EVALUATION OF SAFETY AND QUALITY OF THE LAKE VICTORIA SARDINES ALONG THE VALUE CHAIN

NKONDOLA THOMAS

A DISSERTATION SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCEIN FOOD QUALITY AND SAFETY ASSUARANCE OF SOKOINE UNIVERSITY OF AGRICULTURE, MOROGORO, TANZANIA.

2016

ABSTRACT

Quality deterioration of Lake Victoria sardines is one of the most common claims from the final consumers which causes the change of use from human food to animal feed. Evaluation of post-harvest loses of Lake Victoria sardine was done by using three different methods, which are chemical laboratory analysis, microbial analysis and sensory evaluation. In this study it was shown by significant increase in total bacteria count seen from all samples taken along the steps of the value chain starting from fishing ground vessel (FGV) samples (10^2), off shore processors samples (OSP) (more than 10^3) up to market samples (OMS) (more than 10^3). The same trend was shown by total *coliform* count as well as *Escherichia coli,* tested in all the samples that ranged from (10^2) to (more than 10^3). Yeast and moulds showed remarkably large number of growth in all samples, starting from fishing ground vessel (FGV) samples, which was due to the state in which samples were taken to the laboratory since all the samples were taken to the laboratory in the dried form. However, there was no growth of *Salmonella* in all the samples. Lead was the only heavy metal tested in this study and among the samples only one sample taken from off shore processors came up with a positive result of 0.01mg/L of this metal. Sensory evaluation results of the products showed significant differences among the samples starting with high mean intensity scores for fishing ground samples.Minimum scores were observed in open market samples. Consumer study in sensory evaluation of the fish samples also suggested the same and shown by preference mapping results in which most consumers preferred fishing ground samples to the same as off shore samples just before processing. Improvement of the drying techniques and off shore processing environment as well as transportation and packaging facilities are necessary for achieving quality improvement and preventing post-harvest losses of sardines.

DECLARATION

I, Thomas Nkondola, do hereby declare to the Senate of Sokoine University of Agriculture that, this dissertation is my own original work and that it has neither been submitted nor concurrently being submitted for a degree award in any other University.

_____ _____

Thomas Nkondola **Date**

(MSc. Candidate)

The above declaration is confirmed

_____ _____

ProfessorH. S. Laswai **Date**

(Supervisor)

COPYRIGHT

ACKNOWLEDGEMENT

God was the first one to be on my side for giving me physical and mental health as well as enabling me to undertake this study successfully, indeed it was his blessings which made my studies possible; to him be the glory!

Next is my supervisor Professor H. S. Laswai from Department of Food Technology, Nutrition and Consumer Sciences,Sokoine University of Agriculture for providing me with his lifetime research experience and guidance through his constructive criticisms, broad knowledge encouragement and mentoring; to him I am indebted and accord heartfelt appreciation!

I am also thankful to workers of the National Fisheries Quality Control Laboratory,Mwanza for their tireless support and providing me with moral and material needs during my sample collection as well as laboratory analysis. Also, I would like to extend my deepest appreciation to National Fish Quality Control Laboratory (NFQCL) workers in NyegeziMwanza, Fisheries Education and Training Agency (FETA) and Tanzania Bureau of Standards (TBS) food and chemistry laboratory works for their support.

Last but not least to my lovely wife Neema John SemburaI thank her so much for her tireless support throughout the studies.

DEDICATION

This work is dedicated to my mother RozinaNgalawa and my brother DismasNkondola, who made me who I am now. My mother gave me the care I needed for me to grow up a responsible individual in the society and my brother provided me with all the support I needed for me to get basic needs including education since the death of our father while I was only ten.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ABBREVIATIONS AND ACRONYMS

AOAC	Association of Official Analytical Chemists
CFU	Colony Forming Unit
FAO	Food and Agriculture Organization of the United Nations
FETA	Fisheries Education and Training Agency
FGV	Fishing Ground Vessel
GDP	Gross Domestic Product
GHP	Good Hygienic Practices
GMP	Good Manufacturing Practices
HACCP	Hazard Analysis Critical Control Point
NFQCL	National Fish Quality Control Laboratory
OSP	Off Shore Processors
OBP	Off shore just Before Processing sample
OMS	Open Market Samples
PCA	Plate Count Agar
PCA	Principle Component Analysis
SUA	Sokoine University of Agriculture
TBS	Tanzania Bureau of Standards
UNIDO	United Nations Industrial Development Organization
URT	United Republic of Tanzania
WHO	World Health Organization

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background Information

The fisheries sector is among the important economic sub sectors of the economy in Tanzania. The sector provides substantial employment, income, livelihood, foreign earnings and revenue to the country. More than 4,000,000 people engaged in fisheries and fisheries related activities while more than 400,000 fisheries operators are directly employed in the sector. In 2009 the fisheries sector contributed 1.3% to GDP, the per capita fish consumption is 8.0 kilogram and about 30% of animal protein consumption in Tanzania is from fish, (URT, 2010).

Tanzania is well endowed with abundant natural resources from aquatic resource base. The total inland water area covers nearly 61,500 km^2 or about 6.5 per cent of the total land area. The total water area is 62,000 km^2 distribution of which is as follows; 35,088 km^2 - Lake Victoria, 13,489 km^2 Lake Tanganyika, 5,760 km^2 Lake Nyasa, 3,000 km^2 Lake Rukwa, 1,000km^2 Lake Eyasi, and 1,000km^2 other small water bodies. Most of these water bodies have substantial fisheries resources. On the marine side the country has a Territorial Sea of about 64,000 km^2 and a coastal line of 1,424 km. The Exclusive Economic Zone (EEZ) is up to 200 nautical miles covering an area of 223,000 km^2 providing the country with additional marine area and fisheries resources. (Kweka*et al*., 2006)

The fresh water resources are found in the shared waters of the East African Great Lakes namely, Lake Victoria, Lake Nyasa and Lake Tanganyika. In addition, the country is endowed with other small natural and manmade lakes, rivers systems and wetlands. Recent assessment indicates that the potential yield is 730,000 metric tonnes (Kweka*et*

al., 2006) distributed as follows: Lake Victoria (200,000 metric tonnes), Lake Tanganyika (300,000 metric tonnes), Lake Nyasa (100,000 metric tonnes), Other lakes (30,000 metric tonnes) and marine waters (100,000 metric tonnes).

The fisheries sector has a significant contribution in poverty reduction endeavours. The sector contributes about 10% of the Gross Domestic Product (Kweka*et al*., 2006). Its contribution in the growth of GDP for the last five years has been between 1.6% and 3.1%. Foreign exchange earnings have been shooting up in recent years. For example, foreign exchange earnings from fish sales rose from USD 61.8 million in 1996 to USD 92.2 million in 2004 (Kweka*et al*., 2006).

One third of the Tanzanian populationderive its protein from fish. Almost fifty percent of the Tanzania population live below the poverty line of 1USD per day. This section of the population depends to a large extent on fish for their protein intake, as they cannot afford other protein-rich foods.The fisheries sector is one of the significant sources of employment in the country. It is estimated that 80,000 fishers are employed full time in the fisheries sector. Also, others derive their livelihood from fisheries related activities such as animal feeds industries and boat building. (Kweka*et al*., 2006)

Furthermore, the fisheries sector is a source of recreation, tourism and foreign exchange. In view of these potentials, the Government of Tanzania has established marine parks and reserves to conserve marine resources. There are various types of fisheries in Tanzania, namely, marine fisheries, inland (or freshwater fisheries), industrial fisheries, artisanal fisheries and aquaculture. The marine fishery is practiced along the EEZ in the islands of Zanzibar and Pemba. Freshwater fishery is mainly on Lake Nyasa, Lake Tanganyika and Lake Victoria. Eighty five percent of the entire freshwater fisheries yields come from

Lake Tanganyika and Lake Victoria. The Nile perch (NP) is exclusively found in Lake Victoria. NP exports account for a significant part of Tanzanian exports. Aquaculture has been identified as an area of opportunity but as yet is not highly developed in Tanzania, (Kweka*et al*., 2006).

Fisheries are an important sector in the Tanzanian economy in terms of food supply and generation of foreign exchange through exports. Fisheries as an economic activity do not only generate incomes for the households but also creates employment to a significant proportion of people living around lakes and seashores. In short it provides a source of livelihood to a significant proportion of the population.

One such area is the Lake Victoria region. Lake Victoria is the second largest fresh Water Lake in the world covering about 68,800 km^2. The Lake is a shared resource among Tanzania, Uganda and Kenya. Of the total area, Tanzania has 51% of the total Lake area as its share while Uganda has 43% and Kenya the rest. Shared resources as is the lake, require an integrated management so as to avoid any abuse and degradation, thus facilitate a sustainable management of the Lake Victoria fishery, (Kulindwa, 2001).

Lake Victoria supports the most important fishery in Tanzania in terms of quantity and value. In 2009 the lake accounted for 238,703 metric tonnes which is 85% of total fish production in Tanzania. The fishery is based on three main important fish stocks, the Nile perch (*Latesniloticus*), sardines and Nile tilapia (*Oreochromisniloticus*), which are the backbone of commercial fishery in that order. In Tanzania over 75% of the Nile perch goes directly to the fish processing factories for export while *dagaa* and tilapia are sold on the regional and local markets, (Ibengwe and Kristófersson, 2012).

