743:2015, Microbiology of the food chain – Detection of Trichinella larvae in meat by artificial digestion method • ISO 18744:2016, Microbiology of the food chain – Detection and enumeration of Cryptosporidium and Giardia in fresh leafy green vegetables and berry fruits • ISO/TS 18867:2015, Microbiology of the food chain – Polymerase chain reaction (PCR) for the detection of food-borne pathogens – Detection of pathogenic Yersinia enterocolitica and Yersinia pseudotuberculosis • ISO 19020:2017, Microbiology of the food chain – Horizontal method for the immunoenzymatic detection of staphylococcal enterotoxins in foodstuffs • ISO 19036:2019, Microbiology of the food chain – Estimation of measurement uncertainty for quantitative determinations • ISO 19343:2017, Microbiology of the food chain – Detection and quantification of histamine in fish and fishery products – HPLC method

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- ISO/DIS 20836, Microbiology of the food chain – Polymerase chain reaction (PCR) for the detection of food-borne pathogens – Thermal performance testing of thermal cyclers
- ISO/TS 20836:2005, Microbiology of food and animal feeding stuffs – Polymerase chain reaction (PCR) for the detection of food-borne pathogens – Performance testing for thermal cyclers
- ISO 20837:2006, Microbiology of food and animal feeding stuffs – Polymerase chain reaction (PCR) for the detection of food-borne pathogens – Requirements for sample preparation for qualitative detection
- ISO 20838:2006, Microbiology of food and animal feeding stuffs – Polymerase chain reaction (PCR) for the detection of food-borne pathogens – Requirements for amplification and detection for qualitative methods
- ISO 20976-1:2019, Microbiology of the food chain – Requirements and guidelines for conducting challenge tests of food and feed products – Part 1: Challenge tests to study growth potential, lag time and maximum growth rate
- ISO/WD 20976-2, Microbiology of the food chain – Requirements and guidelines for conducting challenge tests of food and feed products – Part 2: Challenge tests to study inactivation potential and kinetic parameters
- ISO 21527-1:2008, Microbiology of food and animal feeding stuffs – Horizontal method for the enumeration of yeasts and moulds – Part 1: Colony count technique in products with water activity greater than 0,95 ISO 21527-2:2008, Microbiology of food and animal feeding stuffs – Horizontal method for the enumeration of yeasts and moulds – Part 2: Colony count technique in products with water activity less than or equal to 0,95
- ISO 21528-1:2017, Microbiology of the food chain – Horizontal method for the detection and enumeration of Enterobacteriaceae – Part 1: Detection of Enterobacteriaceae
- ISO 21528-2:2017, Microbiology of the food chain – Horizontal method for the detection and enumeration of Enterobacteriaceae – Part 2: Colony-count technique
- ISO 21567:2004, Microbiology of food and animal feeding stuffs – Horizontal method for the detection of Shigella spp.
- ISO 21871:2006, Microbiology of food and animal feeding stuffs – Horizontal method for the determination of low numbers of presumptive Bacillus cereus – Most probable number technique and detection method
- ISO 21872-1:2017, Microbiology of the food chain – Horizontal method for the determination of Vibrio spp. – Part 1: Detection of potentially enteropathogenic Vibrio parahaemolyticus, Vibrio cholerae and Vibrio vulnificus
- ISO/PRF TS 21872-2, Microbiology of the food chain – Horizontal method for the determination of Vibrio spp. – Part 2: Enumeration of total and potentially enteropathogenic Vibrio parahaemolyticus in seafood using nucleic acid hybridisation
- ISO 22117:2019, Microbiology of the food chain – Specific requirements and guidance for proficiency testing by interlaboratory comparison
- ISO 22118:2011, Microbiology of food and animal feeding stuffs – Polymerase chain reaction (PCR) for the detection and quantification of food-borne pathogens – Performance characteristics
- ISO 22119:2011, Microbiology of food and animal feeding stuffs – Real-time polymerase chain reaction (PCR) for the detection of food-borne pathogens – General requirements and definitions
- ISO 22174:2005, Microbiology of food and animal feeding stuffs – Polymerase chain reaction (PCR) for the detection of food-borne pathogens – General requirements and definitions

