SAFETY AND QUALITY COMPLIANCE FOR CASSAVA FLOUR PRODUCED IN TANZANIA

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ABSTRACT

The aim of this study was to assess compliance of cassava flour processed by Small and Medium Enterprises (SMEs) from Mwanza, Tanga and Coast regions. Flour samples were collected randomly from 22 SMEs in the mentioned Regions. Processing technologies as well as factors that influenced product standardization based on Good Manufacturing Practices (GMP), Good Hygienic Practices (GHP) and storage practices were assessed using pretested structured questionnaire. Chemical composition (moisture, crude fibre, total ash and acid insoluble ash), microbiological (*Salmonella, E. coli*, yeast and mould counts) and toxicological (hydrogen cyanide, aflatoxin B_1 and total aflatoxin) qualities were analyzed using standard methods. The results were compared to National standard. Results indicated that 75.0, 45.5, and 57.1% of cassava flour samples from Tanga, Mwanza and Coast, respectively failed to comply with maximum limit of 12% moisture content while 50.0, 63.6 and 57.1% of samples from Tanga, Mwanza and Coast, respectively failed to comply with the crude fibre standards requirement of 3%. All samples complied for total ash and acid insoluble ash parameters. In the toxicological assessment, majority of the samples were within the maximum acceptable limit of 10 mg/kg of HCN; 40.9% of samples tested were positive for aflatoxin B_1 and total aflatoxin range of 0.01 to 0.9 ppb and 0.05 to 1.4 ppb, respectively. 54.6% of the sample were below the limit for yeasts and moulds while all samples complied with *Escherichia coli* and *Salmonella* specifications. More than 80% of respondents had knowledge on overall quality criteria needed in cassava flour production, 90.9% were knowledgeable on personal hygiene and 86.4% had storage systems needed for storing packed finished products. Majority of processors lacked permits and licenses from regulatory authorities and facilities for quality monitoring during processing. Training and acquisition of permits and licenses are recommended to assure compliance in production of quality flours.

DECLARATION

I, Zena Issa Ramadhani, do hereby declare to the Senate of Sokoine University of Agriculture that this dissertation is my own original work done within the period of registration and that it has neither been submitted nor being concurrently submitted in any other institution.

Zena Issa Ramadhani Date

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The above declaration is confirmed;

Prof. B. Chove Date

(Supervisor)

Prof. H. S. Laswai Date

(Supervisor)

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DEDICATION

I dedicate this work to my father, Issa Ramadhani, my Mother Asia S. Swai; my late grandmother Hawa S. Kweka who laid a good foundation of my education; my children Thuwayba, Nurdin and Zakir and the entire family for the love and encouragement.

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LIST OF ABBREVIATIONS AND SYMBOLS

CFU	Colony Forming Unit
^{o}C	Degree Celsius
EAS	East African Standards
GAP	Good Agricultural Practices
GHP	Good Hygienic Practices
GMP	Good Manufacturing Practices
HACCP	Hazard Analysis Critical Control Points
HPLC	High Performance Liquid Chromatography
L	Litre
Log	Logarithm
MAL	Maximum Allowable Limits
mg	Milligram
ml	Milliliter
pH	Hydrogen ion Concentration
SIDO	Small Industries Development Organization
SMEs	Small and Medium Enterprises
SUA	Sokoine University of Agriculture
TBS	Tanzania Bureau of Standards
TFDA	Tanzania Food and Drugs Authority
TZS	Tanzania Standard
µg/kg	Microgram per kilogram
URT	United Republic of Tanzania

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background Information

Cassava (*Manihot esculenta* Crantz) is one of the oldest root and tuber crops, used by humans to produce food, feed and beverages. Currently, cassava is produced in more than 100 countries and fulfils the daily caloric demands as a primary food source to millions of people living in tropical America, Africa, and Asia (Parmar *et al.*, 2017; Burns *et al.*, 2012). In Tanzania the root is grown in most regions of Tanzania Mainland and Zanzibar as indicated in the map (Figure 1.1). This crop plays an important role in the maintenance of food security and can be attributed to its ease of cultivation and tolerance to poor soils, low water demand and high temperatures, its ability to produce reasonable yields in poor soils, resistance to pests and minimal inputs requirements (Parmar *et al.*, 2017; Lebot, 2009; Oluwole *et al.*, 2007).

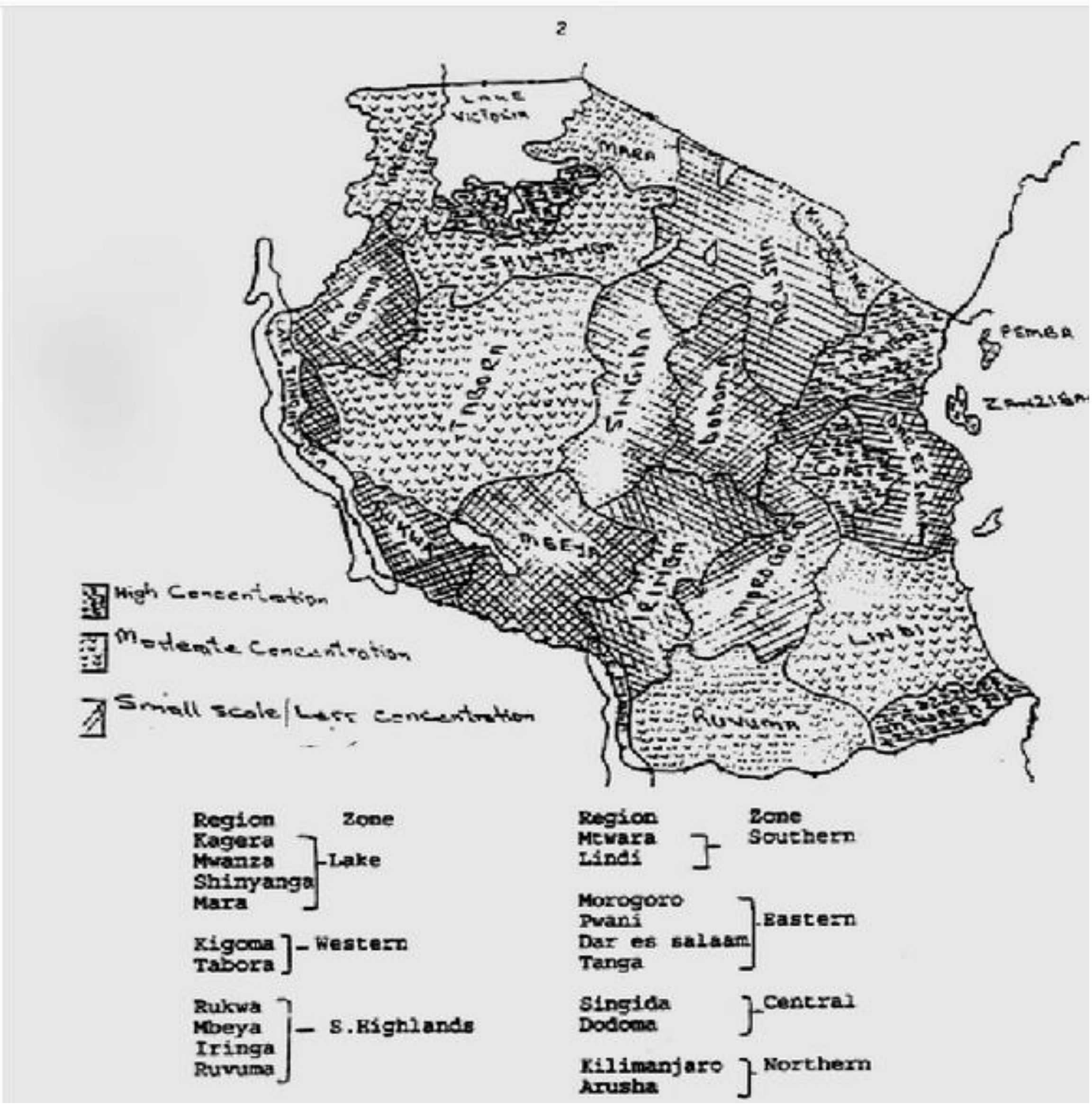

Figure 1.1: Main cassava cropping zones in Tanzania
Source: (Kapinga *et al.*, 2005)

Cassava roots are good source of carbohydrate-based energy and minerals like calcium, iron, potassium, magnesium, copper, zinc and manganese. Contents are comparable to those of many legumes, with the exception of soybeans. The roots are highly perishable due to their higher moisture content whereby according to Mlingi and Ndunguru (2003), it was indicated that the perishability of these roots normally range between 2 to 3 days after harvest. Furthermore, the roots contain anti-nutrients like phytates and oxalates and toxic substances like cyanide that interfere with the digestibility and the uptake of some nutrients thus causing acute toxicity in humans. Cyanide has been indicated to be the most toxic constituent restricting consumption of unprocessed cassava roots, particularly the bitter varieties (Montagnac *et al.,* 2009; Niba *et al.*, 2002). Toxicity of cassava attributable to its cyanide content has been recognized as a serious health hazard in the tropics for many years. Thus, to reduce these effects, cassava roots have been subjected to various processing techniques/methods performed during specific time and in specific sequence, which differ according to locality and the varieties of the cassava roots being processed (COSCA Tanzania, 1996; Khatib, 2008 and Niba *et al.*, 2002). Cassava processing techniques include peeling, crushing, milling, slicing and sun or smoke drying, fermenting, frying, boiling or steaming (FAO/IFAD, 2005; Khatib, 2008 and Omolola *et al.,* 2017). In Tanzania, peeled roots are usually sun-dried for one or two weeks depending on sun intensity and subsequently processed locally into flour called "*Makopa*", "*Kivunde*" or "*Kondowole", "Nyange"* and *"Bada"* (Chacha, 2014). In Tanga, the local processing method results into cassava flour so called "*bada*", in Mwanza the local processing method results into cassava flour called "*makopa*" and in Coast region, the flour produced from local method is called "*kivunde".* Similar mechanical/modern processing methods are applicable in all the regions in Tanzania, irrespective of the location. Altogether, this processing results into cassava flour that has to comply with requirements stipulated in the National standard. *Makopa* processing involve peeling of the roots, splitting or cutting the roots into small pieces sun drying to low moisture content and finally milling into flour. *Bada* processing involves peeling of the roots, cutting followed by covering of the cassava lot with cloth for 2-4 days to allow fermentation, followed by scraping the mould/fungal lot, drying and milling into flour. *Kivunde* processing involves peeling of the roots, soaking of the peeled roots in water for 2–5 days, then shake-drying to remove excess water, breaking into small pieces, sun drying to low moisture content and finally milling into flour. Modern processing technologies for cassava involve chipping and grating of the root, pressing to remove water and consequently the cyanide, sifting of the paste prior sun drying. Once dried it is milled into flour. Cassava flour processed using this method can be obtained in one day. This study therefore aimed at understanding the role of optimum postharvest handling, processing and storage techniques that are implemented to alleviate some of the concerns facing the crop and thereafter to assess compliance of the cassava flour processed locally or mechanically against National standard.

1.2 Problem Statement and Study Justification

Cassava is the basic food staple crop grown in the semi-arid areas (IFAD-FAO, 2005) and in most regions of Tanzania Mainland, including Mwanza, Mtwara, Lindi, Shinyanga, Tanga, Ruvuma, Mara, Kigoma, Coast as well as most regions in Zanzibar (Kapinga *et al.,* 2005). Its annual production is about 6 099 tonnes FAO (2009) whose per capita consumption is 157 kg (twice that of maize, 73 kg) (Minot, 2010). Cassava is used in different forms like fresh, dried chips, biscuit, bread, flour and sometime in making alcoholic beverages (COSCA Tanzania, 1996; Neves *et al.,* 2017; Mezette *et al.,* 2009).

Despite the fact that cassava has a great potential as a food security crop, its processing is mainly done by small and medium enterprises, whose processing methods differ according to locality and are characterized by reduced product quality due improper handling, poor processing and storage conditions that cause contamination. This contamination prevents cassava products from entering local and/or regional markets (Markelova *et al.*, 2009 ; Chacha, 2014). Furthermore, cassava processing industry suffers from a wide range of challenges including: low product quality, inadequate processing technology, unreliable raw material availability and fluctuating market prices (Rodríguez-Sandoval *et al.*, 2008 ; Silayo *et al.*, 2013).

Despite adequate literature on cassava, information on compliance of cassava flour to National standard is still scanty. Therefore, this study strives to evaluate compliance of processed cassava flour from different regions, produced by small and medium enterprises, who dominate the market niche, against the National standard. Therefore, the study focused on assessing different processing technologies and storage conditions of processed cassava flour and establishing the extent of compliance of the cassava flour produced by SMEs to chemical parameters; microbiological and toxicological qualities required by the National standard in the selected regions of Tanzania. Information generated will enable consumers to make informed decisions on purchase and consumption of cassava flour product and enable regulators to identify the action needed to ensure quality and safety of the product.

1.3 Objectives of the Study

1.3.1 General objective

The general objective of the study was to assess compliance of cassava flour from selected regions to the National standard.

1.3.2 Specific objectives

i. To assess different processing technologies and storage conditions of cassava flour processed in the selected regions.
ii. To establish compliance of the cassava flour to chemical parameters required by the National standard.
iii. To establish compliance of the cassava flour to microbiological and toxicological qualities required by the National standard.

1.4 References

Burns, A. E., Gleadow, R. M., Zacarias, A. M., Cuambe, C. E., Miller, R. E. and Cavagnaro, T. R. (2012). Variations in the chemical composition of cassava (*Manihot esculenta* Crantz) leaves and roots as affected by genotypic and environmental variation. *Journal of Agricultural and Food Chemistry* 60(19): 4946 – 4956.

Chacha, J. (2014). Incidence of *Aspergillus flavus* in stored dried cassava products and its association with aflatoxin production. Dissertation for Award of MSc Degree at Sokoine University of Agriculture, Morogoro, Tanzania, 112pp.

COSCA (1996). *Processing Potential for Cassava Production Growth in Africa. Collaborative Study of cassava in Africa*. Working Paper No. 11. International Institute of Tropical Agriculture, Ibadan, Nigeria. 47pp.