Due to the fact that Lake Victoria sardines constitutes over 38% of total fish landings from Lake Victoria in Tanzania and supports a major artisanal fishery in the country, ranking second to the Nile perch in Tanzania, the large volume landed, its wide distribution, high nutritional value and low price are characteristics that have made *dagaa* the most important fishery to the great majority of Tanzanians in supporting food security and sustainable livelihood, (Ibengwe and Kristófersson, 2012).

However, the sardine fishery is associated with high level of post-harvest loss, both physical and quality losses. A recent post-harvest study conducted in Lake Victoria estimated losses in the *dagaa* fishery to be about 32 million USD per annum, which clearly suggests that reduction of losses in this fishery is a potential area for addressing food security and poverty alleviation (Mgawe and Mondoka, 2008).

1.2 Problem Statement and Justification of the Study

Taking into consideration the underlined above potentials of Lake Victoria sardines fishery, it portrays the great potential in improving the economic and nutritional status of the larger part of our population but the great challenge is in changing the significant part of the harvest from being utilized as animal feed due to quality loss and maintain the product quality and safety for human consumption.

There is lack of information on the proper post-harvest processing and management interventions of sardines for reducing post-harvest losses. Better understandings of the basics on processing and quality maintenance intervention measures for reducing *dagaa* post-harvest loss from artisanal fishers in Tanzania, is necessary for improving economy of low income people and their food security standard by maintaining the currently lost part of the product to human consumption which will justify the better option of taking

direct fish protein which is recommended instead of getting it through animals after giving them as fish feed. Physical and quality post harvest loss of Lake Victoria *dagaa* it seems to be brought by a combination of factors among which are;

1.2.1 Post harvest handling

Most fishermen do not care about personal hygiene and safety of the product and end consumers and the bad handling practices cause contamination of the product by sand and environmental microorganisms, which in turn lead to huge post harvest losses. Hence, in this particular study some reasons are put forward according to data obtained after taking samples for laboratory analysis.

1.2.2 Storage problems

Most people tend to store sardines in piles, which is not recommended for quality maintenance of the product since the product needs enough space for ventilation and air circulation after drying, for it to maintain its dry state and not trapping the moisture from the environment or due to temperature rise and cause its quality deterioration. Pressure on fish at the bottom caused by excessive weight also speeds up the spoilage as it causes damage to the caught fish.

1.2.3 Packaging and transportation

The common packaging of the Lake Victoria sardines is in the huge sacks, which do not allow better handling and storage of the product, nevertheless exposing it to many physical, chemical, biological as well as environmental hazards all over the chain of storage and distribution.

Means of transportation also is another hectic part of the industry. All the same from heap sacks packaging, the products are usually distributed by different types of lorry trucks all over the country. This tends to also expose the product to the above mentioned types of hazards, either due to the conditions of the trucks used for transportation or climatic changes along the supply chain. Also, this is a challenge since most of the trucks used to transport sardines are the very same trucks transporting other items together with sardines and sometimes non-food items. As if that is not enough, in some cases people sit on top of the product, which in turn causes cross contamination of the product.

Therefore, this study tried to evaluate some causes of the quality deterioration of Lake Victoria sardines, which lead to huge post-harvest loss and suggest some measures for quality improvement of the product along the value chain and better improvement of our people in terms of their better health and food security status.

1.3 Objectives

1.3.1 Main objective

To evaluate causes for huge post-harvest loss in Lake Victoria sardines and propose ways of minimizing the loss for food security and better health of the community.

1.3.2 Specific objectives

(i) To assess the type and level of microbial contamination of Lake Victoria sardines along the value chain.

(ii) To assess Lake Victoria sardines through determination of the extent of chemical contamination along the value chain.

(iii) To assess consumer response towards the products along the value chain by using sensory evaluation methods.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Lake Victoria Sardines (*Rastrineobolaargentea*)

Rastrineobolaargentea (sardines) is the fish species which has remained abundant in Lake Victoria. It is also locally called *mukene*in Uganda, *omena*in Kenya. The species now supports a major artisanal fishery, ranking second to the Nile perch in Kenya and Tanzania (LVFO 2011). The Lake Victoria sardine constitutes over 38% of total fish landings from Lake Victoria in Tanzania. The demand for *dagaa* has continued to rise over the last decade. The species provides a cheap source of fish proteins for both humans and domestic animals. This is becoming more important following the export drive for processed table fish species, the Nile perch and the tilapia (LVFO, 2011). Although the species supports majority of artisanal fishery, little profit is realized. This is because the chemical composition, rough handling and storage results in contamination of fish flesh and easily spoiled. Fish will become unfit for human consumption for some hours after capture, unless it is subjected to some forms of processing or preservation, (Mbunda, 2013).

2.2 Drying of Fish

According to Arason (2003), drying means removal or extraction of water from a substance, usually by heating. Two things are of primary importance during drying i.e., the heat transfer that causes the evaporation of water and the mass transfer of the evaporated water through the substance and subsequently the removal of moisture away from the surface of the substance. In Tanzania fish drying is done in different ways using sun energy. These include open sun drying where fish is spread on raised racks, on rocks and even on sand along the beach. In addition to open sun drying the use of solar panels is also common when relatively higher quality dried sardine is required. When raised racks

or solar panel techniques are used, sardines are washed and in some cases fish is brined in a brine solution of 3% before drying. The addition of salt is important to enhance taste and slow down bacterial activities and other spoiling agents. Furthermore, it facilitates the drying process resulting in decreased drying time (Clucas and Ward, 1996).

There are a number of reasons why a significant proportion of dried fish is spoiled by the time it reaches the markets. The fish may have been spoiled before drying. The drying process may not have been quick and, therefore, the fish took a long time to dry and quality deterioration occurs during the drying process. Weather conditions can affect the efficiency of sun drying. The dried fish may have been held in storage at the market for a prolonged period leading to quality deterioration during storage (Ward and Jeffries, 2000). Furthermore, Owaga *et al*. (2015) reported that sun drying process leads to irregular and unpredictable quality as a result of slow drying. The harvesting and handling of the *dagaa* is a potential source of bacterial contamination due to lack of basic infrastructure such as the chilling and hygiene facilities at the landing, processing and marketing sites. The implications of reducing the amount of spoiled fish and proper processing is that, the trader in the market will receive a high price because the quality of the fish is good. If the quality of fish is good when the fish arrives in the market, then the processor should also gain from a higher price (Mbunda, 2013).

2.2.1 Fish and food security

Around 1.5 billion people depend upon fish for food, income & livelihood worldwide. 2.6 billion people receive more than 20% of their animal protein from fish, compared to 8% in developed countries. Up to 50% of animal protein in some countries comes from fish (Laswai, 2014).

Fish are a key dietary staple for many Tanzanians, providing over 40% of animal protein. Similarly, millions of families rely on catching, processing and trading fish to provide their main source of cash income. These benefits need to be protected if hunger and poverty are to be reduced.Food security and nutrition are fundamental towards poverty alleviation. Fish are a main source of vital nutrients, especially for the poor (Budeba, 2014).

According to FAO (2014), Tanzanian fish per capita consumption of fishery products is low at 5.7kg, below the African average (9.4kg), and far below the world average of 18.4kg. Species like *dagaa* have a lead role in the fish diet of local population. Per capita consumption has showed a downward trend since the mid-90's, when it was estimated at 11.1kg in 1995.Supply of fish for food is decreasing, due to a strong increase in exports. This is reflected in lower per capita consumption. Domestic production accounts for 97% of the total supply; therefore there is a direct trade-off between income generation through exports and supply for the domestic market, which results in lower availability and consumption, FAO (2014).

2.2.2 Sensory evaluation

Sensory evaluation is often described using the definition of Institute of Food Technology – a scientific method used to evoke, measure, analyze and interpret those responses to products as perceived through the senses of sight, smell, touch, taste and hearing. Sensory evaluation can be divided into two categories of testing: objective and subjective. In objective testing, the sensory attributes of a product are evaluated by a selected or trained panel. In subjective testing, the reactions of consumers to the sensory properties of products are measured.

Selection and training of expert assessors who can act singly or as members of a panel to evaluate the food samples and/or products is very important. It is expected that the assessors will score the freshness or liking of samples on a numeric scale, but the same training be used for assessors who will be required to classify food samples into grades. Loss of freshness and spoilage is a complex phenomenon involving chemical, physical and microbiological changes in the food products. It is a continuous, irreversible process, but a consistent sequence of changes can be observed in the raw and in the cooked foods. Loss of freshness merging into spoilage is a continuum starting when the food has just produced and can be considered perfectly fresh, and ending at some imprecise point when the food is putrid. The objective of training is to enable the assessor to place a food sample on this continuum using the sensory properties of the sample, and to position the sample in a structured scoring or grading system (Emmanuel *et al,*. 2012).