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- ISO/IEC GUIDE 23:1982, Methods of indicating conformity with standards for third-party certification systems
- ISO GUIDE 27:1983, Guidelines for corrective action to be taken by a certification body in the event of misuse of its mark of conformity
- ISO/IEC GUIDE 60:2004, Conformity assessment – Code of good practice
- ISO/IEC GUIDE 68:2002, Arrangements for the recognition and acceptance of conformity assessment results
- ISO/IEC 17000:2020, Conformity assessment – Vocabulary and general principles
- ISO/IEC 17007:2009, Conformity assessment – Guidance for drafting normative documents suitable for use for conformity assessment
- ISO/IEC 17011:2017, Conformity assessment – Requirements for accreditation bodies accrediting conformity assessment bodies
- ISO/IEC 17020:2012, Conformity assessment – Requirements for the operation of various types of bodies performing inspection
- ISO/IEC 17021-1:2015, Conformity assessment – Requirements for bodies providing audit and certification of management systems – Part 1: Requirements
- ISO/IEC 17021-2:2016, Conformity assessment – Requirements for bodies providing audit and certification of management systems – Part 2: Competence requirements for auditing and certification of environmental management systems
- ISO/IEC 17021-3:2017, Conformity assessment – Requirements for bodies providing audit and certification of management systems – Part 3: Competence requirements for auditing and certification of quality management systems

Conformity assessment
• ISO/IEC TS 17021-4:2013, Conformity assessment – Requirements for bodies providing audit and certification of management systems – Part 4: Competence requirements for auditing and certification of event sustainability management systems • ISO/IEC TS 17021-5:2014, Conformity assessment – Requirements for bodies providing audit and certification of management systems – Part 5: Competence requirements for auditing and certification of asset management systems • ISO/IEC TS 17021-6:2014, Conformity assessment – Requirements for bodies providing audit and certification of management systems – Part 6: Competence requirements for auditing and certification of business continuity management systems • ISO/IEC TS 17021-7:2014, Conformity assessment – Requirements for bodies providing audit and certification of management systems – Part 7: Competence requirements for auditing and certification of road traffic safety management systems • ISO/IEC TS 17021-8:2019, Conformity assessment – Requirements for bodies providing audit and certification of management systems – Part 8: Competence requirements for auditing and certification of management systems for sustainable development in communities • ISO/IEC TS 17021-9:2016, Conformity assessment – Requirements for bodies providing audit and certification of management systems – Part 9: Competence requirements for auditing and certification of anti-bribery management systems • ISO/IEC TS 17021-10:2018, Conformity assessment – Requirements for bodies providing audit and certification of management systems – Part 10: Competence requirements for auditing and certification of occupational health and safety management systems • ISO/IEC TS 17021-11:2018, Conformity assessment – Requirements for bodies providing audit and certification of management systems – Part 11: Competence requirements for auditing and certification of facility management (FM) management systems • ISO/IEC TS 17021-12:2020, Conformity assessment – Requirements for bodies providing audit and certification of management systems – Part 12: Competence requirements for auditing and certification of collaborative business relationship management systems • ISO/IEC TS 17023:2013, Conformity assessment – Guidelines for determining the duration of management system certification audits • ISO/IEC 17024:2012, Conformity assessment – General requirements for bodies operating certification of persons • ISO/IEC 17025:2017, General requirements for the competence of testing and calibration laboratories • ISO/IEC TR 17026:2015, Conformity assessment – Example of a certification scheme for tangible products • ISO/IEC TS 17027:2014, Conformity assessment – Vocabulary related to competence of persons used for certification of persons • ISO/IEC TR 17028:2017, Conformity assessment – Guidelines and examples of a certification scheme for services • ISO/IEC 17029:2019, Conformity assessment – General principles and requirements for validation and verification bodies • ISO/IEC 17030:2003, Conformity assessment – General requirements for third-party marks of conformity • ISO/IEC TR 17032:2019, Conformity assessment – Guidelines and examples of a scheme for the certification of processes • ISO/TS 17033:2019, Ethical claims and supporting information – Principles and requirements • ISO 17034:2016, General requirements for the competence of reference material producers • ISO/IEC 17040:2005, Conformity assessment – General requirements for peer assessment of conformity assessment bodies and accreditation bodies • ISO/IEC 17043:2010, Conformity assessment – General requirements for proficiency testing • ISO/IEC 17050-1:2004, Conformity assessment – Supplier's declaration of conformity – Part 1: General requirements • ISO/IEC 17050-2:2004, Conformity assessment – Supplier's declaration of conformity – Part 2: Supporting documentation • ISO/IEC 17065:2012, Conformity assessment – Requirements for bodies certifying products, processes and services • ISO/IEC 17067:2013, Conformity assessment – Fundamentals of product certification and guidelines for product certification schemes