FAO (2009). Food and agriculture data. [http://www.faostat3.fao.org/download/Q/QC/E] site visited on 10/3/2018.

FAO/IFAD (2005). A review of cassava in Africa with country case studies on Nigeria, Ghana, the United Republic of Tanzania, Uganda and Benin. *Proceedings of the Validation Forum on the Global Cassava Development Strategy.* Rome, Italy. 66pp.

Kapinga, R., Mafuru, J., Simon, J., Rwiza, E., Kamala, R., Mashamba, F. and Mlingi, N. (2005). *Status of Cassava in Tanzania: Implications for Future Research and Development.* United Republic of Tanzania, Dar es Salaam, Tanzania. 94pp.

Khatib M. A. (2008). Effect of grating, chipping, dry fermentation and sun drying on cyanide level of cassava in Tongwe village. Dissertation for Award of MSc Degree at Sokoine University of Agriculture, Morogoro, Tanzania, 90pp.

Lebot, V. (2009). *Tropical Root and Tuber Crops: Cassava, Sweet Potato, Yams and Aroids.* Working Paper No. 17. Centre for Agriculture and Biosciences International, London. 326pp.

Markelova, H., Meinzen-Dick, R., Hellin, J. and Dohn, S. (2009). Collective action for smallholder market access. *Food Policy* 34: 1 – 7.

Minot, N. W. (2010). Staple food prices in Tanzania. *Prepared for the Comesa Policy Seminar on Variation in Staple Food Prices. Causes Consequence and Policy Options.* Maputo, Mozambique 25 – 25 January, 2010. pp. 1 – 15.

Mlingi, N. V. and Ndunguru, G. T. (2003). A review of post-harvest activities on cassava in Tanzania. *Paper Presented in the 13th Symposium of International Society for Tropical Root Crops*, 10 – 14 November 2003, Arusha International Conference Centre, Arusha, Tanzania. pp. 506 – 513.

Montagnac, J. A., Davis, C. R. and Tanumihardjo, S. A. (2009). Nutritional value of cassava for use as a staple food and recent advances for improvement. *Comprehensive Reviews in Food Science and Food Safety* 8(3): 181 – 194.

Neves, E. C. A., Neves, D. A., de Sousa Lobato, K. B., do Nascimento, G. C. and Clerici, M. T. P. S. (2017). Technological aspects of processing of cassava derivatives. *Handbook on Cassava* 6: 105 – 127.

Niba, L. L., Bokanga, M. M., Jackson, F. L., Schlimme, D. S. and Li, B. W. (2002). Physicochemical properties and starch granular characteristics of flour from various *Manihot esculenta* (cassava) genotypes. *Journal of Food Science* 67(5): 1701 – 1705.

Oluwole, O. S. A., Onabolu, A. O., Mtunda, K. and Mlingi, N. (2007). Characterization of cassava (*Manihot esculenta* Crantz) varieties in Nigeria and Tanzania, and farmers' perception of toxicity of cassava. *Journal of Food Composition and Analysis* 20(7): 559 – 567.

Omolola, A. O., Kapila, P. F. and Mchau, G. A. (2017). Effect of selected processing and modification methods on quality of cassava and its starch. *Asian Journal of Agricultural Research* 11: 48 – 56.

Parmar, A., Sturm, B. and Hensel, O. (2017). Crops that feed the world: Production and improvement of cassava for food, feed, and industrial uses. *Food Security* 9(5): 907 – 927.

Rodríguez-Sandoval, E., Fernández-Quintero, A., Sandoval-Aldana, A. and Cuvelier, G. (2008). Effect of processing conditions on the texture of reconstituted cassava dough. *Brazilian Journal of Chemical Engineering* 25(4): 713 – 722.

Silayo, V. C. K., Lazaro, E. L., Yustas, Y. and Laswai, H. S. (2013). Cassava sun drying performance on various surfaces and drying bed depths. *Tanzania Journal of Agricultural Sciences* 12(1): 31 – 36.

CHAPTER TWO

Manuscript One

2.0 Influence of Processing, Storage Conditions and Knowledge on the Compliance to Standards for Cassava Flour

2.1 Abstract

A total of 22 Small and Medium Enterprises (SMEs) processing cassava flour from Mwanza, Tanga and Coast regions were assessed during product processing based on the basic requirements for different processing technologies and storage conditions of cassava flour processed in the selected regions. The data from the survey documented different processing technologies involved in cassava flour processing as well as factors that influence product standardization based on the Good Manufacturing Practices (GMP), Good Hygienic Practices (GHP) and storage practices. Results indicated that SMEs applied different techniques in processing cassava flour as per the training provided which include GMP, GHP, good storage as well as compliance to standards and other requirements. It was revealed that 81.8% of the SMEs interviewed had knowledge about the overall quality criteria for consideration during cassava flour production; 81.8% lacked competency in checking the cyanide level in the finished product; 86.4% had storage systems for storing packed finished products. More than seventy two percent had no license to produce cassava flour from TFDA while 100% did not possess TBS license to produce the product. All these demonstrated that business formalization was also a challenge to SMEs engaged in the processing of cassava flour. Therefore, all the authorities mandated to innovate or promote technologies, protect consumers and facilitate trade need to address the limitations provided by these SMEs to enable compliance to standard of the cassava flour product and finally facilitate fair competition of their products at all market levels be it National, Regional or International.

Keywords: Cassava flour, processing, storage, compliance, standards

2.2 Introduction

Cassava is a cheap and reliable source of carbohydrate which makes Cassava to be among important food crops for developing countries. Cassava is the main source of energy for between 200 and 300 million people worldwide (Laswai *et al.,* 2006; Uchechukwu-Agua *et al.,* 2015). This crop is bulky and highly perishable, but is available all year round thus contributing to food security (Laswai *et al.,* 2006). This situation makes food safety programmes implementation to be an important pillar throughout the production chain in order to protect vast number of consumers from food-borne diseases as well as other health effects resulting from poor quality control of cassava products.

Plant-based foods in which cassava roots are inclusive are subjected to various processing techniques in order to increase their palatability and to prolong their shelf life while maintaining their original sensorial, biophysico-chemical and nutritional properties during their expected shelf life (Mukantwali, 2014; Khatib, 2008). Different processing techniques applied during cassava flour production result into flour of different quality and hence the need to comply with the set National standards. Likewise, good storage practices are important since they are important quality determining factors in ensuring the quality of final product. However, in many cases, these practices are not fully attainable due to a number of limiting factors facing food processing sector, including inadequate raw materials; inadequate infrastructure to store raw materials and final products; transportation issues once inappropriate packages are used. In addition; poor technological equipment where traditional production processes are implemented, which are mostly time-consuming, labor intensive and prone to human error. The objective of this study was therefore to assess different processing technologies and storage conditions of cassava flour processed in the selected regions and suggest improvements.

2.3 Materials and Methods

2.3.1 Study area

This study was carried out in Tanga, Mwanza and Coast regions of Tanzania. Cassava flour produced in these selected regions includes *Udaga, Kivunde, Bada and Makopa* whose processing methods differ.

2.3.2 Study design

The study employed cross sectional design for data collection using structured pretested questionnaire (Appendix 1). The data from the survey documented different processing technologies involved in cassava flour processing as well as factors that influence product standardization based on the Good Manufacturing Practices (GMP), Good Hygienic Practices (GHP) and storage practices. Purposive sampling was done using all 22 Small and Medium Enterprises (SMEs) processing cassava flour from Tanga, Mwanza, and Coast regions as per the list provided by Small Industries Development Organization (SIDO). The selected sample of SMEs were trained on entrepreneurial skills and recognized by SIDO on cassava flour commercialization.

2.3.3 Statistical data analysis

Data from the survey was summarized and analyzed using SPSS software version 20 (2011) for frequency distribution, means and percentages. Chi-square values were computed to assess relationship between categorical variables by comparing the means.

2.4 Results and Discussion

2.4.1 Socio-economic characteristics of SMEs processing cassava flour

Socio-economic characteristics of the respondents have a great implication in processing and storage of quality cassava flour. Most of the SMEs visited in all the three regions produced cassava flour in groups while few produced individually. For those who produced in groups, the respondents included nine secretaries, one accountant and four selected members within the groups. The data is summarized in Table 2.1.

Table 2.1: Socio -economic characteristics of SMEs processing cassava flour

Parameter	**N**	**%**
Position of interviewee		
Accountant	1	4.5
CEO	2	9.1
Member	4	18.2
Owner	4	18.2
Production manager	2	9.1
Secretary	9	40.9
Sex	19	86.4
Male	3	13.6
Female		
Education level		
Primary school	18	81.9
Secondary school	3	13.6
Technical college	1	4.5

Key: N= Number of respondents % = Percentage

For the individually operated manufacturing premises, four were owners and one was the production manager. Also, the overall proportion of males was 19, which made 86.4% of all who were interviewed, with only three females. Despite the fact that male accounted mostly as heads of group, it was noted that in the group composition there were more males than females. This indicated that males were highly involved in cassava flour processing activities in all study regions. This is supported by a previous study done by Nweke (1999), which indicated that, the share of males responsibilities were not only in the field but also in the cassava processing and marketing. This implies that cassava processing interventions targeting male as heads of group will impact positively in food contamination reduction since both genders can be allowed to participate. Furthermore, the level of education for most of respondent varied from primary school to technical college (Table 2.1). This result indicated that these SMEs are educated as supported in the study done by Theodory (2010); National Baseline Survey Report (2012); Yahya and Mutarubukwa (2015) that most small business owners completed primary and secondary school education.

2.4.2 Possession of license by the SMEs to manufacture cassava flour

The situation regarding possession of different licenses by the respondents is shown in Table 2.2. Results obtained in this study indicated that 72.7% of the respondents had no license to operate the enterprise. Some respondents were not aware of TBS and TFDA and the necessity to attain license from these organizations; some were in the process of acquisition while others did not qualify for the licenses. These results implies that there is a huge challenge on formalization of business enterprises especially to regulatory authorities controlling safety and quality of food. Similar observation was narrated in the study done by Mitumba, 2015; Chijoriga, 2017 indicated that the biggest challenge Tanzania is facing with the private sector is informal operation of many enterprises as well as possession of quality and safety license from TFDA and TBS, respectively despite the type of product they were producing.

Business formalization puts an enterprise in a better position to access credit, subcontract and establish business linkages and access to external markets. This helps them to grow and be able to penetrate the markets locally, nationally and internationally, including the EAC market (Yahya and Mutarubukwa, 2015).Therefore, as this study unveil these gaps it’s high time to ensure that these SMEs comply with regulatory requirements for consumer protection.

Table 2.2: Possession of license by the SMEs to manufacture cassava flour

Parameter	N	%
Have license		
No	16	72.7
Yes	6	27.3
Name of license		
Not applicable	16	72.7
Business license	3	13.7
Municipal council	1	4.5
TFDA	2	9.1
TFDA license		
No	20	90.1
Yes	2	9.1
Reasons for not having TFDA license		
Not applicable	3	13.6
Low production	2	9.1
Not aware about necessity of having TFDA license	7	31.8
Not registered by SIDO	1	4.5
On process of accomplishing it	8	36.4
Under Municipal council	1	4.5
TBS license		
No	22	100
Yes	0	0.0
Reasons for not having TBS license		
Don't have qualification for having TBS license	5	22.7
Lack of communication	1	4.5
Low production of cassava	3	13.6
Not aware of necessity to have TBS license	1	4.5
Not aware of TBS existence	6	27.3
In the process of acquisition	6	27.3

Key: N= Number of respondents   % = Percentage

2.5 Knowledge of quality control during cassava flour processing

2.5.1 Knowledge

Knowledge of quality control during cassava flour processing is shown in Table 2.3. To ensure success of SMEs, the study assessed SMEs knowledge in processing cassava flour and observed that 81.8% (n=18) had that knowledge (Table 2.3). There has been an increasing interest in transforming cassava roots into various products, including cassava flour, which requires proper knowledge in order to produce safe and quality product.

Safety and quality knowledge in cassava flour processing is paramount since it determines quality of the final product.

Table 2.3: Knowledge status about quality control during cassava flour processing

Parameter	N	%
Knowing procedures of quality assurance		
No	4	18.2
Yes	18	81.8
Procedures		
Not applicable	4	18.2
Healthy cassava processing procedures	11	50.0
Washing, packaging and storage	2	9.1
Procedures of processing cassava	4	18.2
Trained on product improvement	1	4.5
Knowledge about criteria of cassava flour quality		
No	16	72.7
Yes	6	27.3

Key: N= Number of respondents % = Percentage

2.5.2 Procedures

For those having the knowledge of cassava quality assurance procedures, 50 percent (n=11) understood the safe cassava processing procedures, 18.2 percent (n=4) understood just procedures of processing cassava while 9.1 percent had knowledge of washing, packaging and storage. Very few (4.5 percent, n=1) had attended training on product improvement.

2.5.3 Criteria for quality requirements

Majority (72.7 percent, n=16) as seen in Table 2.3, had knowledge based on criteria/quality requirements for cassava flour. Also, those SMEs lacked basic knowledge on packaging and labeling, overall cassava flour handling procedures, cyanide and effects of its presence in cassava flour were as indicated in Tables 2.3 and 2.4. Substantially low knowledge of cassava food safety among processors implies that their level of education did not really translate to high knowledge of food safety. Increasing knowledge of correct food safety and hygiene practices through awareness campaigns and sensitization will drive home the importance of food safety practices (Thomas and Philips, 2015).

2.5.4 Knowledge about cyanide

Cassava root typically contains about 100 to 500 mg HCN equivalent/kg on wet weight (Barceloux, 2009). However, amount of cyanide retained in cassava food products depends solely on the effectiveness of the processing methods applied. Therefore, knowledge on various processing techniques, suitable for reducing cyanide levels in cassava roots are highly required. Consumption of cassava and cassava products containing large amounts of cyanide can cause acute intoxication, with symptoms of dizziness, headache, nausea, vomiting, stomach pains, diarrhoea and some-times death; Nhassico, *et al.*, 2008). Furthermore, cyanide intake from cassava aggravates goiter, tropical ataxic polyneuropathy or partial paralysis or konzo (Nhassico *et al.*, 2008; Cardoso *et al.*, 2005; Reddy *et al.*, 2017 and Cumbana *et al.*, 2007).