2.2.3 Sensory tests of fish

The term quality in fish should imply more than just how the fish looks. It involves more than how good the fish is to eat: eating quality is perhaps the most important component of overall quality and is greatly influenced by how well the fish is kept, whether in ice or in frozen storage. But 'quality' also includes such aspects as how valuable the fish is, how suitable the fish is for processing.Sometimes assessment of fish quality is based on the use of only one sense. Thus, deciding whether the fish is fit or unfit for human consumption is done by mere sight alone. On other occasions, two or more senses can be used to come into conclusion.

In objective sensory assessment of fish the effects of personal influence are minimized by avoiding, as far as possible, bias and feelings of liking or disliking. An objective assessment should be a dispassionate and as far as possible, accurate description of some

particular fish quality aspect, like this fish tastes of seaweed or this fish is in size grade 3.Also, it can involve statement like this fish product is very soft. In subjective assessment, a person's natural feelings of liking, pleasure, and acceptance of valuation are freely expressed by giving free statement as I don't like the taste of this fish, I prefer this product more than that product this product is delicious and/or I would buy this product. Due to involvement of pleasure expressions in subjective assessments, they are often called hedonic (Junior*et al,*. 2013).

It is essential to use objective sensory assessment wherever standards of quality need to be established, controlled or assured. Since the prosperity of most fish businesses depends on maintaining the quality of their products at a consistently high level, the importance of objective assessment is obvious. There is a strong case for all those who handle, process and sell fish to receive some formal instruction in those aspects of sensory assessment that concern them. Some aspects of quality measurable by sensory methods can sometimes be estimated also by objective non-sensory methods. For example, instruments or chemical or bacteriological analysis can be used in some circumstances to estimate freshness or degree of deterioration.However,such non-sensory methods are only secondary and are not exact substitute measures of quality as understood by consumers. This is because instruments and analyses cannot yet replace human senses. Objective sensory assessment as used in industry employs the same human senses used by consumers when they make subjective judgments about quality, and is thus an intrinsically more secure way of obtaining information about quality than is non-sensory assessment.For this reason it should be used wherever possible.

Subjective or hedonic assessment is used in product development and market research, and is largely confined to finding out what ordinary consumers think about fish products.

The hedonic responses of consumers to fish and fish products in shops and eating places are the main factors in determining sales and repeat sales. They are, therefore, of vital interest to the industry and it is often necessary for carrying out surveys of consumer likes and dislikes. Sometimes, companies can carry out consumer testing themselves, but because it is a specialized activity it is often carried out by specialized personnel. Some of the qualityaspects measured in sensory evaluation are shown in Table 1.

Table 1: Some quality aspects of fish and their assessment criteria

Sense	Aspect of quality
Sight	General appearance and condition, size, shape, physical blemishes, colour, gloss, identity
Smell	Freshness, off-odours and -flavours, taints, oiliness, rancidity, smokiness
Taste	Freshness, off-tastes and flavours, taints, oiliness, rancidity, smokiness, astringency, the primary tastes of acidity, bitterness, saltiness, sweetness
Touch (by fingers & mouth)	General texture, hardness, softness, elasticity, brittleness, roughness, smoothness, grittiness, gumminess, fluidity, wetness, dryness, crispness, presence of bones
Hearing	Brittleness, crispness

Source:(Pvt, 2016)

2.3 Sardine as Human Food

The presence of macro-nutrients and micro-nutrients in sardines without having a high fat content makes them very useful for human body. Prevention of heart problems is one of the health benefits of sardine and this is due to its high possession of omega-3 fatty acids, which are very important nutrients in preventing heart diseases. The omega-3 fatty acids found in sardines play an important role in controlling heart diseases. Research has shown that omega-3 fatty acids such asEicosapentaenoic Acid (EPA) andDocosahexaenoicAcid

(DHA) break down bad Low Density Lipoprotein (LDL) cholesterol in the body hence its effect in lowering the risk of getting heart diseases. Omega-3 fatty acids are also known to break down arterial plaque, which blocks arteries and increases blood pressure. By clearing the plaque, these fatty acids help in controlling blood pressure as well.

Also omega-3 fats said to prevent blood clotting in the artery system the phenomenon which is dangerous for the cardiovascular system. Regular intake of omega-3 fats, which are found in fish like sardines, is good for the heart because it helps in reducing cholesterol and blood pressure, thereby preventing strokes and atherosclerosis (Pvt, 2016)

Age related macular degeneration trend can be lowered by simply consuming sardines regularly as part of daily food. Age related Macular Degeneration (AMD) is a condition which is usually seen among people aged 50 or more Macular and retinal degeneration over the years results in loss of vision. Recent studies have shown that taking fish, particularly fish like sardines, resulted in a reduced risk of developing AMD. On the other hand, taking regular fat or saturated fat can increase the risk of developing AMD,(Pvt, 2016).

Intake of calcium and vitamin D can be very helpful in preventing certain types of cancers, including colorectal cancer. Sardines are one of the best sources of calcium and vitamin D.As mentioned, sardines are a good source of calcium and regular calcium helps in strengthening bones. A good amount of calcium, coupled with exercise can strengthen bones and prevent diseases, such as osteoporosis, in the future. Consuming sardines can help in building up the immune system that sardine fish oil may improve immune system by increasing the count of immune cells.

The essential fats found in sardines also play an essential role at the cellular level in skin cells. It is believed that it can decrease skin inflammation as well as make skin more beautiful.

Insulin resistance is one of the major factors to look for in diabetes. In cases where there is insulin resistance, the insulin produced in the body is utilized less efficiently. This, in turn, means that there is more glucose in the blood than there usually should be. This insulin resistance can be reduced by consuming sardines. The protein found in sardines has shown itself to be effective in reducing insulin resistance, compared to casein protein. Also sardines contain selenium, which is helpful in neutralizing the free radicals and protecting the organs from damage,(Pvt, 2016).

Table 2: Nutritional contents for sardines and food ranking

Nutrient	Amount	DRI/DV (%)	Nutrient Density	World's Healthiest Foods Rating
Vitamin B_{12}	8.11 mcg	338	32.2	excellent
Selenium	47.81 mcg	87	8.3	excellent
Phosphorus	444.52 mg	64	6.1	very good
Omega-3 fats	1.46 g	61	5.8	very good
Protein	22.33 g	45	4.3	very good
Vitamin D	175.09 IU	44	4.2	very good
Calcium	346.54 mg	35	3.3	good
Vitamin B_3	4.76 mg	30	2.8	good
Iodine	36.00 mcg	24	2.3	good
Copper	0.17 mg	19	1.8	good
Vitamin B_2	0.21 mg	16	1.5	good
Choline	68.04 mg	16	1.5	Good

Source:(Pvt, 2016)

2.4 Sardines Utilization in Tanzania

Sardines were mainly sold for feeding animals and the poor, but now various products of sardines are penetrating markets. Currently Dar es Salaam — Dried sardines, known in Kiswahili as *dagaa* from Tanzania's fresh water bodies, have begun penetrating the Australian and Canadian markets to boost fish exports in the country but the biggest challenge of all is the quality of the product since most of the sardines produced seems to have animal feed quality instead of human food quality (URT, 2015).

2.5 Post-harvest Loss of Fish

The Tanzania fishing industry is divided into the artisanal (small scale) and commercial/industrial (large scale) fisheries. The artisanal fishery in Tanzania is the most important fisheries as it lands most of the inland and the marine catches and contributes about98% of total landings. In Africa, over 60% of the fish supply to domestic and regional markets, as well as export-oriented processing units, is of artisanal origin (NEPAD, 2005). In Tanzania, the artisanal fisheries sector is faced with many challenges including that of incurring high post-harvest fish losses, especially in the *dagaa* (*Rastrineobolaargentea*) fishery on Lake Victoria, (Ibengwe and Kristoffersson,2012).

Two main types of post-harvest losses are said to contribute much in *dagaa* which are physical and quality loss. According to Laswai (2014) fish post-harvest physical loss in Tanzania accounts for 5 to 20% while quality loss account for up to 60% of the total loss. The average catch per year for one fisher was estimated to be 5 tonnes/year/fisher. The FAO PHLA data identified 59 % of *dagaa* post-harvest loss (physical and qualityloss) per year. Based on an average catch of 5 metric tonnes per year, fishers will incurfinancial losses of approximately 1,139 USD per annum. Using proper processing and handling practices can reduce post-harvest loss by half.Therefore *dagaa* post-harvest loss (physical

and quality loss) will be reduced to 30% after using proper treatments per fisher/year (Ibengweand Kristoffersson, 2012).

Post-harvest losses and quality improvement are key issues to include in future action plans. The lack of adequate food standard *dagaa* product in market implies significant losses and inadequate access of the population to quality product and that account for large part of the Lake Victoria *dagaa* being used as a complement in animal feed instead of being used as human food.