ANNEX D

LIST OF TEST METHODS FOR CASSAVA PRODUCTS

- ISO 712, Cereals and cereal products – Determination of moisture content – Reference method
- ISO 750, Fruit and vegetable products – Determination of titratable acidity.
- ISO 2171, Cereals, pulses and by-products – Determination of ash yield by incineration
- ISO 2447, Fruit and vegetable products – Determination of tin content
- ISO 5498, Agricultural food products – Determination of crude fibre content – General method
- ISO 4833, Microbiology of food and animal feeding stuffs – Horizontal method for the enumeration of microorganisms – Colony-count technique at 30 degrees C
- ARS 844 2014, Cassava and cassava products – Determination of total cyanogens – Enzymatic assay method
- ISO 7952, Fruits, vegetables and derived products – Determination of copper content – Method using flame atomic absorption spectrometry
- ISO 6633, Fruits, vegetables and derived products – Determination of lead content – Flameless atomic absorption spectrometric method
- ISO 6634, Fruits, vegetables and derived products – Determination of arsenic content – Silver diethyldithiocarbamate spectrophotometric method
- ISO 7251, Microbiology of food and animal feeding stuffs – Horizontal method for the detection and enumeration of presumptive Escherichia coli – Most probable number technique
- ISO 21527-2 Microbiology of food and animal feeding stuffs – Horizontal method for the enumeration of yeasts and moulds – Part 2: Colony count technique in products with water activity less than or equal to 0.95
- ISO 10520, Native starch – Determination of starch content – Ewers polarimetric method
- ISO 5517, Fruits, vegetables and derived products – Determination of iron content – 1,10- Phenanthroline photometric method
- ISO 6561-1, Fruits, vegetables and derived products – Determination of cadmium content – Part 1: Method using graphite furnace atomic absorption spectrometry
- ISO 6561-2, Fruits, vegetables and derived products – Determination of cadmium content – Part 2: Method using flame atomic absorption spectrometry
- ISO 6579, Microbiology of food and animal feeding stuffs – Horizontal method for the detection of Salmonella spp.
- ISO 6636-1, Fruits, vegetables and derived products – Determination of zinc content – Part 1: Polarographic method
- ISO 16050, Foodstuffs – Determination of aflatoxin B1, and the total content of aflatoxin B1, B2, G1 and G2 in cereals, nuts and derived products – High performance liquid chromatographic method
- ISO 1871 – 1979 (e) Agricultural Food Products – General Directions for the Determination of Nitrogen by the Kjeldahl Method
- AOAC- 2000, Official Method 915.03, Hydrocyanic Acid Determination B-Alkaline Titration Method). (AOAC)
- EAS 744, Cassava and cassava products – Determination of total cyanogens – Enzymatic assay method
- ISO 3094, Fruit and vegetable products – Determination of copper ISO 6637 Fruit and vegetable products – Determination of mercury content – Flameless atomic absorption method
- ISO 762:2003, Fruit and vegetable products – Determination of mineral impurities content
- ISO 763:2003, Fruit and vegetable products – Determination of ash insoluble in hydrochloric acid
- ISO 2164:1975, Pulses – Determination of glycosidic hydrocyanic acid
- AOAC 972.25 (Codex general method), determination of lead. Atomic absorption spectrophotometry
- ISO 1842:1991, Fruit and vegetable products – Determination of pH
- ISO 2447:1998, Fruit and vegetable products – Determination of tin content ISO 2448:1998, Fruit and vegetable products – Determination of ethanol content
- ISO 3188:1978, Starches and derived products – Determination of nitrogen content by the Kjeldahl method – Titrimetric method
- ISO 5378:1978, Starches and derived products – Determination of nitrogen content by the Kjeldahl method – Spectrophotometric method
- ISO 750:1998, Fruit and vegetable products – Determination of titratable acidity
- ISO 9526:1990, Fruits, vegetables and derived products – Determination of iron content by flame atomic absorption spectrometry