Table 2.4: Status of knowledge about cyanide

Parameter	N	%
Knowledge about cyanide poison in cassava		
No	4	18.2
Yes	18	81.8
Knowledge about amount of cyanide		
No	19	86.4
Yes	3	13.6

Key: N= Number of respondents % = Percentage

Results in Table 2.4 indicated that compliance of SMEs with set product standards was confronted with a lot of challenge, including lack of knowledge, which ultimately had impact on the final produce. Non-compliance with the cassava food safety practices by processors could be adduced to low level of knowledge and unfavourable attitude towards cassava food safety. The implication of this finding is that products consumed from this kind of practice can cause different kinds of ailments or even death (Thomas and Philips, 2015). Furthermore, the study done by Iwuoha and Eke (1996) correlates with the findings of this study that lack of knowledge of the processes and their characteristics pose limitations to traditional processing of fermented food.

2.5.5 Quality control criteria for consideration during cassava flour processing

For strategic control as well as continuous improvement during cassava flour processing, there were several criteria registered by SMEs interviewed as their mechanism to monitor compliance with product standards during processing. These included assessment of taste and texture, moisture content, dirt as well as overall hygienic processing procedures. It was observed (Table 2.5) that 40.9 percent (n=9) assessed moisture content using traditional method since they did not have moisture meter, 27.3 percent (n=6) assessed the overall hygienic processing procedures, which if not well observed might affect product quality and safety. Furthermore, 9.1 percent (n=2) used other indicators such as assessment of taste and texture, and 4.5 percent (n=1) assessed dirt as a visible characteristics that might affect product quality as indicated in Table 2.5.

Table 2.5: Quality control criteria for consideration during cassava flour processing

Parameter	N	%
Signs used to identify and maintain quality		
Assessment of tastes and texture	2	9.1
The use of trained personnel during assessment of the product	3	13.6
Assessment if there is any moisture	9	40.9
Assessment if there is any dirt	1	4.5
Hygienic processing procedures	6	27.3
Assessed by fellow entrepreneurs	1	4.5

Key: N= Number of respondents % = Percentage

This criteria act as a check for improvement of product quality without necessarily depending on end product testing (Cormier *et al.,* 2007). Therefore, as observed in this study, if these criteria will be properly controlled and a mechanism of analysis is provided, it will facilitate product compliance. Consumer preference for safe and quality food products is increasing and the need to develop strategy to improve safety for product competitiveness as well as guarantee product acceptability and consistency (Oguntoyinbo, 2012).

2.5.6 Storage systems for the processed cassava flour

Table 2.6 summarizes status of cassava flour storage systems in percentage obtained from three selected regions of Tanga, Mwanza and Coast.

Table 2.6: Status of storage systems for the processed cassava flour

Parameter	N	%
Area of storing cassava flour		
No	3	13.6
Yes	19	86.4
If no, how was the cassava flour stored		
Not applicable	19	86.4
Special storage room	2	9.1
Store in group building	1	4.5

Key: N= Number of respondents % = Percentage

Results of the survey on the storage systems used by SMEs (Table 2.6) shows that 86.4 percent (n=19) had separate area for storing cassava flour packed in polypropylene bags, well arranged on wooden pallets. The rest stored the product in a group owned building either on wooden pallets or in big plastic cans without packing in polypropylene bags. This implies that, efforts were made by SMEs regarding provision of adequate area for cassava flour storage, thus protecting post-processing contamination of the product. Similar results were reported in Uganda, that out of the 90 farmer households surveyed, 63.3% indicated storing cassava products in interwoven polypropylene bags in the huts (grass thatched) mud and wooden structures with earth floor used as housing or semi-permanent houses (Kaaya and Eboku, 2010). Good storage depends on the moisture content of the products, temperature and relative humidity of the storage environment. Also, the type of bag used for packing affects shelf life, depending on the ability of the material to maintain safe product moisture levels (Simonyan, 2014).

2.5.7 Good hygienic practice at the cassava flour manufacturing premises

Table 2.7 summarizes the parameters that determine good hygienic practice at the cassava flour manufacturing premise. Food hygiene means all conditions and measures necessary to ensure the safety and suitability of food at all stages of the food chain. This means that all stages within the supply chain should be considered in order to ensure safety in cassava flour consumption. In particular, this includes identifying any specific points in such activities where a high probability of contamination may exist and taking specific measures to minimize that probability (Codex, 1997).

Table 2.7: Status of the good hygienic practice at the cassava flour manufacturing premises

Parameter	No		Yes	
	n	%	N	%
Knowledge about washing hands before working	2	9.1	20	90.9
Official means of cleanliness	5	22.7	17	77.3
Roof cleaning	8	36.4	14	63.6
Dumping area for wastes	8	36.4	14	63.6
Have tins for collecting wastes and garbage	13	59.1	9	40.9
Equipment for collecting wastes and garbage	9	40.9	13	59.1
Have ways of checking performance after cleanliness	8	36.4	14	63.6

Key: N= Number of respondents accepting the status n= Number of respondents rejecting the status
% = Percentage

Due to the importance of adhering to food hygiene principles during cassava flour processing. SMEs knowledge was assessed based on personal hygiene, cleanliness in general and management of waste produced. Results indicated that 90.9 percent of the respondents had knowledge on personal hygiene. They were in favour that other food hygienic practices as indicated in Table 2.7 are important task to be carried out in their day to day activities to ensure quality of cassava flour produced. Also, it was noted that, most of the respondents did not have tins for collecting garbage during processing. This implies that these SMEs are aware of the food hygiene principles but failed to prioritize issues pertaining to food safety.

2.5.8 Area for dumping waste and equipment used

Results in Table 2.8 indicated that 63.6 percent of the respondents (n=14) had a separate area for dumping wastes while 36.4 percent used garbage produced during cassava flour production for agricultural purposes and thus there was no provision for dumping. This implies that few respondents were aware of waste product management and thus more training is required since waste generation is an inevitable in any food processing factory. This result further supports an assertion in a study conducted in Nigeria by Coker *et al*. (2010) that there is a significant potential of utilizing cassava waste as a sustainable energy source for heating and electrification of the cassava processing environment.

2.5.9 Dumping of wastes

Among the respondents interviewed on how to dump industrial wastes and garbage, 63.6 and 22.7 percent disposed this industrial waste in garbage area and some used them as home-made fertilizer, respectively (Table 2.8).

Table 2.8: Dumping of the industrial waste and garbage

Parameter	N	%
How do you dump industrial wastes and garbage		
Disposed in garbage area	14	63.6
Used as food and water for livestock	3	13.6
Used as home-made fertilizer	5	22.7

Key: N= Number of respondents % = Percentage

Only few of them (13.6 percent) used their industrial waste as feed and water for livestock. Wastes transformation offers the possibility of creating marketable value-added products. It has been noted that cassava wastes can be processed and converted into value-added components such as methane (biogas), pig meat, ethanol, surfactant and fertilizer (Ubalua, 2007) . These results obtained demonstrated that the study population is aware of the basic knowledge and adhere to general conduct of the good hygienic practices during cassava flour processing. Failure in adhering to hygienic procedures has been associated with the cause of food-borne diseases (Greig *et al.,* 2007; Todd *et al.,* 2010). These results are contrary to what was reported by Walker *et al*. (2003) that 82 percent of food handlers employed in food businesses lacked basic hygiene knowledge and understanding. This could be a major barrier to the effective implementation of hazard analysis critical control point programme in small food businesses.

2.5.10 Training status of SMEs processing cassava flour

Due to its importance, the study assessed the training status of SMEs and observed that about 80 percent of the staff attended training leaving only 20 percent who did not attend (Table 2.9).

Table 2.9: Training status to SMEs processing cassava flour

Parameter	N	%
Attendance of training	5	22.7
No	17	77.3
Yes		
Type of training		
Not applicable	5	22.7
Systems of quality management	9	40.9
Hygiene and control	6	27.3
Regulations of health and production	2	9.1

Key: N= Number of respondents % = Percentage

For those who attended training, 40.9 percent attended the training on systems of quality management and the rest on hygiene and control and regulations of health and production, making 27.3 percent and 9.1 percent, respectively (Table 2.9). This implies that most of these SMEs were well trained on issues pertaining to quality despite poor application of knowledge which hinder their compliance to regulatory requirements. Notably, training of processors about Hazard Analysis Critical Control Points (HACCP), processing, environmental sanitation and personal hygiene were suggested as strategies to improve the safety of traditional fermented food products. Thus, training presents a prime opportunity to expand knowledge base of processor, increasing organizational stability and flexibility as well as enhancing competitiveness in the production of quality and safe product (Oguntoyinbo, 2012).Therefore, emphasize geared towards training evaluation is necessary in order to assess training effectiveness and application to all trained personnel for continuous improvements and enforcement.

2.5.11 Challenges encountered by SMEs processing cassava flour

Regarding challenges encountered during manufacture of cassava flour, respondents registered a number of challenges including absence of processing machines, too much dependence on sun rays for drying cassava, inaccessibility of raw materials and absence of packaging materials (Table 2.10).

Table 2.10: Challenges encountered by SMEs processing cassava flour

Parameter	N	%
Challenge		
Accessibility of raw materials	3	13.6
Too much dependent on sun rays in drying cassava	6	27.3
Shortage of water	2	9.1
Absence of electricity	2	9.1
Absence of packaging materials	3	13.6
Unreliable market	2	9.1
Absence of processing machine	8	36.4
Wear and tear of the building	2	9.1
Absence of finance loan and subsidies	2	9.1
Absence of trained personnel for processing cassava	2	9.1

Key: N= Number of respondents   % = Percentage

Results obtained in this study corresponds with the results obtained from studies conducted (Sanni *et al.*, 2009; Khatib, 2008 and Chijoriga, 2017) whereby all of the registered challenges was also facing the SMEs in their studies despite differences in the type of food product.

2.6 Conclusion

Results of this study showed that cassava processing techniques differed according to locality. Majority of processors were trained on basic knowledge of cassava flour processing as well as food quality and safety criteria to follow during processing. Despite the fact that these SMEs personnel were trained, they did not know the importance of business formalization that consequently resulted into fewer possession of license from authoritative bodies like TFDA and TBS. Therefore, all the authorities mandated to innovate or promote technologies, protect consumers and facilitate trade need to address the limitations provided by these SMEs to enable compliance to standard of the cassava flour product and finally facilitate fair competition of their products at all market levels be National, Regional or International. Also, the technologies involved in processing and storage needs to be improved to enable consistent production of quality cassava flour and protect post processing quality deterioration. Furthermore, enforcement of regulations governing the food safety is of paramount importance in order to safeguard cassava flour consumers who make a significant number.

2.7 References

Chijoriga, Z. (2017). Quality and safety of peanut butter processed by small and medium enterprises in Dar es Salaam region. Dissertation for Award of MSc Degree at Sokoine University of Agriculture, Morogoro, Tanzania, 107pp.

Codex Alimentarius Commission (1997). *Recommended International Code of Practice General Principles of Food Hygiene.* Food and Agriculture Organization, Rome. 31pp.

Coker, A., Achi, C. and Sridhar, M. K. (2010). Utilization of cassava processing waste as a viable and sustainable strategy for meeting cassava processing energy needs: Case Study from Ibadan City, Nigeria. In: *Proceedings of the Thirtieth International Conference on Solid Waste Technology and Management.* Philadelphia, USA. pp. 3 – 6.

Cormier, R. J., Mallet, M., Chiasson, S., Magnússon, H. and Valdimarsson, G. (2007). Effectiveness and performance of hazard analysis critical control points based programs. *Food Control* 18(6): 665 – 671.

Cumbana, A., Mirione, E., Cliff, J. and Bradbury, J. H. (2007). Reduction of cyanide content of cassava flour in Mozambique by the wetting method. *Food Chemistry* 101(3): 894 – 897.

Greig, J. D., Todd, E. C. D., Bartleson, C. A. and Michaels, B. S. (2007). Outbreaks where food workers have been implicated in the spread of foodborne disease. Part 1.Description of the problem, methods, and agents involved. *Journal of Food Protection* 70: 1752 – 1761.

Iwuoha, C. I. and Eke, O. S. (1996). Nigerian indigenous fermented foods: their traditional process operation, inherent problems, improvements and current status. *Food Research International* 29(6): 527 – 540.

Kaaya, A. N. Eboku, D. (2010). Mould and aflatoxin contamination of dried cassava chips in Eastern Uganda: Association with traditional processing and storage practices. *Journal of Biological Sciences* 10(8): 718 – 729.

Khatib M. A. (2008). Effect of grating, chipping, dry fermentation and sun drying on cyanide level of cassava in Tongwe Village. Dissertation for Award of MSc Degree at Sokoine University of Agriculture, Morogoro, Tanzania, 90pp.

Laswai, H., Silayo, V. C. K., Mpagalile, J. J., Ballegu, W. R. and John, J. (2006). Improvement and popularization of diversified cassava products for income generating and food security: A case study of Kibabu. *African Journal of Food, Agriculture, Nutrition and Development* 6(1): 1 – 15.

Mitumba, J. O. (2015). Bureaucracy and business informality in Tanzania. *Regional Conference on Building Democratic Developmental States for Economic Transformation in Southern Africa*. 20 – 22 July, 2015, Pretoria, South Africa.1 – 30pp.

Mukantwali, C. (2014). Compliance of small and medium scale pineapple processing enterprises with national and international standards in Rwanda. Thesis for Award of PhD degree at Sokoine university of Agriculture, Morogoro, Tanzania, 210pp.

Nhassico, D., Muquingue, H., Cliff, J., Cumbana, A. and Bradbury, J. H. (2008). Rising African cassava production, diseases due to high cyanide intake and control measures. *Journal of the Science of Food and Agriculture* 88(12): 2043 – 2049.

Nweke, F. I. (1999). *Gender Surprises in Food Production, Processing, and Marketing with Emphasis on Cassava in Africa.* Working Paper No. 19. International Institute of Tropical Agriculture, Nigeria. 51pp.

Oguntoyinbo, F. A. (2012). Development of hazard analysis critical control points and enhancement of microbial safety quality during production of fermented legume based condiments in Nigeria. *Nigerian Food Journal* 30(1): 59 – 66.