CHAPTER THREE

3.0 CHAPTER THREE

3.1 MATERIALS AND METHODS

3.2 Description of the Study Area

The study based on regions around Lake Victoria in the side of Tanzania where most of the consumed *dagaa* were landed. Also, various different destination markets for *dagaa* were visited for the purpose of survey and sample collection. Sample analysis was conducted in different laboratories including National Fish Quality Control Laboratory (NFQCL) Mwanza, Tanzania Bureau of Standards (TBS) Laboratory and Sokoine University of Agriculture (SUA) Morogoro.

3.3 Research Design

A cross sectional study design was used. The study allows data to be collected at a single point without repetition. It involved field survey, sample collection and laboratory analysis for different parameters identified under this study.

3.4 Sampling Procedures

Four fishing grounds by fisherman vessels landing in different sites, four off shore processing sites and four final markets of Lake Victoria sardines were randomly selected from Lake zone to Eastern coast of Tanzania. The study population was the whole value chain along which Lake Victoria sardines are passing. On the other hand, processed samples were collected randomly from fishing societies and from open markets in Dar es Salaam, Tanga, Bagamoyo and Morogoro.

3.5 Data Collection

As stipulated by Boyd *et al*. (1981), the minimum sample size to set as a representative sample of (n/N) 100 figure should be greater or equal to 5%, where; 'N' is total population and 'n' is the total sample size. Therefore, stratification of the regions around Lake Victoria (Mwanza, Geita) where landing sites are located before random sampling of the sites was done and came up with twelve fish practitioners out of 132 fish practitioners at the locations. True representative samples of the products were taken, four from fishing sites, four from off shore processing sites and another four from final markets where Lake Victoria sardines are sold. Samples from each level were then mixed and homogenized to obtain sub-samples that were then taken for laboratory analysis.

3.6 Laboratory Analysis

3.6.1 Total bacterial count

Total number of microorganisms were analyzed according to the ISO 4833 (2003) procedures. About 12 to 15 ml of the plate count agar (PCA) at 44 to 47 °C was poured into each Petri dish and carefully the inoculum was mixed with the medium by rotating the Petri dishes and the mixture was allowed to solidify by leaving the Petri dishes standing on a cool horizontal surface. After complete solidification, prepared dishes were inverted and placed in the incubator at 30 ± 1 °C for 72 h. After the specified incubation period the colonies were counted. The counted and number of colony forming units (CFU) per gram were calculated using the following formula;

$$CFU/g = \frac{\sum C}{(n1+n2)d} \quad \textbf{(1)}$$

Where; ∑C is the sum of colonies counted on the dishes retained

n1 is the number of dishes retained in the first dilution

n2 is the number of dishes retained in the second dilution

d is the dilution factor corresponding of the first dilution.

3.6.2 Total coliform

Total coliform was determined according to the ISO7251 (2005) procedures. This method is based on MPN procedures using the lauryl sulphatetryptose Brilliant-Green lactose bile broth each being incubated at 37^{o}C for 24-48 hours. Fecal coliform (*E.coli*) EC broth was used, incubated at 44^{o}C for 48 hours. On confirmation for the presence of *E.coli* KOVAC's reagent was used.

3.6.3 Fungi (yeast and moulds)

Yeast and moulds were determined according to ISO 6611 (2004) procedures. About 15 ml of the medium containing chloramphenicol previously melted and maintained at 45°C in the water bath into each petri dish was carefully mixed with the inoculum. The petri dishes were rotated and allowed the mixture to solidify by leaving the petridishes to stand on a cool horizontal surface. The prepared dishes were inverted and placed them (while keeping in an upright position) in the incubator set at 25°C for 5 days. The colonies were counted on each dish distinguishing between colonies of yeasts and colonies of moulds on the basis of their morphological characteristics. The counted and number of colony forming units (CFU) per gram were calculated using the following formula;

$$CFU/g = \frac{\sum C}{(n1+n2)d} \quad \text{(2)}$$

Where; $\sum C$ is the sum of colonies counted on the dishes retained

n1 is the number of dishes retained in the first dilution

n2 is the number of dishes retained in the second dilution

d is the dilution factor corresponding of the first dilution

3.6.4 Analysis of *Salmonella*

Determined according to ISO 6579 (2002). The procedure involved first enrichment in BPW broth (37 °C for 18h). Second enrichment was in Rappaport-Vassiliadis (RV) broth (41.5 °C for 24h) and tetrathionate broth (41.5 °C for 24 h). From these broths, streaking onto two solid media: XLD and BG (37 °C for 24 h) was done. Typical colonies (2-4) were inoculated into TSI-agar and LI agar (37 °C for 24 h).

3.6.5 Analysis of *Escherichia coli*

A liquid selective enrichment media was inoculated with initial suspension of the test sample. The tube was then incubated at 37^0C for 48h and examined for gas production. Then the tube was sub-cultured to a tube containing a liquid selective (EC broth). The tube obtained was then incubated at 44^0C for 48h and examined for gas production and then taken to indole-free peptone water for indole production test. Tubes showing all of the above behaviours were taken to enumeration since they depicted the presence of *E. coli*.

3.6.6 Heavy metal analysis

Lead was the only heavy metal tested in all the samples from (FGV) samples to (OMS) and the method used was (AAS ICE 3300). The main reason was that there are no cases of mercury and other metal contaminations of the Lake but lead is one of the metals likely to be produced in household waste water that could reach the river.

3.7 Sensory Evaluation

3.7.1 Quantitative Descriptive Analysis (QDA)

Sensory evaluation part was done at Fisheries Education and Training Agency (FETA) Laboratory by trained sensory panel of FETA students comprising of 9 assessors, within

whom 4 were males and 5 females with their age between 22 to 35 years. The assessors were selected and trained according to protocol developed for trained panelists (Elia, 2011). In a pre-testing session the assessors were trained in developing sensory descriptors and the definition of the sensory attributes. Sensory attributes involved in this training with regard to the samples to be tested were colour hue, aroma, taste, mouth feel, crispiness and flavour. An unstructured line scale was used for rating the intensity of an attribute.The left side of the scale corresponded to the lowest intensity of each attribute (value 1) and the right side corresponded to the highest intensity (value 5) (Appendix 2). Panel Check software was used to analyze the data obtained from assessors real testing. Description of terms used in the analysis was as agreed by the panelists as shown in Table 3.

Table 3: Terms used to define sensory attributes in descriptive sensory analyses

	Attribute	**Definition**
Colour	Colour	Bright shining silver like colour
Aroma	Fishy	Aromatics associated with fresh fish odour
Taste	Fish	The taste associated with fresh fish taste
Mouth feel	Sand less	Free from any sort of sand or anything alike
Flavour	Fresh	No trace of spoiled fish smell and texture
Crispiness	Breakable	Breakability on bending

Source: Study panelists

3.7.2 Consumer behaviour sensory analysis

A total of seventy (70) consumers from around Fisheries Education and Training Agency were used for consumer test of sensory evaluation in this study. Five point hedonic scale was used in which 1 represented the lowest and 5 represented the highest score. Their definitions were; (1 =Dislike extremely and 5 = Like extremely). Consumer Check software was used to analyze the data obtained from this consumer behaviour test.

3.7.3 Preference mapping

The same attributes of samples were used to assess consumer preferences on each sample as suggested by Ayne*et al,*. (2010) and the test was conducted on each product using a 5-point hedonic scale (1= Dislike extremely, 2 = Dislike, 3 = Neither like nor dislike 4=Like, 5 = Like extremely.

3.8 Data Analysis

Data from sensory evaluation were organized and analyzed by using PANEL CHECK and CONSUMER CHECK sensory evaluation softwares.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Microbial Results

4.1.1 Total plate count

The change in Total Plate Count (TPC) of sardine samples from fishing ground vessels (FGV) to open market samples (OMS) was so variable as shown in Table 4. In general, the TPC increased remarkably from (FGV) samples to off shore processors (OSP) samples and the same trend was shown by (OMS) as seen in Table 4.

Table 4: Total bacterial count

SAMPLE	FGV	FGV	OSP	OSP	OMS	OMS
(CFU/g)	257	84	$>10^3$	$>10^3$	$>10^3$	92

The TPC for all sardine samples was low at the first stage of value chain, that is, at the fishing ground as observed in the fishing ground vessel samples. These values increased after first step of value addition, which was at the off shore processing step. However, the increase in TPC of all samples observed showed higher values at the higher level of value chain compared to that shown by the low level sardine samples. This clearly show that, given the ambient condition of handling the catch, it was inevitable to escape microbial contamination and/or multiplication. Furthermore, the longer the handling time the higher the counts would be, as environmental temperatures were usually higher than those of the fishing water and therefore conducive for microbial multiplication.

As some studies suggest, heaping of sardines on the ground after harvest at ambient temperatures accelerates the rate of deterioration. Besides, soil is the source of both spoilage and pathogenic microorganisms, which may subsequently contaminate the

product (Olsen and Hammack, 2000). The keeping quality of fresh fish can be improved via good handling practices including soon after harvest (Brigitte *et al.*, 2004).

4.1.2 Yeasts and moulds

The content for yeasts and moulds in the samples from (FGV) samples to (OMS) showed high values with different types as shown in the Table 5.

Table 5: Yeasts and moulds results

SAMPLE	(CFU/g)	CLASSIFICATION
FGV	$>10^3$	-*Penicillium*spp
FGV	$>10^3$	-*Aspergillus*spp
OSP	$>10^3$	-*Penicillium*spp
OSP	16	-*Aspergillus* (Mixture of species)
OMS	$>10^3$	-*Cladosporium*spp
OMS	$>10^3$	-*Aspergillus* (Mixture of species)

As from fishing ground, dried samples mould and yeast growth showed $>10^3$ CFU/g, increasing up to the higher levels of value chain, that is open market samples. As in the previous explanation, it was again shown that contamination with yeasts and moulds increased from the point the sardines were harvested to where they were finally processed for the market. Mould growth in sardines usually takes place during processing and specifically on drying process. This is observed when the drying is not fast enough and the products are stored or left with higher moisture on the course of repeatedly drying under the sun. This can also be an indication of poor handling of the product during processing.

According to literature, high microbial load in sardines could be attributed to poor handling and sanitation practices. Possible sources of high microbial counts in dried

sardines are poor sanitary conditions during fishing, processing/drying, storage and transportation (Abowei and Tawar, 2011).

4.1.3 Total coliform count

In general, total coliform count increased from the low level of value chain to high levels (Fig. 1).

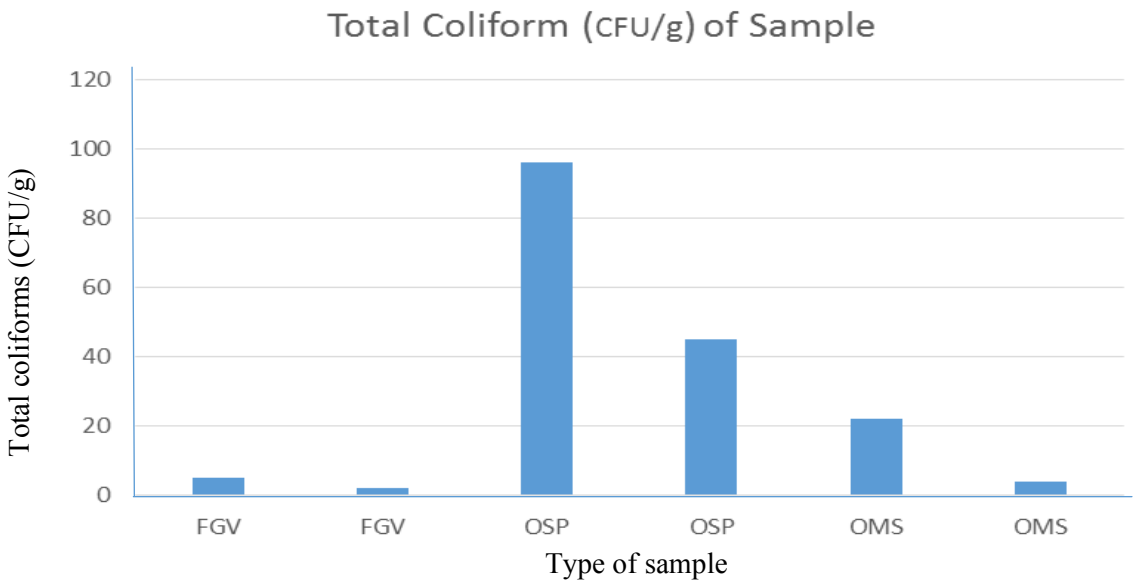


Figure 1: Total coliforms in the samples

Higher counts of total coliform were found in the sample at off shore processors level, where smallscale processors were just processing the sardines by natural/traditional solar drying over sandand/or rocks. The FGV sardines had the lowest count compared to those from OSP and OMS. However, it was observed that total coliform count was relatively lower for the market samples when they were compared with those of off shore processors samples. This also shown in the study by Bagge – Ravn*et al.*(2003)

4.1.4 *Escherichia coli*

The presence of *E. coli* in the samples appeared at the off shore processors samples (OSP) while nothing was observed in the fishing ground vessels samples (Fig. 2)..

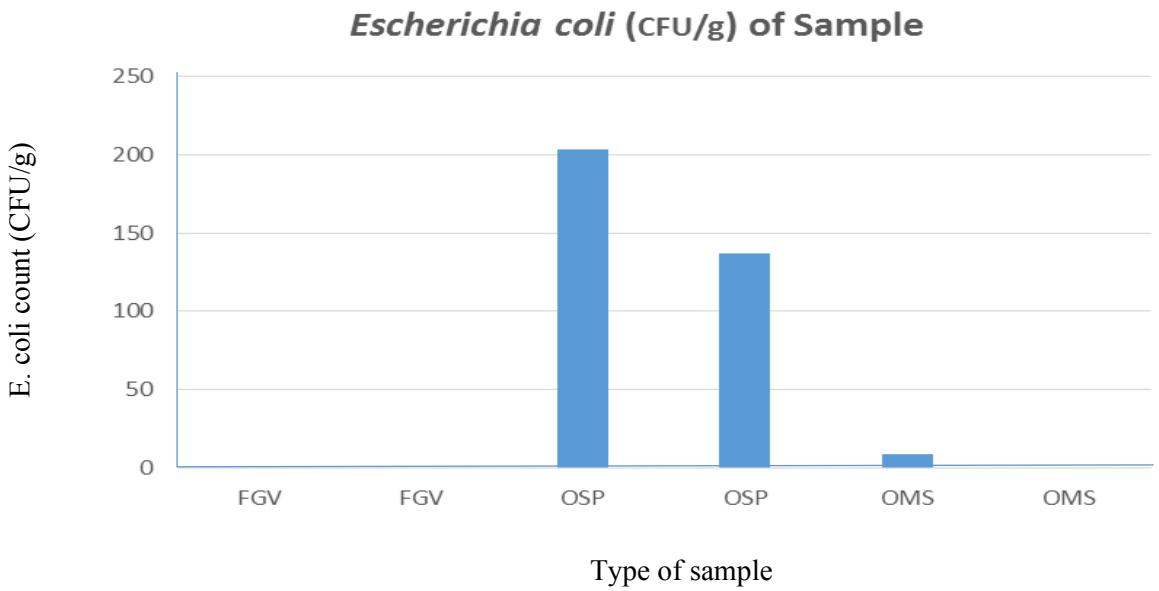


Figure 2: *Escherichia coli* results

Higher counts of *E. coli* were found in the off shore processors samples, where smallscale processors were just processing the sardines by common solar drying over the sand or rocks. The FGV sardines had no *E. coli* count at all when this was compared to that from OSP and OMS. However, it was observed that *E. coli* count was relatively low in the market samples compared with that from off shore processors samples. It was also evident that most of the contamination came from handling and possibly holding time at the off shore stage. A similar trend was also shown in the study done by Brigitte *et al.* (2004).

4.1.5 *Salmonella*

Salmonella analysis of all samples from fishing vessels (FGV), off shore processors (OSP) to open market samples (OMS) showed negative results. This therefore ruled out

presence of *Salmonella* in the sardines, irrespective of the stage at which these sardines were sampled. From *Salmonella* stand point, there should be no worries at all regarding consumption of sardines obtained from the lake, handled or processed as was encountered in this study. In general the results show that salmonellosis in sardines does not originate from lake water but rather by what will follow after the harvesting. Also, from this study, it is clear that the marketed fish from those areas from where the samples were obtained, was not contaminated by *Salmonella.*

4.1.6 Heavy metals

Lead was the only heavy metal tested in all the samples obtained from fishing ground to open market and the results were as shown in the Table 6.

Table 6: Heavy metal results

Heavy metal tested	Test method	FGV	OSP	OMS
Lead Content (mg/L)	AAS	Not detected	0.01	Not detected

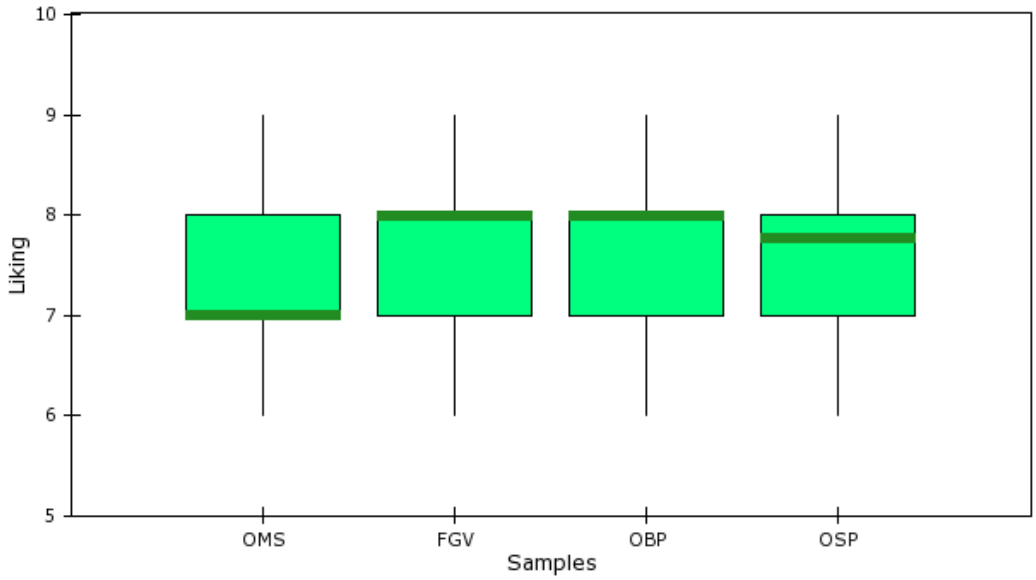
There were negative results for all samples except one sample obtained from off shore fish processors (OSP), which showed reasonable quantity of lead as detected by AAS method. The amount of lead detected was within the acceptable range for fish since the maximum allowed level is 0.5 mg/kg (USDA, 2006).