Reddy, T. R. K., Kim, H. J. and Park, J. W. (2017). *Potential Uses of Cassava Products and Its Future Challenging Opportunities.* Nova Science Publishers Inc., New York. 18pp.

Sanni, L. O., Onadipe, O. O., Ilona, P., Mussagy, M. D., Abass, A. and Dixon, A. G. O. (2009). *Successes and Challenges of Cassava Enterprises in West Africa: A Case Study of Nigeria, Benin and Sierra Leone*. International Institute of Tropical Agriculture, Nigeria, 19pp.

Simonyan, K. J. (2014). Cassava post-harvest processing and storage in Nigeria: A review. *African Journal of Agricultural Research* 9(53): 3853 – 3863.

Theodory, M. (2010). Evaluation of introduced cassava processing technologies on production and consumption using goal programming approach. Dissertation for Award of MSc Degree at Sokoine University of Agriculture, Morogoro, Tanzania, 86pp.

Thomas, K. A. and Philips, O. N. (2015). Assessment of food safety practices among cassava processors in selected rural communities of Oyo State, Nigeria. *African Journal of Food, Agriculture, Nutrition and Development* 15(4): 10317 – 10334.

Todd, E. C. D., Michaels, B. S., Smith, D., Greig, J. D. and Bartleson, C. A. (2010). Outbreaks where food workers have been implicated in the spread of food-borne disease. Part 9. Washing and drying of hands to reduce microbial contamination. *Journal of Food Protection* 73: 1937 – 1955.

Ubalua, A. O. (2007). Cassava wastes: treatment options and value addition alternatives. *African Journal of Biotechnology* 6(18): 2065 – 2073.

Uchechukwu-Agua, A. D., Caleb, O. J. and Opara, U. L. (2015). Postharvest handling and storage of fresh cassava root and products: A review. *Food and Bioprocess Technology* 8(4): 729 – 748.

URT (2012). *Micro Small and Medium Enterprises in Tanzania:* National Baseline Survey, Dar es Salaam, Tanzania. 106pp.

Walker, E., Pritchard, C. and Forsythe, S. (2003). Food handlers' hygiene knowledge in small food businesses. *Food Control* 14(5): 339 – 343.

Yahya, M. and Mutarubukwa, P. (2015). Capacity of Tanzania micro, small and medium enterprises in tapping the business opportunities in the East African Community. *Business Education Journal* 1(1): 1 – 20.

CHAPTER THREE

Manuscript Two

3.0 Compliance of Locally Processed Cassava Flour to Chemical Parameters Stipulated by the National Standard

3.1 Abstract

The aim of this study was to establish compliance of the cassava flour produced by SMEs from three regions namely Tanga, Mwanza and Coast, which practice different processing techniques. Samples were collected from 22 SMEs processing cassava flour and subjected to chemical analysis (moisture content, ash content, crude fibre content and acid insoluble ash), and compared against the requirements stipulated in the National standard. Data obtained from the laboratory analysis were statistically analyzed using R- statistical package software version 3.3.0. Analysis of Variance (ANOVA) was carried out to determine the significant difference ($p<0.05$) for the chemical composition data between the processing methods. Principal component analysis was also used to determine systematic variations between variables. Moisture content results indicated that 75.0, 45.5 and 57.1% of cassava flour sample from Tanga, Mwanza and Coast, respectively failed to comply with maximum limit of 12%. Furthermore, 50.0, 63.6 and 57.1% of samples from Tanga, Mwanza and Coast, respectively failed to comply with the crude fibre standards requirements of 3%. All samples complied for total ash and acid insoluble ash parameter.

Keywords: Cassava flour, compliance, moisture, ash, crude fibre, acid insoluble ash

3.2 Introduction

Cassava (*Manihot esculenta Crantz*) is an important subsistence food crop in Tanzania, especially in the semi-arid areas. The country realizes the importance of cassava as a major source of carbohydrate and a drought tolerant crop and has given it the second priority ranking staple food next to maize. Eighty four (84) percent of the total production in the country is utilized as human food used in different forms and the remaining percentages are for other uses like starch making, livestock feed and export (Kapinga *et al.,* 2005). Cassava is also considered as one of the major tropical staple foods alongside yam, plantain and sweet potato; a good source of carbohydrate and the fourth most energy-giving diet (Mudombi, 2010). Since the crop takes its countable weight as a food security crop, the societies which cultivate and produce much of the crop consider product diversification as a way to improve products shelf life as well as to maximise the use of the potential product they produce. Product diversified in cassava roots includes cassava flour which either undergo fermentation or not during processing. That's why this study was carried out in Tanga, Mwaza and Coast regions which are the leading cassava producer and consumer in Tanzania (Mtunda *et al.*, 2003). Furthermore, cassava flour processing techniques from these regions differ according to localities which also trigger different quality characteristics of the final product. Examples of cassava flour products named according to processing method and location include called "Makopa" along Lake Victoria Zone; "Kivunde", "Kibadi" and "Nyange" along Lake Tanganyika as well as Coast regions and "Bada" in Indian Ocean Coast strip specifically in Tanga region. Information on compliance of cassava flour undergoing different processing techniques is scanty. Hence, this necessitates conducting of this study.

3.3 Materials and Methods

3.3.1 Study area

This study was carried out in Tanga, Mwanza and Coast regions of Tanzania .Cassava flour produced in these selected regions includes *Udaga, Kivunde, Bada and Makopa* whose processing methods differ.

3.3.2 Materials

Materials used for this study were cassava flour samples from three regions including Tanga, Mwanza and Coast. Other materials such as packaging material, cool boxes purchased from supplier in Dar es Salaam; chemicals, analytical reagents, apparatus and laboratory equipment's were obtained from TBS laboratories.

3.3.3 Study design

3.3.3.1 Sampling plan and data collection

Purposive sampling plan was used to collect samples from selected SMEs processing cassava flour in three regions of Tanga, Mwanza and Coast. A total of 22 cassava flour samples (1 kilogrammes each) were randomly collected from the production lots after observing the processing flow. Obtained samples were transported and stored in dry boxes until they reach TBS laboratory for proximate analysis.

3.3.4 Chemical analysis of cassava flour

Cassava flour samples were subjected to chemical analysis to establish their proximate composition status. The samples were analyzed for moisture content, ash, crude fibre and acid insoluble ash using standard method elaborated hereunder. These analyses were conducted in duplicate.

3.3.4.1 Moisture content

Moisture content of the collected cassava flour sample was analyzed as per ISO 712:2009. During the analysis, crucible weights were recorded, then approximately 1g of the samples was used. The moisture dishes plus the samples were dried in an electric oven at 105°C for 3 h, and weights after drying and cooling recorded. Analysis of samples was done in duplicate and calculation for the moisture content was then done as per the following formula.

$$\% \text{ Moisture } = \frac{(M_1 - M_2)}{(M_1 - M)} \times 100$$

Where:

M_1 = mass in g of the dish with material before drying

M_2 = mass in g of the material with material after drying

M= mass in g of the empty dish

3.3.4.2 Total ash

Total ash content of the collected cassava flour samples was analysed according to ISO 2171:2007. Approximately 3g of sample was weighed in a dried crucible, incinerated in a muffle furnace maintained at 550°C for 2 h. The ash was then cooled in a desiccator and weighed. Total ash content was calculated as per the following formula.

$$\% \text{ Total ash} = \frac{(M_2 - M)}{(M_1 - M)} \times 100$$

Where:

M_1= mass in g of the crucible with the sample taken for the test,

M_2 = mass in g of the crucible with ash and

M = mass in g of the empty crucible.

3.3.4.3 Crude fibre

Crude fibre content of the collected cassava flour samples was analysed according to ISO 5498:1981. Approximately 2g of sample was weighed in the flask then boiled with sulphuric acid solution (0.255N) followed by separation using filter paper and washing of the insoluble residue with hot water. Thereafter, the residue was transferred into the flask with 200ml of boiling sodium hydroxide solution (0.313N) followed by separation, washing with hot water until it is free from alkali and then with 10ml of alcohol, drying at 105-110°C for about 2 h, cooled to room temperature in the desiccator and weighing of the insoluble residue. Crude fibre content was calculated as per the following formula.

$$\text{Crude fibre\% by weight} = 100\,\frac{(W_1 - W_2)}{W}$$

Where:

W is the weight of the sample (g),

W_1 is the weight of crucible and content after drying (g) and

W_2 is the weight of crucible and ash after incineration (g)

3.3.4.4 Acid insoluble ash

Acid insoluble ash of the collected cassava flour samples was analysed according to EAS 82:2000. Approximately 1g of ash obtained from total ash determination was boiled for 5 minutes with 25 mL of hydrochloric acid (~70 g/l); thereafter the insoluble matter obtained after rinsing and filtration was collected and placed in a crucible, which was then dried and ignited at about 500 °C to constant weight. The acid-insoluble ash was weighed, and the percentage of acid-insoluble ash was calculated.

3.4 Statistical Data Analysis

Laboratory data were analyzed using R- statistical package software version 3.3.0. Analysis of Variance (ANOVA) was carried out to determine the significant difference ($p<0.05$) for the chemical composition data between the processing methods. Principal component analysis was also used to determine systematic variations between variables. Results were expressed as mean ± standard deviation.

3.5 Results and Discussion

Table 3.1 shows the results for moisture content, crude fibre, total ash and acid insoluble ash analyzed in 22 cassava flour samples obtained during processing between three regions of Mwanza, Tanga and Coast.

Table 3.1: Chemical composition and standard values of cassava flour between regions

Region	Moisture content (%)		Total ash (%)		Acid insolube ash (%)		Crude fibre (%)	
	Local	**Modern**	**Local**	**Modern**	**Local**	**Modern**	**Local**	**Modern**
Coast	13.0±1.53[a]	11.7±0.43[a]	1.8± 0.54[a]	1.7± 0.75[a]	0.1±0.00[a]	0.1±0.00[a]	1.7±1.61[b]	5.1±2.94[a]
Tanga	12.1±0.23[a]	12.4±0.33[a]	1.4± 0.17[a]	1.6± 0.64[a]	0.2± 0.01[a]	0.2±0.01[a]	4.3±3.24[a]	1.6±1.43[b]
Mwanza	11.6±0.71[a]	11.2±2.11[a]	1.5 ±0.00[a]	1.3± 0.87[a]	0.1± 0.03[a]	0.1±0.03[a]	1.8±1.32[b]	2.2±1.54[b]
Max Limit [1]	12		3		0.35		2	

Values in the same column having the same superscript letters are not significantly different (P<0.05)
[1]TZS 466:2010 and regional standard (EAS 740:2010)

3.5.1 Compliance status of cassava flour on chemical parameters between regions

The results from this study indicated that values for total ash and acid insoluble ash in all the 22 samples complied with National standards requirements of 3% and 0.35%, respectively (Table 3.1). This may be due to the soaking stage applied by all processors during cassava flour processing that render the final product with minimal ash content due to the leaching out of both macro- and micro-elements into the soaking water. Also as observed, the visited SMEs used racks for holding the cassava grates/chips/pieces during drying process, thus reduced chances of contamination by foreign matter like sand, hence low acid insoluble ash in the flour samples.

Furthermore, as the results revealed that there is no significant variation ($p<0.05$) in values obtained from samples processed between regions, crude fibre content indicated variations in which 50, 63.6 and 57.1% of samples from Tanga, Mwanza and Coast, respectively failed to comply with the standards requirements of 3%. Among the local processed flour samples, those from Tanga had significantly higher crude fibre content (4.3±3.24 g/ 100 g DM) than values obtained in samples from Coast and Mwanza regions. Also, the modern processed flours from Coast region had highest crude fibre value (5.1±2.94 g/ 100 g DM), compared to values obtained in samples from Tanga and Mwanza region (Table 1). Crude fibre content is used as a guide for evaluation of dietary fibre contents in food product as a tool in the control of oxidative processes as well as indicator of the level of the nutritional value of the food and purity of the flour. The higher the proportion of fiber in the food product the lower the nutritional value (Eleazu *et al.*, 2012). Also the observed findings which are also similar with results obtained by Souza *et al.* (2008a) could be due to the effects of processing techniques since food processing may affect the functionality and nutritional quality of the food products either positively or negatively.

Evaluation of moisture content is crucial since this parameter influences the shelf life of the food product. Higher moisture content above 12% will trigger mould growth thus compromising flour storage (Eleazu *et al.,* 2012; Aryee *et al.,* 2006). Moisture content results indicated that 75.0, 45.5, and 57.1% of cassava flour sample from Tanga, Mwanza and Coast, respectively failed to comply with maximum limit of 12% moisture content. This could be due to difficult in temperature control since the drying technique used by all SMEs. It was observed that 99% of the visited SMEs used sun rays for drying cassava roots through which the final moisture content depended on the sun rays intensity and exposure time. Also SMEs did not have moisture meter to verify the available moisture content in the final products before storage thus difficulty in understanding the status whether to prolong the drying stage or to stop the drying stage.

Results obtained from this study correspond to what was reported by Souza *et al.* (2008a) and Joana Maria Leite de Souza (2008b) that all samples obtained in their studies contained higher moisture content. Furthermore, these results were contrary to what was reported in the studies done by Oladunmoye *et al.* (2014); Eleazu *et al.* (2014) and Ihedioh *et al.* (1996) that the moisture contents of the cassava flour samples were within the acceptable limits of 12%. Therefore, it is important to train these SMEs on importance of moisture control during processing as well as measuring the moisture content of the product before and after milling. Since, low moisture content can be attained and is a good indicator of microbial stability, improved shelf life and may facilitate reduction of staling in baked food products (Agrahar-Murugkar and Jha, 2011).

3.5.2 Compliance status on the chemical parameters of cassava flour processed using different methods between different varieties

Variations of cassava flour chemical parameters between different varieties in each region are shown in Figure 2 (A-D). Chemical composition differed significantly ($p<0.05$) between varieties in each processing method except for moisture content. The observed variation of the chemical parameters between varieties may have been due to intrinsic characteristics of the cassava roots used. This was also reported in the study done by Chisté *et al*. (2006) and Aryee *et al*. (2006), which reported parameters such as ash, proteins and lipids that could vary between the samples of flour due to differences in the cassava varieties used. Furthermore, the study done by Joana Maria Leite de Souza (2008b) on the physicochemical characteristics of flours derived from cassava varieties used in the Juruá Valley, Acre indicated differences in ash, lipids, protein, crude fibre, carbohydrates, acidity, pH due to varietal differences. As for the moisture content parameter that did not change according to flour variety, moisture content was not affected by intrinsic characteristics but rather due to extrinsic characteristics. Mixed flour variety processed under modern methods had lower ash and acid insoluble ash values of 1.02 and 0.04 %, respectively than flour samples from other varieties with respective values of 1.5 and 0.05-0.07%. However, the same variety samples had significantly higher crude fibre values for both locally (2.8%) and modern processed samples (3.3%). In addition, mixed varieties had higher insoluble acid ash contents of 0.14% for traditional processed flour. Bitter varieties had higher (0.14%) insoluble acid ash contents for traditional processed flour than other varieties (0.04 - 0.07%) under the same processing methods. Sample varieties were above the maximum National standards values of 12 and 2% for moisture and crude fibre contents, respectively (Figure 2A and D).

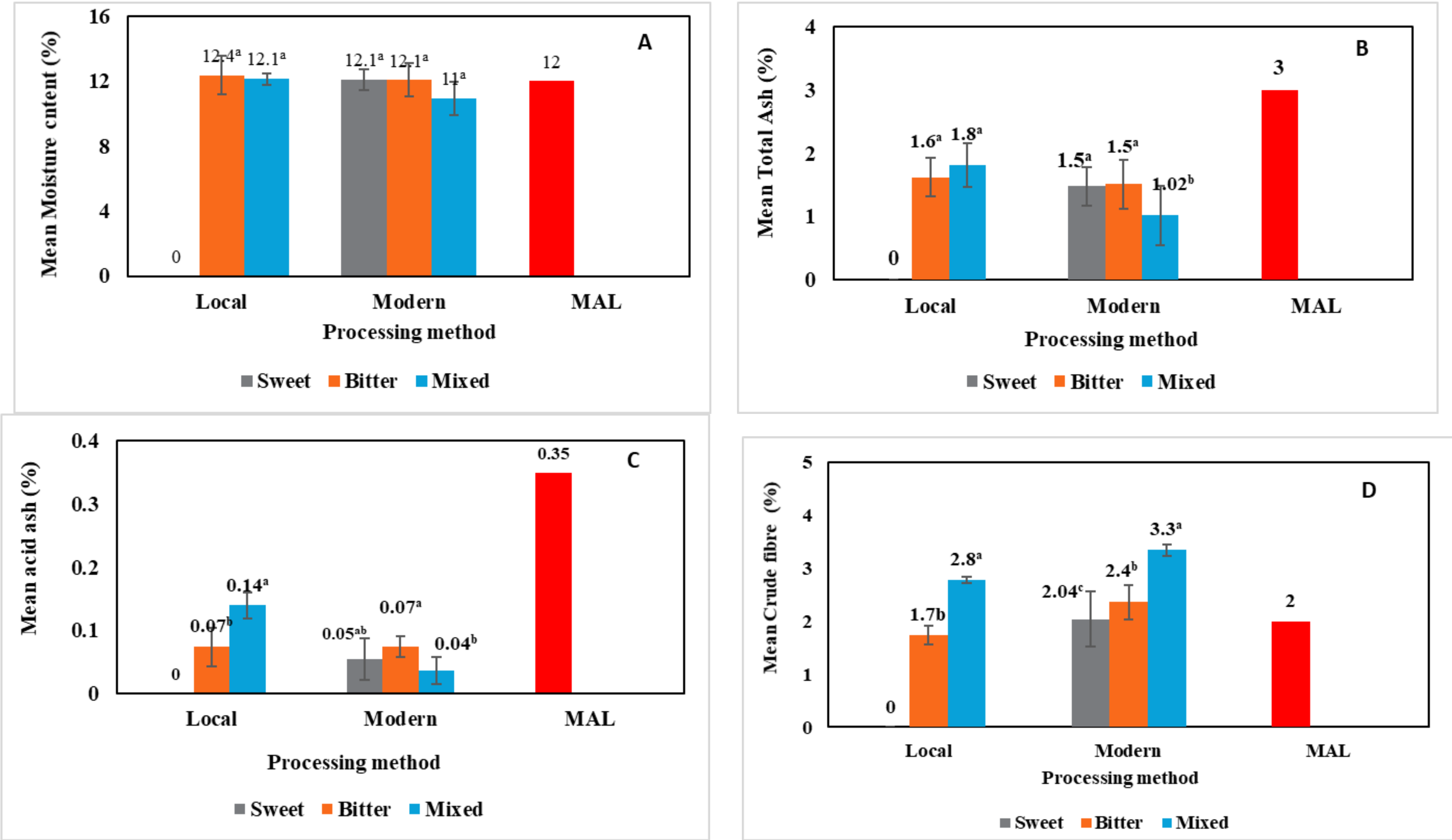

Figure 3.1: (A-D) Compliance of cassava flour produced from different processing methods using different cassava varieties in each region to chemical parameters required by the National standard.

Key: MAL = Maximum Allowable Limits, A= Figure for moisture content, B=Figure for total ash, C= Figure for acid insoluble ash and D=Figure for crude fibre

3.6 Conclusion

The study showed that there were no significant ($p < 0.05$) variations in moisture content, acid insoluble ash and total ash in flour from similar processing method between the three regions with the exception of crude fibre. Among the local processed flour samples, Tanga samples had significantly higher crude fibre content than samples from Coast and Mwanza regions. On the other hand, the modern processed flours from Coast region had the highest crude fibre value compared to samples from Tanga and Mwanza regions. However, despite the insignificant variation in moisture content in each processing method between the three regions, locally processed samples from Coast region had higher value than the locally processed samples from Tanga, and modern processed samples from Coast and Mwanza regions. All samples from both processing methods in all regions complied with National standards in total ash and acid insoluble ash contents. Therefore, this indicate that compliance status to moisture and crude fibre is a challenge unlike that for total ash and acid insoluble ash contents and thus measures to ensure compliance to cassava flour produced by these SMEs is of paramount importance. A combination of interventions including provision of appropriate operation and expense for the drying technology; provision of moisture meter; training on GMP for cassava flour, effects of failure for each chemical parameter and consequences in human health as well as standards enforcement is necessary.

3.7 References

Agrahar-Murugkar, D. and Jha, K. (2011). Influence of storage and packaging conditions on the quality of soy flour from sprouted soybean. *Journal of Food Science Technology* 48: 325–328.

Aryee, F. N. A., Oduro, I., Ellis, W. O., and Afuakwa, J. J. (2006). The physicochemical properties of flour samples from the roots of 31 varieties of cassava. *Food Control*, 17: 916 – 922.

Chisté, R. C., Cohen, K. D. O., Mathias, E. D. A., Júnior, R. and Araújo, A. G. (2006). Quality of cassava flour from a dry group. *Food Science and Technology* 26(4): 861 – 864.

Eleazu, O. C., Eleazu, K. C., Kolawole, S. (2014). Use of indigenous technology for the production of high quality cassava flour with similar food qualities as wheat flour. *Acta Sci. Pol., Technol. Aliment*. 13(3): 249 – 256.

Eleazu, C. O., Eleazu, K. C., Awa, E. and Chukwuma, S. C. (2012). Comparative study of the phytochemical composition of the leaves of five Nigerian medicinal plants. *Journal of Biotechnology and Pharmaceutical Research* 3(2): 42 – 46.

Ihedioh, O. C., Akingbala, J. O. and Oguntimein, G. B. (1996). The effect of holding cassava roots up to four days on quality characteristics of flour milled from the roots. *Journal of food Processing and Preservation* 20(1): 13 – 23.

Joana Maria Leite de Souza (2008b). Physical chemical characterization of cassava flour from cassava varieties used in the Juruá valley *Food Science and Technology* 28(8): 900 – 912.

Kapinga, R., Mafuru, J., Simon, J., Rwiza, E., Kamala, R., Mashamba, F. and Mlingi, N. (2005). *Status of Cassava in Tanzania: Implications for Future Research and Development.* United Republic of Tanzania, Dar es Salaam, Tanzania. 94pp.

Mtunda, K. J., Muhanna, M., Raya, M. D. and Kanju, E. E. (2003). Current status of cassava brown streak virus disease in Tanzania. *Cassava Brown Streak Virus Disease: Past, Present, and Future*. *Proceedings of an International Workshop,* Mombasa, Kenya, 27 – 30 October, 2002. pp.7 – 11.

Mudombi, C. R. (2010). An ex-ante economic evaluation of genetically modified cassava in South Africa. Dissertation for Award of MSc Degree at University of Pretoria, South Africa, 113pp.

Oladunmoye, O. O., Aworh, O. C., Maziya-Dixon, B., Erukainure, O. L. and Elemo, G. N. (2014). Chemical and functional properties of cassava starch, durum wheat semolina flour, and their blends. *Food Science and Nutrition* 2(2): 132 – 138.

Souza, J. M. L. D., Negreiros, J. R. D. S., Álvares, V. D. S., Leite, F. M. N., Souza, M. L. D., Reis, F. S. and Felisberto, F. Á. V. (2008a). Physicochemical variability of cassava flour. *Food Science and Technology* 28(4): 907 – 912.

TZS 466/EAS 740 (2010). *Cassava Flour Specification.* Published by the East African Community. Arusha, Tanzania, 10pp.

CHAPTER FOUR

Manuscript Three

4.0 Compliance Status on Toxicological and Microbiological Parameters for Cassava Flour Processed in Tanga, Mwanza and Coast Regions in Tanzania

4.1 Abstract

Cassava (*Manihot esculenta Crantz*) is an important subsistence food crop in Tanzania, especially in the semi-arid areas. The country realizes the importance of cassava as a major source of carbohydrate and a drought tolerant crop and has given it the second priority ranking staple food next to maize. Handling and processing of cassava flour in Tanzania is mainly done by SMEs applying different processing methods depending on location whose practices expose the products to toxicological and microbiological contamination. Cassava flour produced from the selected regions includes *Udaga*, *Kivunde*, *Bada* and *Makopa*, in local names. The objective of this study was to assess compliance of cassava flour processed by SMEs from Mwanza, Tanga and Coast regions to the National and regional standards TZS 466:2010 and EAS 740:2010 so as to establish its safety for human consumption. Cassava flour samples (22) from the three selected regions were evaluated for: HCN, aflatoxin (B_1 and total), *Salmonella*, yeast and moulds, and *Escherichia coli* counts. The results indicated that 95.5% of all the samples were within the maximum acceptable limit of 10 mg/kg of HCN for cassava flour as stipulated in the National standard (TZS 466:2010 / EAS 740:201). Furthermore, 40.9% of samples tested positive for aflatoxin B_1 and total aflatoxin, with the range between 0.01 to 0.9 ppb and 0.05 to 1.4ppb, respectively. Microbial analysis of cassava flour samples from both processing methods was evaluated using standard microbiological methods. Yeast and mould count of cassava flour samples collected from Tanga, Mwanza and Coast regions ranged from 3.01 to 5.02log cfu/g, 2.78 to 3.54log cfu/g and 2.52 to 3.24log cfu/g, for the three regions, respectively. About 45.5% of the cassava flour samples had higher limits for yeast and moulds than recommended thus failing to comply with the limits stipulated in the National standard. All samples complied for *Escherichia coli* and *Salmonella* specifications. Higher yeast and mould counts obtained in this study were indicative of potential spoilage agents and possible mycotoxin contamination of the flours. Low content of HCN, aflatoxin B_1 and total aflatoxin is still a safety alert that needs further investigation to assure the safety and quality of cassava flours consumed in various food preparations in the selected regions. Therefore, further studies to this population whose main meals are cassava flour-based is necessary to investigate toxin retention effect and pathological state of the consumers due to prolonged exposure to consumption of these cassava flour products.

Keywords: Cassava flour, HCN, aflatoxin**,** yeast and moulds, *Escherichia coli* and *Salmonella*

4.2 Introduction

Cassava (*Manihot esculenta Crantz)* is a dietary staple to most people from sub-Sahara Africa whereby in Tanzania cassava is approximately grown in all region of Tanzania. According to Mtunda *et al.,* 2003, cassava production capacity for coastal strip along the Indian Ocean (Dar es Salaam, Tanga, Lindi and Mtwara) is 48.8%, around Lake Victoria (Mwanza, Mara and Kagera) is 23.7% and along the shores of Lakes Nyasa (Ruvuma) is 13.7% and Tanganyika (Kigoma) is 7.9%. Cassava root is composed of moisture (70%), starch (24%), fibre (2%), protein (1%) and other elements (3%). The roots are highly perishable due to their higher moisture content (Abass *et al.,* 2016). According to Mlingi and Ndunguru (2003), the perishability of the roots normally ranges between 2 to 3 days after harvest. Therefore, in order to prevent early deterioration and to facilitate preparation of the shelf stable products, cassava is usually traded in processed forms like cassava flour, chips, cassava gums, starch, biscuits, bread, alcoholic beverages and animal feeds (Neves *et al.,* 2017; Mezette *et al.,*2009: Mlingi and Ndunguru, 2003; Kapinga *et al.,* 2005; Falade and Akingbala, 2010; Eleazu and Eleazu, 2012).