4.2 Sensory Evaluation Results

4.2.1 Consumer preference

As seen in Johnson *et al.* (1999) in their work regarding preference mapping, analysis of data obtained from consumer behaviour followed similar technique and showed that most

consumers preferred Fishing Ground Sample (FGV) the same way as they preferred Off shore just Before processing Samples (OBP). This was followed by Off Shore Processors samples (OSP). The Open Market Samples (OMS) were the least preferred (Figures 3 and



4).

Figure 3: Box plot showing degree of consumer liking for each sample

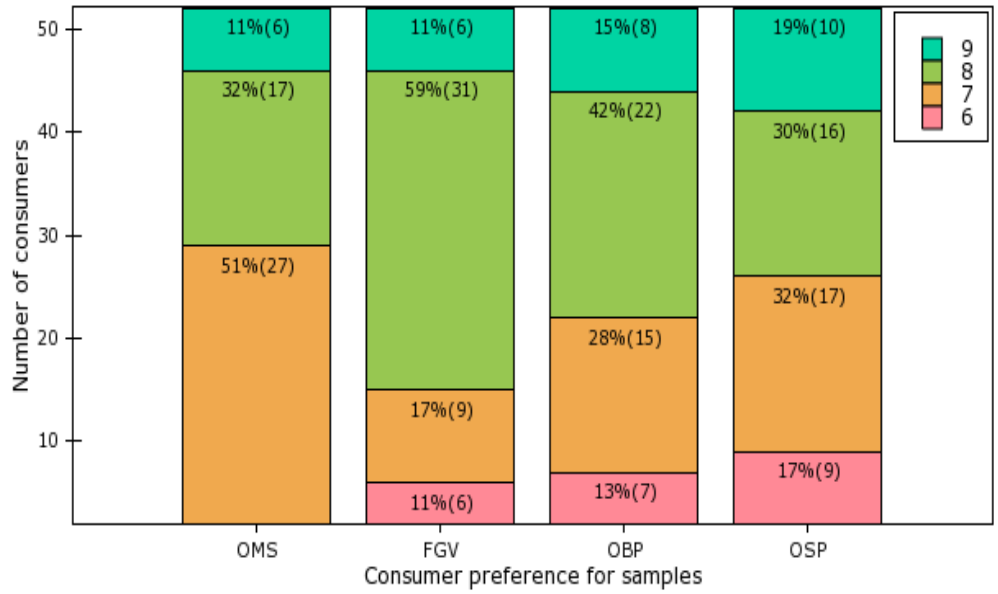


Figure 4: Stacked histogram plot showing percentage consumer liking for each sample

4.2.2 Descriptive analysis

4.2.2.1 Principle Component Analysis (PCA)

Principle Component Analysis (PCA) from two way analysis of variance (2way-ANOVA) showed difference between samples. Samples from open market (OMS) proved the most inferior and the attributes tested were close, showing taste and mouthfeel the most affected (Figure 5). This suggests that samples from open market contained unacceptable components, especially a lot of sand and other alike contaminating physical debris as per definition used in descriptive sensory analysis panellist training.

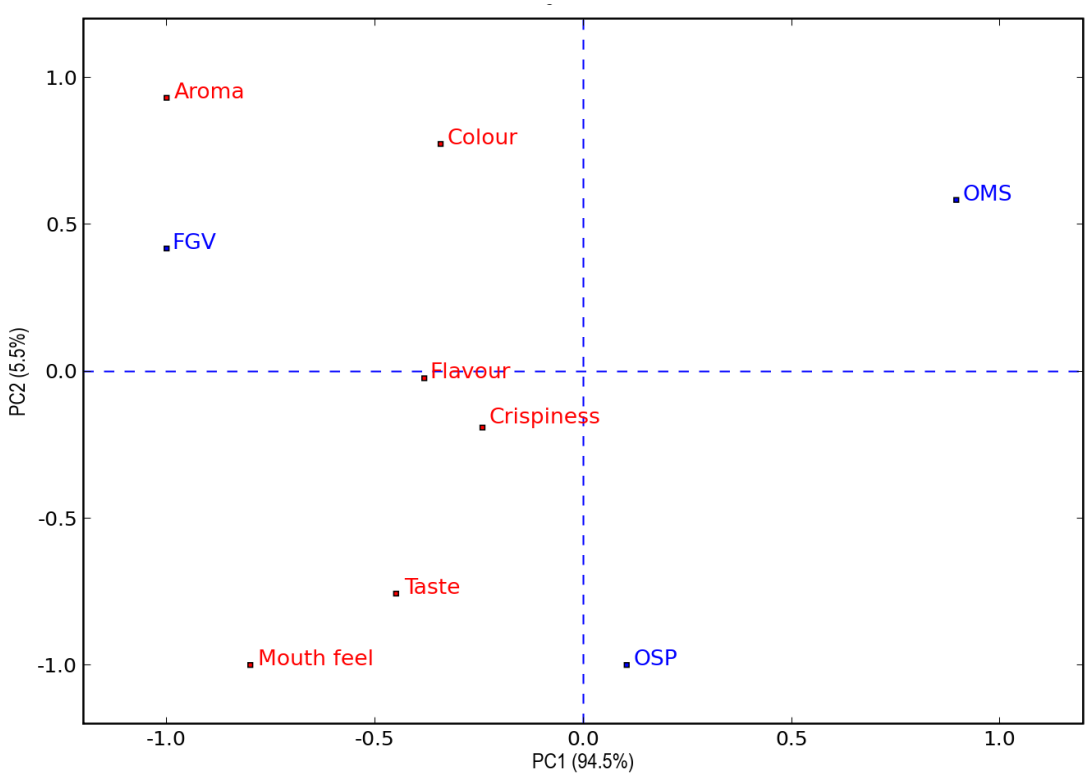


Figure 5: Bi-plot from PCA for descriptive sensory analysis of samples

4.2.2.2 Mean separation

Analysis of data from descriptive sensory test under 2 way analysis of variance (2 way-ANOVA) indicated differences in samples. Sample attributes with different levels of significance were as indicated in Figure 6 and Figure 7.