Furthermore, the roots contains two cyanogenic glucosides namely linamarin and lotaustralin in a ratio of about twenty to one in which upon enzymatic hydrolysis of these glucosides compartments it yields toxic compounds known as hydrogen cyanide and acetone (Essers, 1995; Ndubuisi and Chidiebere, 2018). Linamarin accounts for more than 80% of the cassava cyanogenic glucosides. It is a β-glucoside of acetone cyanohydrin and ethyl-methyl-ketone-cyanohydrin (Ndubuisi and Chidiebere, 2018).With respect to cyanide levels in cassava, a very toxic compound present in the root, the amount is dependent on the cassava variety as well as climate change in years of low rainfall due to water stress (Cardoso *et al.,* 2005). Cassava varieties are categorized as bitter or sweet. Most bitter cassava is known to contain high cyanide content while most sweet cassava varieties have low cyanide content. (Essers, 1995; Montagnac *et al.,* 2009; Bolarinwa *et al.,* 2016; Ndubuisi and Chidiebere 2018).Values from 15- 400 mg of HCN/kg of fresh weight of cassava roots have been reported for bitter varieties. Sweet varieties of cassava typically contain approximately 15-50 mg hydrogen cyanide/kg fresh cassava (Ndubuisi and Chidiebere 2018; Nerves *et al.*, 2017 and Setiyo *et al.*, 2017). The toxicity of cassava attributable to its cyanide content has been recognized as a serious health hazard in the tropics for many years. Thus, to reduce these effects, cassava roots have been subjected to various processing techniques/methods performed during specific time and in specific sequence differing according to locality and the varieties of the cassava roots being processed to render it suitable for human consumption (COSCA Tanzania, 1996; Khatib, 2008). Cassava processing techniques include peeling, crushing, milling, slicing, and sun or smoke drying, fermenting, frying, boiling or steaming (FAO/IFAD, 2005; Khatib, 2008 and Omolola *et al.,* 2017). In Tanzania, peeled roots are usually sun-dried for one or two weeks depending on sun intensity or fermented and dried and subsequently processed into storable products called “Makopa”, “Kivunde” or “Kondowole”, “Nyange” and “Bada” (Chacha, 2014). Improper preparation of cassava can leave enough residual cyanide which cause intoxication and goitre and may even cause ataxia or partial paralysis or konzo (Cardoso *et al.,* 2005; Reddy *et al.,* 2017 and Cumbana *et al.,* 2007).

Aflatoxin contamination in food products has become a worldwide food safety concern. Aflatoxins are produced by the fungi *Aspergillus flavus* and *Aspergillus parasiticus* (Goldblatt, 2012; Rustom, 1997). Optimal thermal conditions for fungal growth are 36 to 38°C, while maximum toxin production occurs at 25 to 27°C. Growth in storage facilities is favoured by humidity above 85% the condition which occurs in most areas of Africa (Shephard, 2003).These fungi strains are highly toxic, mutagenic, teratogenic, carcinogenic, immune system suppressor and anti-nutritional contaminants in many food commodities including peanuts, maize, rice and cottonseed (Rustom, 1997; Chiona *et al.*, 2014; Kimanya, 2015 and Matumba *et al.*, 2014d). Thus governments have instituted food safety regulations to control mycotoxin, which aflatoxin is included, as well as research have been conducted to investigate occurrence of aflatoxins in a range of local foods that are widely consumed by the societies (Shephard, 2003).

Microbiological contamination can occur at all stages of agricultural products, from harvesting to processing, packaging, transportation, storage and by various means, whether soil, water, air, including various physical, mechanical or manuals contacts (Ferreira Neto *et al.*, 2004). Cassava flour processed from these regions is mainly done by SMEs mostly applying traditional methods depending on sun for drying their products. Drying is carried out under unhygienic environment resulting in products of low hygienic quality. The wet produce are usually spread on bamboo, tarpaulin, rocky surfaces, and concrete floors thus exposing them to chemical, physical and microbiological hazards (Ogori and Gana, 2013).

Despite adequate literature on cassava, information on compliance of cassava flour to National standard is still scanty. Therefore, this study strives to evaluate compliance of processed cassava flour from different regions, produced by small and medium enterprises that dominate the market niche, against a National standard. The study focused on assessment of different processing technologies and storage conditions of cassava flour processed and established the extent of compliance of the cassava flour to microbiological and toxicological qualities required by the National standard in the selected regions of Tanzania.

4.3 Materials and Methods

4.3.1 Study area

This study was carried out in Tanga, Mwanza and Coast regions which are the leading cassava producers and consumers of cassava flour products. Cassava flour produced in these selected regions includes *Kivunde* (Coast regions), *Bada* (Tanga), *Udaga and Makopa* (Mwanza) whose processing methods differ.

4.3.2 Materials

Materials used for this study were cassava flour samples from Tanga, Mwanza and Coast regions. Cassava flour samples were from *Udaga*, *Kivunde*, *Bada* or *Makopa* processed by local methods and modern flour samples processed by modern/mechanical process. *Makopa* processing involve peeling of the roots, splitting or cutting the roots into small pieces sun drying to low moisture content and finally milling into flour. *Bada* processing involves peeling of the roots, cutting followed by covering of the cassava lot with cloth for 2-4 days to allow fermentation, followed by scraping the mould/fungal lot, drying and milling into flour. *Kivunde* processing involves peeling of the roots, soaking of the peeled roots in water for 2–5 days, then shake-drying to remove excess water, breaking into small pieces, sun drying to low moisture content and finally milling into flour. Modern processing technologies for cassava involve chipping and grating of the root, pressing to remove water and consequently the cyanide, sifting of the paste prior sun drying. Once dried it is milled into flour. Cassava flour processed using this method can be obtained in one day. Other materials such as packaging material, cool boxes purchased in Dar es Salaam; chemicals, analytical reagents, apparatus and laboratory equipment's were obtained from TBS and IITA laboratories.

4.4 Study Design

4.4.1 Sampling plan and data collection

Purposive sampling plan was used to collect samples from selected SMEs processing cassava flour in the three regions of Tanga, Mwanza and Coast. A total of 22 cassava flour samples (1.5 kilogrammes each) were randomly collected from the production lots after observing the processing flow which are different. During sampling, samples were separated thus in each lot half kilogramme and one kilogramme sample was packed differently bearing similar codes. Half kilogramme from each lot was kept in the refrigerator and transported using cool boxes until they reached IITA laboratory for HCN determination. Each one kilogramme obtained from those 22 lots was transported and stored in dry boxes until they reached TBS laboratory for aflatoxin and microbiological analyses.

4.4.2 Microbiological and toxicological analysis of cassava flour samples

Cassava flour samples were subjected to microbiological and toxicological analysis in which parameters including *Salmonella*, yeast and moulds as well as *Escherichia coli* and HCN, aflatoxin B_1 and total aflatoxin were analyzed to establish compliance status. Methods used for analysis were as follows:-

4.4.3 Analysis of hydrogen cyanide

Analysis of cyanogenic potential which include the sum of concentration of cyanogenic glucosides, cyanohydrins and cyanide in cassava flour was determined as per the Essers *et al.*, 1993 method validated by IITA laboratory. The method involves extraction of 30g of homogenized cassava flour sample in 250 ml of 0.1M orthophosphoric acid, which prevents endogenous linamarise from degrading cyanogenic glucosides and stabilizes the cyanohydrins. Then the extract was then treated with an excess amount of exogenous linamarise, the pH was raised to convert all cyanohydrins and hydrogen cyanide to cyanide ions. Cyanide ions were quantified using a specific and stoichiometric reaction with 0.2M NaOH, 0.1M buffer pH 6, chloroamine T, isoniconate and dimethyl barbiturate which produce a coloured dye. The reading of the colour absorbance at the 605nm atomic absorption spectrophotometer was recorded between 10 to 30 minutes incubation at room temperature in which triplicate readings were obtained. The absorbance of the colour produced was proportional to the concentration of cyanide ions in the sample. Using data from concentration of standard and absorbance readings a standard curve was obtained and its slope, from plotting absorbance values (Y axis) against standard concentrations (X axis).

The cyanogenic potential concentration was calculated as follows:

$$\text{Cyanogenic potential (mg/kg)} = \frac{\text{Absorbance of unknown sample x 250 x 0.4151}}{\text{Slope x weight of sample (g)}}$$

4.4.4 Analysis of aflatoxin

The determination of aflatoxin B_1 and total aflatoxin was carried out as per the Standard Operating Procedure (SOP) no. FCL/SOP-TM/13-01 which followed Romer Labs procedures (EC-Directive EC/178/2010) in addition to ISO 16050: 2014 procedures for quantification of aflatoxin by reverse-phase high-performance liquid chromatography (HPLC) with fluorescence detection and post-column derivatization. The tested sample of 25g cassava flour was extracted with a mixture of HPLC grade methanol and water (70: 40 methanol; water).The sample extract was filtered using filter paper Whatman No.1, 4 ml of sample were taken to 14 ml teflone tube, diluted with phosphate buffer solution (12 ml) and applied to an affinity column containing antibodies specific for aflatoxins B_1, B2, G_1 and G_2. The aflatoxins were isolated, purified and concentrated on the column then removed from the antibodies with methanol. Calibration standards were prepared and run with the Quality Control (QC) sample alongside the cassava flour samples. The QC data results were used to generate control chart by using excel sheet. The calibration curves were generated whereby the data collected were analysed with the Agilent Chem Station software, and quantification was achieved by comparing the peak areas of the samples and those of the aflatoxin standards solutions. The results were expressed in ppb.

The sample concentration was calculated as follows:

Aflatoxin concentration of the sample (ppb)

$$= \frac{\text{HPLC conc found (ppb)} \times 1\ \text{ml} \times 100\ \text{ml} \times 3.33\ \text{dilution factor}}{4\ \text{ml} \times \text{weight of the sample taken (g)}}$$

4.4.5 Analysis microbial parameters

Microbial analysis was done to determine microbial compliance of cassava flour from the selected regions for yeast and moulds, *Escherichia coli* and *Salmonella* parameters as per ISO 21527-1, 2008, ISO 7251, 2005 and ISO 6579-1, 2007, respectively.

4.4.6 Statistical data analysis

Data were analyzed using R- statistical package software version 3.3.0. Analysis of Variance (ANOVA) was carried out to determine whether the microbiological and toxicological (HCN and aflatoxin B_1 & total) values obtained from the analysis of cassava flour showed any significant difference ($p<0.05$) between different processing methods. Principal component analysis was also used to determine systematic variations between variables. Results were expressed as mean ± standard deviation.

4.5 Results and Discussion

Table 4.1 shows the results of hydrogen cyanide (HCN), aflatoxin (B_1 and total) of the 22 cassava flour samples obtained during processing between three regions of Mwanza, Tanga and Coast.

Table 4.1: Toxicological composition values of cassava flour in each processing method between regions (n=22)

Region	HCN(mg/kg)		Aflatoxin B_1(ppb)		Aflatoxin Total(ppb)	
	Local	Modern	Local	Modern	Local	Modern
Coast	$1.13{\pm}1.22^{b}$	$1.5{\pm}1.55^{b}$	$0.9{\pm}\ 0.76^{a}$	$0.6{\pm}\ 0.44^{a}$	$1.4{\pm}0.96^{a}$	$1.0{\pm}0.97^{a}$
Tanga	$2.1{\pm}0.13^{b}$	$1.9{\pm}0.81^{b}$	$0.05{\pm}\ 0.06^{b}$	$0.1{\pm}\ 0.13^{b}$	$0.05{\pm}\ 0.06^{b}$	$0.1{\pm}0.12^{b}$
Mwanza	$6.65{\pm}2.93^{a}$	$7.5{\pm}2.96^{a}$	$0.15\ {\pm}0.16^{b}$	$0.01{\pm}\ 0.03^{b}$	$0.2{\pm}\ 0.27^{b}$	$0.05{\pm}0.11^{b}$
Max Limit[1]	10		5		10	

Values in each column with different superscript are significantly different ($p<0.05$)

[1]TZS 466:2010 and regional standard (EAS 740:2010)

The National standard TZS 466:2010 (EAS 740:2010) stipulates the compositional requirements for cassava flour that needs to be considered safe for human consumption. It requires that cassava flour have a maximum HCN content of 10 mg/kg and aflatoxin B_1 and total in foods should not be more than 5 ppb and 10 ppb, respectively. Therefore, the following is the status of compliance on toxicological parameters in the cassava flour samples.

4.5.1 HCN status in cassava flour

The results for the HCN content of the collected cassava flour samples processed between regions ranged from 1.13 to 7.5 mg/kg. There was significant ($p< 0.05$) variation between HCN mean values of cassava flour samples processed by different methods between regions. Statistical analysis showed that 95.45% of all the samples were within the maximum acceptable limit of 10 mg/kg of HCN for cassava flour as stipulated in

TZS 466:2010 (EAS 740:2010) (Table 4. 1). Variations in HCN content was observed in flour from different processing method (modern and local) between regions. Some flour processed by modern method contained more hydrogen cyanide than the prescribed limit of 10 mg/kg. These results may be attributed to the quick method applied during processing which was characterized with higher cyanogen retention than the slow drying technology. This had been attributed to the combination of rapid removal of moisture in cassava roots resulting in low reaction time (reduction of enzyme activity) and inactivation of endogenous linamarase, which breaks down linamarin and release HCN, by high temperature drying (Udensi *et al.*, 2005 ; Nambisan, 2011). The observed results from this study were similar to studies done in Nigeria by Eleazu and Eleazu (2012); Udensi *et al.* (2005), which indicated that fermented cassava flour samples had lower HCN content.

Also, as the results provided, the reduction in HCN content in 95.45% of the cassava flour processed by local and modern methods which employed slow drying technology could be credited by the complete rupture of cells during crushing and drying process which enabled maximum contact between enzyme and substrate thus allows 95% removal of cyanogenic glucoside (Nambisan, 2011; Mlingi and Bainbridge 1994).

Furthermore, in this study there was also variation noted between sundried and fermented cassava flour products. The observed results from this study indicated that sundried samples retained more cyanide than fermented cassava flour since literatures report that fermentation detoxify cyanide in cassava flour as it facilitate breakdown of cyanogenic glucosides to low total cyanogen levels. Processes like dipping of cassava roots in water during wet fermentation process makes the root soft and causes cells rupture, hence releasing linamarase (Nambisan 2011; Gidamis *et al.*, 1993 and Muzanila *et al.*, 2000).

Furthermore, microbial growth and root softening occurring during cassava fermentation had been efficient in elimination of cyanogens (Westby & Choo, 1994). This observation correlates with the studies carried out by Mlingi and Bainbridge (1994); Nhassico *et al*. (2008) that sun drying process is ineffective compared to fermentation process as it still leaves unacceptably high levels of cyanogen in the flour especially during drought. Also it does not stop the occurrence of konzo in Eastern, Southern and Central Africa (Nhassico *et al*., 2008; Eleazu and Eleazu, 2012). Also, Teles (2002) indicated that the process of sun drying reduces 60 to 70% of the HCN in the first two months of preservation. However, the residual HCN is very high, reaching levels of 30 to 100 mg/kg. The cyanogens present in cassava and cassava products can cause acute intoxication leading sometimes to death, they exacerbate goiter, cretinism and stunting in children (Nhassico *et al*., 2008; Chacha, 2014; Khatib, 2008 and Nambisan, 2011).

Also, analysis of the results was done to study the differences in cyanide retention that occurred between the flour processed from different cassava roots varieties including those processed from sweet cassava variety, bitter cassava variety and or mixed (sweet and bitter) varieties which applies different processing methods. One cassava flour processed from mixed variety contained higher cyanide amount than the rest of the samples. The low cyanide levels in the flour samples could be attributed to the application of slow drying technique which includes fermentation and sun drying that were reported as proper method for cyanide reduction (Eleazu and Eleazu, 2012; Bradbury 2004 and Nhassico *et al*., 2008). The failed sample used quick drying method that results into higher retention of the cyanide content in the sample than the maximum permissible level of 10 mg/kg. These levels indicate that there is a clear demand to improve this processing technique to decrease the cyanide levels. Despite the fact that the analyzed samples had the least amount of cyanide, their consumption as staple food need to match with high consumption of protein rich foods. This is because cassava is known to contain least amount of protein while the body's detoxification mechanism of cyanide conversion into thiocyanate uses up part of the pool of the sulphur-containing essential amino acids; methionine, cysteine and cystine that can only be obtained from the food consumed. Thus any shortfall of these sulphur-containing amino acids could limit protein synthesis. Consequently, this causes stunted growth to children. Furthermore, the results from this study indicated that the population in the study area is exposed through diet containing least cyanide. Therefore possible hazards due to cyanide may exist since consumption of cyanide for a long period may overwhelm detoxification mechanism of rhodanese thus causing effects like konzo, cerebral brain damage or parkinsonism (Eleazu and Eleazu, 2012; Nhassico *et al.*, 2008; Cardoso *et al.*, 2004 and Banea-Mayambu *et al*., 2000). Although the study indicated that cassava flour produced by these SMEs is fit for human consumption, further studies are needed to investigate toxin retention and pathological state caused by prolonged exposure or consumption of cassava flour contaminated by low cyanogen concentration to this community whose main meal is from cassava flour.

4.5.2 Aflatoxin status in cassava flour

Table 4.1 presents simple descriptive status of cassava flour compliance on the parameter for aflatoxin B_1 and total aflatoxin. Among 22 cassava flour samples analyzed for aflatoxin B_1 and total aflatoxin, 40.9% were detected with aflatoxin ranging from 0.01 to 0.9 ppb and 0.05 to 1.4 ppb, respectively. The low quantities of aflatoxin in the present study may be attributed to shorter storage period of cassava flour from the time of sample collection as well as proper drying during processing. These findings correlates with results reported by Muzanila *et al.* (2000) who did the study in Tanga, Mwanza and Ukerewe, whose results indicated no aflatoxin contamination in the cassava samples. Also this study results are in line with the survey conducted in Tanzania and Rwanda by

Sulyok *et al.* (2015); Ghana by Wareing *et al.* (2001); Nigeria by Ibeh *et al.* (1991); Zambia and Malawi by Chiona *et al.* (2014), which reported the low or no incidence of aflatoxin contamination in cassava flour. Also, the study done in Kenya by Gacheru *et al.* (2015) and in Benin by Gnonlonfin *et al.* (2008) indicated no aflatoxin contamination of cassava chips samples which are later milled into cassava flour. The results from this study revealed that the cassava flour produced complied to standards since low or no aflatoxin contamination detected although further studies to evaluate risk of consuming small repeated doses of aflatoxin is vital in these selected regions.

4.5.3 Microbial status of cassava flour

Table 4.3 shows microbiological results of the 22 cassava flour samples obtained during processing between three regions of Mwanza, Tanga and Coast.

Table 4.3: Compliance statuses of cassava flour on microbial parameters as required by the National standard (n=22)

Region	Yeast and mould		*Escherichia coli*		*Salmonella*	
	Local	**Modern**	**Local**	**Modern**	**Local**	**Modern**
Coast	3.24 ± 0.40^a	2.52 ± 0.34^b	$<1 \times 10^1$	$<1 \times 10^1$	Not detected	Not detected
Tanga	3.01 ± 0.66^a	5.02 ± 1.59^a	$<1 \times 10^1$	$<1 \times 10^1$	Not detected	Not detected
Mwanza	3.54 ± 1.15^a	2.78 ± 1.68^a	$<1 \times 10^1$	$<1 \times 10^1$	Not detected	Not detected
Max Limit[1]	3		Nil		Nil	

[1]TZS 466:2010 and regional standard (EAS 740:2010)

*Values in each column with different superscript are significantly different ($p<0.05$)

The National standard TZS 466: 2010 (EAS 740:2010) sets the acceptable microbiological limits for the cassava flour to be considered safe for human consumption. These are: yeast and mould maximum limit 3.0 log cfu/g, *Escherichia coli* and *Salmonella*, both should be absent.

Yeast and mould counts in the cassava flour samples collected from Tanga, Mwanza and Coast regions ranged from 3.01 to 5.02log cfu/g, 2.78 to 3.54log cfu/g and 2.52 to 3.24log cfu/g, respectively. The yeast and mould counts reported in 25, 54.54 and 71.43% of cassava flour from Tanga, Mwanza and Coast regions, respectively, were below the set limit of 3.00 log cfu/g stipulated in the National standard. These results account for about 54.55% of all the cassava flour samples collected in the three selected regions which were attributed to proper drying done during cassava flour processing that resulted to moisture content of cassava flour below 12%. Ogiehor and Ikenebomeh (2006) indicated that moisture content of any produce will depend on factors such as location, season and processing method. Lower moisture content in flour is a good indication of microbial stability and may also contribute to reducing the tendency of staling in baked food products thus facilitate shelf life stability of cassava products. Low count of yeast and mould in cassava flour in this study agreed with previous studies done in Kenya by Gacheru *et al*. (2016) and in Nigeria by Ogori and Gana (2013) that low yeast and mould counts were due to bioload proliferation and fairly constant high temperature together with solid substrate surfaces provided by cassava chunks on drying.

Seventy five, 45.5 and 28.6% of cassava flour samples collected in Tanga, Mwanza and Coast regions, respectively had yeast and mould counts above the set limit of 3.00log cfu/g as provided in the TZS 466:2010 (EAS 740:2010). These high yeast and mould counts is an indication of potential spoilage agent and mycotoxins food poisoning (Ogori and Gana, 2013). These may be attributed to poor processing and drying methods that resulted into relatively higher moisture content in the sample. Also use of fungal spoiled cassava roots may be attributed to higher yeast and mould counts. Therefore, for raw cassava to be processed into a safe product it should be clean and of good quality. Also, use of starter cultures that have antimicrobial properties with the capability to detoxify, in addition to sustaining adequate and clean surrounding and use of sterilized packaging material to pack the processed fermented food is recommended as also documented by Adetunji *et al.* (2017). Furthermore, it is important to note that cassava roots are characterized by higher moisture content (Abass *et al.,* 2016) and are easily contaminated by fungi (Wareing *et al.,* 2001). Processing of cassava flour from these regions is done by SMEs and depends on sun for drying their product. Thus factors like sun intensity, contact and exposure time as well as availability of moisture meter to verify moisture content of the final product are among the challenges constraining these SMEs resulting in failure on yeast and mould limits. Higher counts for yeast and mould were also reported by Tsav-Wua, 2004 who reported that *Aspergillus* and *Penicillium* species were the predominant moulds present in all the traditionally processed cassava flour samples. The author recommended further investigation to ascertain their mycotoxigenicity since these potential spoilage agents have been implicated in mycotoxin food poisoning. Many studies indicated higher yeast and mould counts for cassava flour, cassava chips and cassava derived products obtained from market (Kaaya and Eboku., 2010; Oyeyiola *et al*., 2014; Adebayo-Oyetoro *et al.*, 2013 and Jonathan *et al.*, 2017). Therefore further studies are on microbiological counts and isolates are necessary to capture market status of cassava flour samples from these study regions.

Parameters for *Escherichia coli* and *Salmonella* counts in cassava flour samples from these three regions were below 1 x 10^1 and not detected, respectively (Table 4.2). This indicated that 100% of the samples collected complied with requirements stipulated in the National standard TZS 466:2010 (EAS 740:2010) and they are safe for human consumption. Presence of *Escherichia coli* and *Salmonella* in food product is an indication of fecal contamination (Clarence *et al.,* 2009) and poor raw material including water sources that were utilized during processing, respectively. Similar results were presented in the study done by Ferreira Neto *et al.* (2004) that samples presented sterility for *Escherichia coli* and *Salmonella spp.* These results could be attributed to low level of contamination of the samples during processing, proper handling, processing and storage. This ensured unfavorable conditions of the samples for the development of the microorganisms due to low moisture content in cassava flour and thus reduction of viable microbiota.

4.6 Conclusion

This study has established the microbiological and toxicological quality of cassava flour obtained during processing between three regions of Mwanza, Tanga and Coast. Microorganisms implicated in mycotoxin food poisoning were highlighted, HCN levels in most cassava flour sample were a bit high approaching the limit specified in the standard. This may render toxic effects to this population whose main meal are from cassava. Therefore, there is a need to provide simple method and or kit for cyanide detection during processing; provide education regarding favourable weather condition that favour mould growth which ultimately results into mycotoxin food poisoning. In addition provide nutrition education to enable consumption of balanced diet or food rich in sulphur containing amino acids since body's detoxification mechanism of cyanide conversion into thiocyanate uses up part of the pool of the sulphur - containing essential amino acids. Further studies are needed to investigate toxin retention and pathological state caused by prolonged exposure or consumption of cassava flour products contaminated by low cyanogen concentration. Finally, regulatory authorities should be proactive in the overall quality control of cassava flour processed and marketed in the country.

4.7 References

Abass B., Awoyale, W., Alenkhe, B., Malu, N., Asiru, B. W., Manyong, V. and Sanginga, N. (2016). Can food technology innovation change the status of a food security crop? A review of cassava transformation into "bread" in Africa. *Food Reviews International* 34(1): 87 – 102.

Adebayo-Oyetoro, A. O., Oyewole, O. B., Obadina, A. O. and Omemu, M. A. (2013). Microbiological safety assessment of fermented cassava flour "lafun" available in Ogun and Oyo states of Nigeria. *International Journal of Food Science* 2013: 1 – 5.

Adetunji, C. O., Akande, S. A., Oladipo, A. K., Salawu, R. A. and Onyegbula, A. F. (2017). Determination of the microbiological quality and proximate composition of fermented cassava food products sold in Ilorin-west local government area, Nigeria. *Ruhuna Journal of Science* 8: 76 – 89.

Banea-Mayambu, J. P., Tylleskär, T., Tylleskär, K., Gebre-Medhin, M. and Rosling, H. (2000). Dietary cyanide from insufficiently processed cassava and growth retardation in children in the Democratic Republic of Congo formerly Zaire. *Annals of Tropical Pediatrics* 20(1): 34 – 40.

Bolarinwa, I. F., Oke, M. O., Olaniyan, S. A. and Ajala, A. S. (2016). A review of cyanogenic glycosides in edible plants. *Toxicology-New Aspects to This Scientific Conundrum*. INTECH, London. 179pp.

Bradbury, J. H. (2004). Wetting method to reduce cyanide content of cassava flour. *Cassava Cyanide Diseases Network News* 4: 3 – 4.

Cardoso, A. P., Ernesto, M., Nicala, D., Mirione, E., Chavane, L., N'zwalo, H. and Bradbury, J. H. (2004). Combination of cassava flour cyanide and urinary thiocyanate measurements of school children in Mozambique. *International Journal of Food Sciences and Nutrition* 55(3): 183 – 190.

Cardoso, A. P., Mirione, E., Ernesto, M., Massaza, F., Cliff, J., Haque, M. R. and Bradbury, J. H. (2005). Processing of cassava roots to remove cyanogens. *Journal of Food Composition and Analysis* 18(5): 451 – 460.

Chacha, J. (2014). Incidence of *Aspergillus flavus* in stored dried cassava products and its association with aflatoxin production. Dissertation for Award of MSc Degree at Sokoine University of Agriculture, Morogoro, Tanzania, 112pp.

Chiona, M., Ntawuruhunga, P., Benesi, I. R. M., Matumba, L. and Moyo, C. C. (2014). Aflatoxins contamination in processed cassava in Malawi and Zambia. *African Journal of Food, Agriculture, Nutrition and Development* 14(3): 8809 – 8820.

Clarence, S. Y., Obinna, C. N. and Shalom, N. C. (2009). Assessment of bacteriological quality of ready to eat food (Meat pie) in Benin City metropolis Nigeria. *African Journal of Microbiology Research* 3(6): 390 – 395

COSCA (1996). *Processing Potential for Cassava Production Growth in Africa. Collaborative Study of cassava in Africa*. Working Paper No. 11. International Institute of Tropical Agriculture, Ibadan, Nigeria. 47pp.

Cumbana, A., Mirione, E., Cliff, J. and Bradbury, J. H. (2007). Reduction of cyanide content of cassava flour in Mozambique by the wetting method. *Food Chemistry* 101(3): 894 – 897.

Eleazu, C. O. and Eleazu, K. C. (2012). Determination of the proximate composition, total carotenoid, reducing sugars and residual cyanide levels of flours of 6 new yellow and white cassava (*Manihot esculenta Crantz)* varieties. *American Journal of Food Technology* 7(10): 642 – 649.

Essers, A. J. A. (1995). Removal of cyanogens from cassava roots: studies on domestic sun-drying and solid-substrate fermentation in Rural Africa. Thesis for Award of PhD Degree at Wageningen Agricultural University, The Netherlands, 131pp.

Essers, S. A., Bosveld, M., Van Grift, R. M. D. and Voragen, A. G. (1993). Studies on the quantification of specific cyanogens in cassava products and introduction of a new chromogen. *Journal of Food Science and Agriculture* 63(3): 287 – 296.