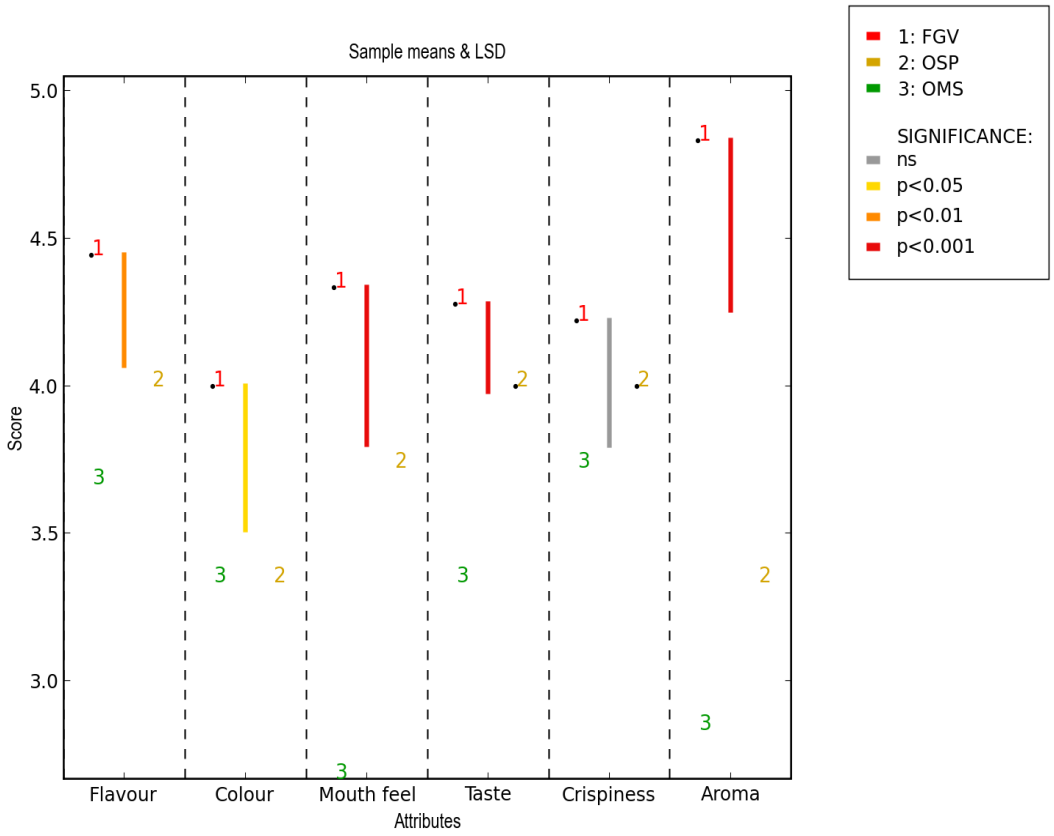


Figure 6: Mean separation for (FGV) and (OSP) with attributes

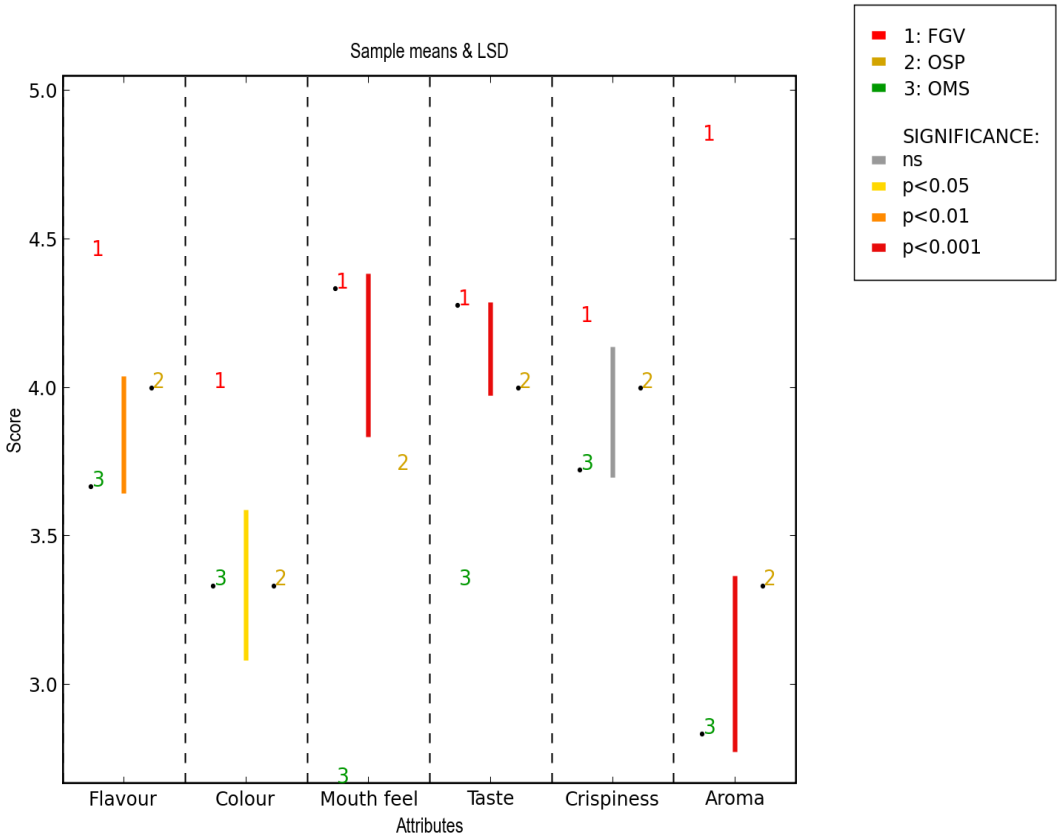


Figure 7: Mean separation for (OSP) and (OMS) with attributes

Samples from fishing ground vessel (FGV) showed the highest mean scores while those from open markets (OMS) had the lowest mean score. Flavour for FGV samples differed significantly ($p < 0.01$) from that of OSP samples. There was no significant difference ($p > 0.01$) between OSP and OMS samples. Also, there was no significant difference in colour ($p > 0.05$) between OSP and OMS samples but significant difference existed between FGV and the other two samples. For the case of mouth feel, all samples showed to differ significantly ($p < 0.001$), hence suggesting a high level of physical contamination among the samples from fishing ground along the entire value chain up to the final product that was the open market point. Taste for fishing ground samples (FGV) seemed to have no significant difference ($p > 0.001$) with that of the off shore processors samples (OSP) but the difference was significant ($p < 0.001$) for samples from off shore processors and those from open market (OMS). Crispiness was the only attribute that seemed to be the same in all the samples. This means the difference in crispiness among the samples was not an issue affecting acceptability of the sardines.

Also, storage time, processing factors and transportation probably contributed to differences among the samples. There was no significant difference ($p >0.001$) in flavour between market samples (OMS) and off shore processors samples (OSP) while the difference was significant ($p < 0.001$) between fishing ground samples (FGV) and off shore processors samples.

The least accepted sardines in sensory evaluation test were those dried by traditional method from Lake Victoria (Nguvava, 2013). The low acceptable scores could most likely be attributed to the high loading density, presence of sand and unhygienic handling practices during drying (Iboke*t al.,* 2009).

4.2.2.3 Mean intensity score

Figure 8 shows mean intensity scores among the samples as per analysis of sensory panel scores.

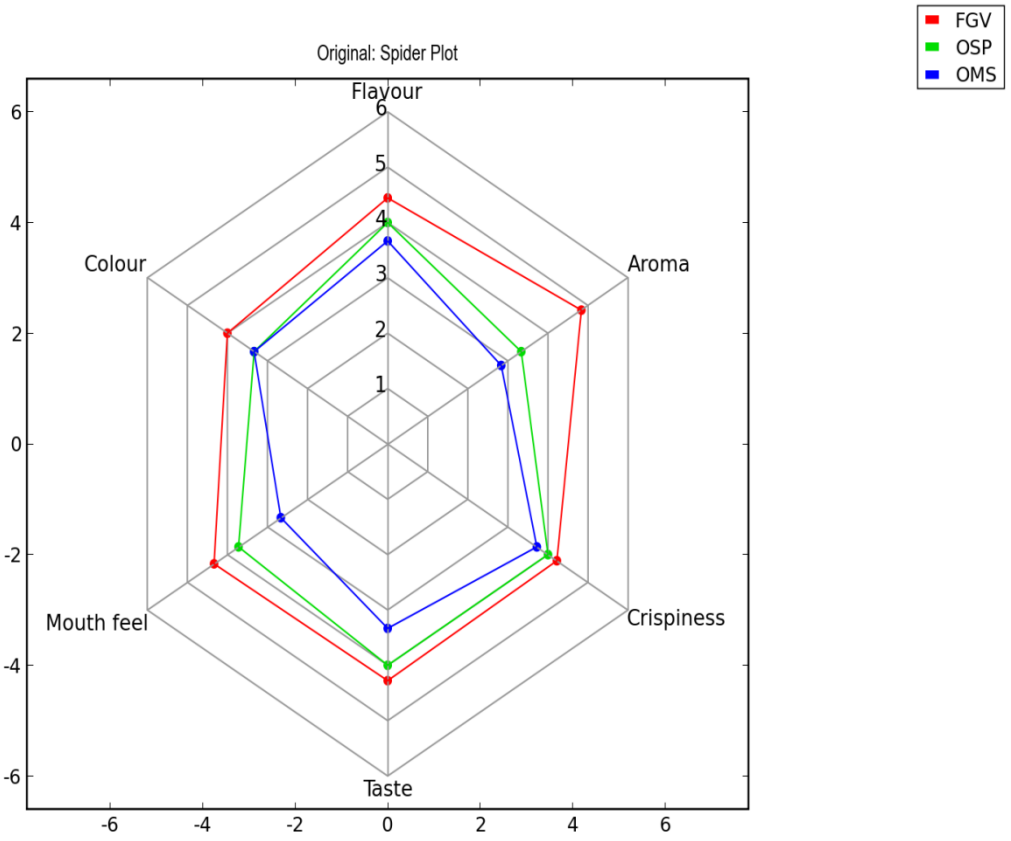


Figure 8: Mean intensity score for (FGV), (OSP) and (OMS) samples

Fishing ground samples showed superiority over the other two samples in all the attributes compared.This was followed by off shore processors samples except for one attribute, that is,colour, in which off shore processors samples and open market samples seemed to have the same mean intensity score. Similar trend was shown in the study by Nguvava (2013).

CHAPTER FIVE

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

According to this study of determining the cause of quality deterioration of Lake Victoria sardines, it shows that generally quality deterioration was more pronounced in the higher levels of value chain compared to the observed trend in the lower level. This means more quality deterioration was seen from off shore fish processors to market samples compared to that seen in the fishing ground samples tested. However, yeast and mould growth showed almost a constant trend, which was probably due to the form of samples that were tested since all the samples were taken to the laboratory in the dried form.

Also, high number of *total coliforms* and *E. coli* at the off shore processors samples (OSP) suggests that most of the quality deterioration of Lake Victoria sardines starts at the shore area where pre' and processing steps began. As for the decreasing trend of microbial load from off shore processor (OSP) samples to that found in market samples (OMS), the cause might have been brought about by decreasing moisture content as the product seemed to dry further as it was exposed to the sun for a long time. This tended to create unfavourable condition for microbial growth hence decreasing their number.