Falade, K. O. and Akingbala, J. O. (2010). Utilization of cassava for food. *Food Reviews International* 27(1): 51 – 83.

FAO/IFAD (2005). A review of cassava in Africa with country case studies on Nigeria, Ghana, the United Republic of Tanzania, Uganda and Benin. *Proceedings of the Validation Forum on the Global Cassava Development Strategy*. Rome, Italy. pp. 1 – 66

Ferreira Neto, C., Nascimento, E. M. D., Figueirêdo, R. M. D. and Queiroz, A. J. D. M. (2004). Microbiology of cassava flour (*Manihot esculenta* Crantz) during the storage. *Ciência Rural* 34(2): 551 – 555.

Gacheru, P. K., Abong, G. O., Okoth, M. W., Lamuka, P. O., Shibairo, S. A. and Katama, C. M. (2015). Cyanogenic content, aflatoxin level and quality of dried cassava chips and flour sold in Nairobi and Coastal Regions of Kenya. *Current Research in Nutrition and Food Science Journal* 3(3): 197 – 206.

Gacheru, P. K., Abong, G. O., Okoth, M. W., Lamuka, P. O., Shibairo, S. A. and Katama, C. K. M. (2016). Microbiological safety and quality of dried cassava chips and flour sold in the Nairobi and coastal regions of Kenya. *Journal of African Crop Science* 24(1): 137 – 143.

Gidamis, A. B., O'Brien, G. M. and Poulter, N. H. (1993). Cassava detoxication of traditional Tanzanian cassava foods. *International Journal of Food Science and Technology* 28: 211 – 218.

Gnonlonfin, G. J. B., Hell, K., Fandohan, P. and Siame, A. B. (2008). Mycoflora and natural occurrence of aflatoxins and fumonisin B_1 in cassava and yam chips from Benin, West Africa. *International Journal of Food Microbiology* 122(2): 140 – 147.

Goldblatt, L. (Ed.) (2012). *Aflatoxin: scientific background, control, and implications*. Elsevier. Shephard, G. S. (2003). Aflatoxin and food safety: recent African perspectives. *Journal of Toxicology: Toxin Reviews* 22(3): 267 – 286.

Ibeh, I. N., Uraih, N. and Ogonor, J. I. (1991). Dietary exposure to aflatoxin in Benin City, Nigeria: A possible public health concern. *International Journal of Food Microbiology* 14(2): 171 – 174.

Jonathan Segun, G., Bello Tunde, S. and Asemoloye Michael, D. (2017). Food values, spoilage moulds and aflatoxin detection in ‘Attiéké’ (A Cassava Fermented Product). *Journal of Microbiology Biochemistry Technology* 9: 244 – 248.

Kaaya, A.N. and Eboku, D. (2010). Mould and aflatoxin contamination of dried cassava chips in Eastern Uganda: association with traditional processing and storage practices. *Journal of Biological Sciences* 10(8): 718 – 729.

Kapinga, R., Mafuru, J., Simon, J., Rwiza, E., Kamala, R., Mashamba, F. and Mlingi, N. (2005). *Status of Cassava in Tanzania: Implications for Future Research and Development.* United Republic of Tanzania, Dar es Salaam, Tanzania. 94pp.

Khatib M. A. (2008). Effect of grating, chipping, dry fermentation and sun drying on cyanide level of cassava in Tongwe Village. Dissertation for Award of MSc Degree at Sokoine University of Agriculture, Morogoro, Tanzania, 90pp.

Kimanya, M. E. (2015). The health impacts of mycotoxins in the eastern Africa region. *Current opinion in Food Science* 6: 7 – 11.

Matumba, L., M., Monjerezi, T., Biswick, J., Mwatseteza, W., Makumba, D., Kamangira, A. and Mtukuso, A. (2014d). A survey of the incidence and level of aflatoxin contamination in a range of locally malnourished, HIV-infected Malawian children. *Acta Pediatrician* 94: 222—225.

Mlingi, N. L. and Bainbridge, Z. (1994, March). Reduction of cyanogen levels during sun-drying of cassava in Tanzania. *International on Cassava Safety* 375: 233 – 240.

Mlingi, N. V. and Ndunguru, G. T. (2003). A review of post-harvest activities on cassava in Tanzania. *Paper Presented in the 13th Symposium of International Society for Tropical Root Crops,* 10 - 14 November 2003, Arusha International Conference Centre, Arusha, Tanzania. pp. 506 – 513.

Montagnac, J. A., Davis, C. R. and Tanumihardjo, S. A. (2009). Nutritional value of cassava for use as a staple food and recent advances for improvement. *Comprehensive Reviews in Food Science and Food Safety* 8(3): 181 – 194.

Mtunda, K. J., Muhanna, M., Raya, M. D. and Kanju, E. E. (2003). Current status of cassava brown streak virus disease in Tanzania. *Cassava Brown Streak Virus Disease: Past, Present, and Future*. *Proceedings of an International Workshop,* Mombasa, Kenya, 27 – 30 October, 2002. pp. 7 – 11.

Muzanila, Y. C., Brennan, J. G. and King, R. D. (2000). Residual cyanogens, chemical composition and aflatoxins in cassava flour from Tanzanian villages. *Food Chemistry* 70(1): 45 – 49.

Nambisan, B. (2011). Strategies for elimination of cyanogens from cassava for reducing toxicity and improving food safety. *Food and Chemical Toxicology* 49(3): 690 – 693.

Ndubuisi, N. D. and Chidiebere, A. C. U. (2018). Cyanide in Cassava: A Review. *International Journal of Genom Data Min* 118: 1 – 10.

Neves, E. C. A., Neves, D. A., de Sousa Lobato, K. B., do Nascimento, G. C. and Clerici, M. T. P. S. (2017). *Technological Aspects of Processing of Cassava Derivatives. Handbook on Cassava.* Nova Science Publishers Inc., New York. 430pp.

Nhassico, D., Muquingue, H., Cliff, J., Cumbana, A. and Bradbury, J. H. (2008). Rising African cassava production, diseases due to high cyanide intake and control measures. *Journal of the Science of Food and Agriculture* 88(12): 2043 – 2049.

Ogiehor, I. and Ikenebomeh, M. (2006). The effect of different packaging materials on the shelf stability of Garri. *African Journal of Biotechnology* 5: 741– 745.

Ogori, A. F. and Gana, J. (2013). Microbiological loads of road side dried cassava flour from cassava balls and chunks. *American Open Journal of Agricultural Research* 7(1): 24 – 39.

Omolola, A. O., Kapila, P. F. and Mchau, G. A. (2017). Effect of selected processing and modification methods on quality of cassava and its starch. *Asian Journal of Agricultural Research* 11: 48 – 56.

Oyeyiola, G. P., Oyeniyi, O. R., Arekemase, M. O. and Ahmed, R. N. (2014). A comparative study on the microbiological and nutritional properties of stored chips and flours. *World Journal of Biological Research* 6(2): 1 – 6.

Reddy, T. R. K., Kim, H. J. and Park, J. W. (2017). *Potential Uses of Cassava Products and Its Future Challenging Opportunities.* Nova Science Publishers Inc., New York. 18pp.

Rustom, I. Y. (1997). Aflatoxin in food and feed: occurrence, legislation and inactivation by physical methods. *Food Chemistry* 59(1): 57 – 67.

Setiyo, G., Zikrina, I., Hakun, W. A., Firdaus, S. and Ira, D. (2017). *Utilization of Modified Cassava Flour and Its By-Products*. *Handbook on Cassava.* Nova Science Publishers Inc., New York. 271pp.

Shephard, G. S. (2003). Aflatoxin and food safety: recent African perspectives. *Journal of Toxicology: Toxin Reviews* 22(3): 267 – 286.

Sulyok, M., Beed, F., Boni, S., Abass, A., Mukunzi, A. and Krska, R. (2015). Quantitation of multiple mycotoxins and cyanogenic glucosides in cassava samples from Tanzania and Rwanda by an LC-MS/MS-based multi-toxin method. *Food Additives and Contaminants* 32(4): 488 – 502.

Teles, F. F. F. (2002). Chronic poisoning by hydrogen cyanide in cassava and its prevention in Africa and Latin America. *Food and Nutrition Bulletin* 23(4): 407 – 412.

Tsav-Wua, J. A., Inyang, C. U. and Akpapunam, M. A. (2004). Microbiological quality of fermented cassava flour ‘kpor umilin. *International Journal of Food Sciences and Nutrition* 55(4): 317 – 324.

Udensi, E. A., Ukozor, A. U. C. and Ekwu, F. C. (2005). Effect of fermentation, blanching, and drying temperature on the fuctional and chemical properties of cassava flour. *International Journal of Food Properties* 8(1): 171 – 177.

Wareing, P. W., Westby, A., Gibbs, J. A., Allotey, L. T. and Halm, M. (2001). Consumer preferences and fungal and mycotoxin contamination of dried cassava products from Ghana. *International Journal of Food Science and Technology* 36(1): 1 – 10.

Westby, A. and Choo, B. (1994, March). Cyanogen reduction during lactic fermentation of cassava. *International Workshop on Cassava Safety* 375: 209 – 216.

CHAPTER FIVE

5.0 Overall Conclusions and Recommendations

5.1 Conclusions

The study on compliance for safety and quality of cassava flour from the selected regions of Mwanza, Tanga and Coast revealed that most of the SMEs were educated and trained on best practices for cassava flour processing and storage. However, they failed to prioritize issues pertaining to food safety resulted into failure to comply with regulatory requirements as well as standards requirements for parameters like HCN, moisture content, crude fibre and yeast and mould counts.

5.2 Recommendations

Based on the study findings the followings are recommended:

i. Authorities mandated to innovate or promote technologies, protect consumers and facilitate trade need to address the limitations provided by these SMEs;
ii. Improve technologies involved in processing and storage of cassava and their products;
iii. Enforcement of regulations governing the food safety;
iv. Provide simple method and or kit for cyanide detection during processing;
v. Provide education regarding favourable weather condition that favour mould growth causing mycotoxin food poisoning;
vi. Provide nutritional education to enable consumption of balanced diet or food rich in sulphur - containing amino acids;
vii. Further studies to investigate toxin retention and pathological state caused by prolonged exposure or consumption of cassava flour contaminated by low cyanogen concentration.

APPENDIX

Appendix 1: Questionnaire for cassava flour processors

Introduction

My name is Zena Issa Ramadhani, a student from Sokoine University of Agriculture pursuing MSc. Food Quality and Safety Assurance. I am currently doing my research on assessment of quality and safety of cassava flour produced by SMEs using different processing techniques/methods. This questionnaire applies to all selected cassava flour processors in Coast, Tanga and Mwanza. It is aimed at getting more information on processing techniques/methods in producing cassava flour, storage practices and challenges regarding the product produced. Furthermore, quality and safety will be evaluated during the interviews to assess if there is any control implemented in the factory/premise to prevent final products from risks of contamination or non-compliant to national standard. You are humbly requested to respond to questions in this questionnaire which are strictly confidential and will be used for study purposes only to facilitate the intended learning at the Sokoine University of Agriculture.

1.0 General Information:

1.1 Processor/enterprise Name……………………………………Code No…………

1.2 Date of Interview……………………………………………………………………

1.3 Name of Person interviewed……………………………………........................

1.4 Gender (circle) ………………………………Female/ Male

1.5 Educational status (Circle)

- No school
- Primary

- Secondary
- University
- Vocational training
- Other (specify)……………………………………..……….…………

1.6 His/her position in a particular processing facility…………......................................

1.7 Processor's Address P. O. Box…………Tel/Mob.……………Email…………..…

District……………………Street…………………..Region……………………........

2.0 Enterprise's attributes

2.1 Do you have business (food) manufacturing permit/ license? (Tick one)

- Yes
- No
- Others (specify)

2.2 Do you have TFDA permit? (Tick one)

i) Yes………

ii) No……….

If No, give brief reasons………………………………………………………………

2.3 Do you have TBS license? (Tick one)

i) Yes……….

ii) No………..

If No, give brief reasons……………………………………………………

3.0 Products details

Product preparation method…………………………………………………………

4.0 Quality and Safety aspects

4.1 Do you know anything about food safety programme? (Circle) Yes No

What do you know? ……………………………………………………………………………

4.2 Do you know the safety and quality requirements for cassava flour and packaging materials used? (Tick one)

i) Yes………

ii) No……….

If Yes mention them …………………………………………………………………………

4.3 Do you have suitable area for storage of processed cassava flour, packaging materials and other staffs used during product processing? (Tick one)

i) Yes……..

ii) No………

If No how do you store the products, packaging materials and other staffs used during product processing……………………………………………………………………………

4.4 Which indicators are you using to monitor and adjust the quality of your product during processing? ....

4.5 Washing hands before work reduces the risk of food contamination. (Tick one)

i) Yes……..

ii) No……….

iii) Do not know…………

If Yes, where in particular (ticking all that apply)

i) The wash room……….

ii) In the toilet ………….

iii) Washing sink/basin in processing area………..

iv) None of the above

4.6 Is there a cleaning plan in your factory/premise? (Tick one)

i) Yes………..

ii) No………..

If Yes, does it include; the roofs? Yes………. No………. (Tick one), the waste storing areas? Yes……. No ………. (Tick one), the dustbins and waste containers? Yes…….No..…… (Tick one), the equipment? Yes…….. No………. (Tick one).

4.7 Do you check effectiveness of cleaning after cleaning operations? (Tick one)

i) Yes…………..

ii) No……………

If YES, what inspection methods do you use?

4.8 How do you dispose off wastes and by-products from the processing plant?

……………………………………………………………………………………………

4.9 Do you and the employees attend any training on quality and safety aspects of processing cassava flour? Yes/No

If YES mention the training attended……………………………………………………

General overview

What are the challenges/Problem(s) encountered during cassava flour processing? ....…....

4.10 Are you aware about the presence of toxic cyanogenic glucosides in cassava and cassava products? Yes/No

4.11 Do you normally analyse/check for residual cyanide in your final product before releasing it to the market? Yes/No

4.12 Do you analyse/check for any microbiological quality of your product? Yes/No

Many thanks for filling this questionnaire.