Sensory evaluation studies also indicated the decreasing trend for consumer liking and preference of the product, from initial stages of the value chain to the final stages as far as this study is concerned in the open market point.

5.2 Recommendations

As it is observed in this study, most of the sardines from Lake Victoria contain low and inferior quality, which make them unfit for human consumption. That is why most of

them are taken as animal feed instead of being used as direct source of protein for human. Due to this, the following recommendations may be put forward;

(i) There is need for proper education to the small scale off shore fish processors on how to handle and process sardines in a proper way so as to avoid any sort of contamination of products, be physical or microbiological.

(ii) Availability of good and enough hygiene and sanitation facilities at the landing sites including toilets and hand washing facilities so as to avoid cross contamination of the products and reduce initial microbial load seem essential.

(iii) Use of proper facilities for drying sardines instead of just sundrying them over the sand or rocks, which contaminate the product and finally the use of proper packaging materials and transportation instead of using open lorries and sucks are all necessary.

REFERENCES

Abowei, J. F. N. and Tawar, C. C. (2011). Some basic principles of fish processing in Nigeria. *Asian Journal of Agricultural Sciences* 3(6): 437 – 452.

Arason, S. (2003).The drying of fish and utilization of geothermal energy ; The Icelandic experience.In International Geothermal Conference, Reykjavík, p. 21–31.

Ayne, O. C. A., Arturo, H. M., Cecilia, B. P., Joel, C. and Eleazar, A. (2010). Preference mapping and rheological properties of four nopal (*Opuntia*spp.) cultivars:University of AutónomaChapingo, México.

Bagge-Ravn, D., Hjelm, Y., Christiansen, M., Johansen, N. J. and Gram, L. (2003).The microbial ecology of processing equipment in different fish industries-analysis of the micro flora during processing and following cleaning and disinfection.*International Journal of Food Microbiology* 87: 239 – 250.

Boyd, H. K., Westfall, P. and Stasch, S. F. (1981).*Marketing Research*: *Texts and Cases*. Illinois, USA. 813pp.

Brigitte, M. B., Boogaard, B. and Heijenen, C. (2004).Preservation of fish and meat. [http://www.fao.org/DOCREP/T0713E/T0713E00.htm] site visited on 13/2/2010.

Budeba, Y. L. (2014) Challenges of increasing the contribution of fish and fisheries to food security in Tanzania. National Workshop on Potential for Increased Contribution of Fish and Fisheries in Improving Food Security held in Dar es Salaam on 12th March 2014.

Clucas, I.J. and Ward, A. R. (1996).Post-harvest Fisheries Development.A Guide to Handling, Preservation, Processing and Quality. United Kingdom: Chatham Maritime, Kent.

Elía, M. (2011). A Procedure For Sensory Evaluation Of Bread: Protocol Developed By A Trained Panel: Journal of Sensory Studies ISSN 0887-8250.

Emmanuel de JesúsRamírez-Rivera, Marco Antonio Camacho-Escobar, Juan Carlos García-López, Virginia Reyes-Borques, Mabel Rodríguez-Delatorre (2012). Sensory analysis of Creole turkey meat with flash profile method.*Open Journal of Animal Sciences*: 2, (1), 1-10.

FAO (2014). Fisheries and Food Security In The ESA-IOC Region Country Brief: Tanzania. National Workshop on Potential for Increased Contribution of Fish and Fisheries in Improving Food Security held in Dar es salaam on 12th March 2014.

Ibengwe, L. and Kristófersson, D. M. (2012).Reducing Post-Harvest Losses of the Artisanal Dagaa(*RastrineobolaArgentea*) Fishery in Lake Victoria Tanzania: *A Cost and Benefit Analysis.*IIFET 2012 Tanzania Proceedings.

Ibok, O., Ofosu, I. W., Adjei, I. A., Franklin, B. Apea, B., Kwetey, P. N., Ankar-Brewoo, G. M., and Ellis, W. O. (2009). Quantitative descriptive sensory analysis of the performance of pregelatinisedstarch-protein admixtures as fat mimetic in wheat bread.*Pakistan Journal of Nutrition* 8 (10): 1559-1566.

ISO 7251 (2005) Microbiology of food and animal feeding stuffs — Horizontal method for the detection and enumeration of presumptive *Escherichia coli* — Most probable number technique.

ISO 6611 (2004) Milk and milk products — Enumeration of colony-forming units of yeasts and/or moulds — Colony-count technique at 25 °C.

ISO 4833 (2003) Microbiology of food and animal feeding stuffs — Horizontal method for the enumeration of microorganisms — Colony-count technique at 30 °C.

ISO (2002) Microbiology of food and animal feeding stuffs — Horizontal method for the detection of *Salmonella spp*.

ISO (1987) Microbiology - General guidance for enumeration of yeasts and moulds - Colony count technique at 25^{O}C.

Johnson, J., Elmore, J. R., Heymann, H., Hewett, J. E. (1999). Preference mapping: relating acceptance of ``creaminess" to a descriptive sensory map of a semi-solid: *Food Quality and Preference*465 – 475.

Júnior,J. J., Cardoso, R. L., Fonseca, A. A., Machado, E. S. (2013). Elaboration and sensorial evaluation of jelly and fruit crystallized cactus pear (*Opuntiaficus-indica* Mill):IDESIA (Chile).

Kweka, J., Musa, J. and Kabelwa, G. (2006). The Linkages Between Trade, Development And Poverty Reduction: The Case Study of Fisheries Sub Sector In Tanzania. Economic and Social Research Foundation.

Nguvava, J. P. (2013). Effects of Post-Harvest Handling on Quality and Sensory Attributes of Sardines.

Kulindwa, K. (2001) The Contribution of Lake Victoria Fisheries to the Economy of Tanzania. Economic Research Bureau, University of Dar es Salaam.

Laswai, H. S. (2014). Contribution Of Fish In Improving Nutrition And Food Security. National Workshop on Potential for Increased Contribution of Fish and Fisheries in Improving Food Security held in Dar es salaam on 12th March 2014.

Lake Victoria Fisheries Organization (2011). *Technical Report: Stock Assessment Regional Working Group*.

Mbunda, A. E. (2013).The Quality Change in Smoked and Dried Fresh Water Sardine (*RastrineobolaArgentea*) and Marine Pelagic Fish (*Capelin)*as Influenced by Processing Methods. United Nations University Fisheries Training Program Skulagata Iceland.

Mgawe, I.Y. and Mondoka, E. M. (2008). Post-harvest Fish Loss Assessment on Lake Victoria Sardine Fishery in Tanzania – *RastrineobolaArgentea*: Report

Presented at the *FAO Second Workshop On Fish Technology, Utilization and Quality Assurance inAfrica*Agadir, Morocco, 24–28 November 2008.

Olsen, A. R. and Hammack, T. S. (2000). Isolation of Salmonella spp. from the housefly, *Muscadomestica*L. and the damp fly, *Hydroteaaenescens*, at caged layer houses. *Journal of Food Protection* 63: 958 – 960.

Owaga, E. E., Onyango C. A., and Njoroge C. K. (2015). "Investigation of mycoflora on *dagaa* (*Rastrineobola argentea*) as affected by washing and drying methods."*Journal of Food Security*3(3):82-86.

Pvt (2016). Health Benefits of Sardines. Organic Information Services.https://www.organicfacts.net/health-benefits/animal-product/health-benefits-of-sardines.html. site visited 20/5/2016.

URT Report (2010). Fisheries Development Program, Dar es Salaam, Tanzania.

URT Report (2015). Fisheries Development Program, Dar es Salaam, Tanzania.

USDA (2006).Foreign Agricultural Service Gain Report. Maximum Levels of Contaminants in Foods.

APPENDICES

Appendix 1: Consumer test form

Sex…… Age…….

Time…….. Date…….....

Please look and taste each of the (4) coded samples. Indicate how much you like or dislike each sample by checking the appropriate sample attribute and indicate your reference (1-5) in the column against each attribute. Put the appropriate number against each attribute.

5- Extremely like

4- Like

3- Neither like nor dislike

2- Dislike

1- Extremely dislike

	SAMPLE CODE			
Attributes	**136**	**257**	**329**	**473**
Colour				
Flavor				
Aroma				
Taste				
Mouth feel				
Crispiness				

Comments

……

……

Appendix 2: Quantitative Descriptive Sensory Evaluation form

Sex……Age…….Time……..……

Please evaluate each sample in the order they are listed. Choose appropriate number in a scale from 1 to 5, where 1 is low intensity and 5 is high intensity. Put the appropriate number against each characteristic.

Sample number

Colour

Grey _____ Bright silver

1 2 3 4 5

Flavour/Taste

Spoiled _____ Very fresh

1 2 3 4 5

Aroma

Purnjent _____ Fishy

1 2 3 4 5

Mouth feel

Sandy _____ Very soft

1 2 3 4 5

Crispiness

Soft _____ Very brittle

1 2 3 4 5