Norwegian University of Life Sciences
Department of Animal and Aquacultural Sciences

Master Thesis 2015
30 credits

PERCEPTION AND SENSORIC QUALITY DIFFERENCE OF TILAPIA FISH SPECIES IN MOROGORO REGION, TANZANIA

SCONTINA JOACHIM MGINA

TITLE PAGE

Title:	Perception and sensoric quality difference of tilapia fish species in Morogoro region, Tanzania
Name:	Scontina Joachim Mgina
Student number:	983077
Class:	AUTUMN 2013
Learning arrangement:	Graduation Project
University Supervisor:	Magny Thomassen
Institute:	Department of Animal and Aquacultural Sciences
Course of Studies:	Aquaculture
Academic year:	2013 – 2015
Date of completion:	15-08-2015
Place:	Ås, Norway/Morogoro, Tanzania

Name of Organisation:	EPINAV
Organisation Supervisor:	Lars Olav Eik

DECLARATION

By

SCONTINA JOACHIM MGINA

Student name
(capital letters)

AQUACULTURE 2013

Study programme and year of start

Regarding submission of written assignments, term papers and exam papers at NMBU.

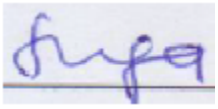
I hereby declare that I have read the description below regarding plagiarism and correct use of sources, understood the nuances and clarified any uncertainties with an academic adviser.

I have also studied all questions in the attached quiz, answered the questions correctly and understood the reasons for all answers.

If I submit plagiarised text as part of an assignment, term paper or exam paper I will not claim that I have received insufficient instruction.

MOROGORO, 14-08-2015

Place and date



Student's signature _____

ACKNOWLEDGEMENT

This study was part of “Improving the productivity of Nile Tilapia (*Oreochromis niloticus*) through selective breeding and mass production of fingerlings” funded by the Government of Norway through the Enhancing Pro-poor Innovation in Natural Resources and Agricultural Value Chains (EPINAV) program, grant No. 1.1/06 at Sokoine University of Agriculture. I believe that without this program, I would not have had the opportunity of carrying out this study.

My special thanks goes to Prof. Lars Olav Eik for his all his support, care supervision and guidance from the very beginning to this stage of completing my thesis.

Primarily, I am heartedly grateful to my main supervisor Magny Thomassen for her esteemed scientific advice, guidance and support from the beginning to end of this thesis.

I am indebted to extend my sincere thanks to Magnus Åsli, Alexander Ringheim, Jens-Erik Dessen for their esteemed scientific guidance, and physical and moral support in statistical analysis and writing of this thesis. Special thanks goes to Prof. Sebastian Chenyambuga from Sokoine University of Agriculture for financial support and scientific guidance when I was conducting this study. Further, I am so grateful to Sebastiaan Lemmens, for him well hearted allowing me to use part of his experimental fish study for my research. His guidance and collaboration is unforgettable in my career.

Further, I would like to thank my family particularly my lovely husband Zabron Nziku for his encouragement, advice and guidance from the beginning up to the end of this work. Moreover, special thanks to my child, parents, brothers, sisters and all relatives who always endure my absence when I was carrying out this study. Special thanks due to family friends,

Sigrid Gjøtterud and Øyvind Lundegaard, Erling Krogh and family, for their love, care and moral support all the time while I am in Norway and Tanzania. Their care and support made this study achievable.

My appreciation also goes to my employer Regional Administrative Secretary (RAS) of Morogoro region Tanzania for giving me two years study leave to pursue this study.

Finally, I would like to appreciate all friends, colleagues and other people not mentioned above who contributed in one way or another when I was conducting this study and made this thesis possible.

ABSTRACT

This study aimed at evaluating consumer perception and quality preference of tilapia fish in the Morogoro region, Tanzania. For consumer preferences, a total of 85 respondents were interviewed from six wards of the Morogoro Municipality. The result show that tilapia ranks third (22.4%) in preference after mackerel (41.2%) and Nile perch (24.7%). This observation may be due to limited availability, and the price level of tilapia found around the Morogoro markets, hence suggests that the expansion of aquaculture in this area is important in order to meet consumers' preference for fish. To investigate quality, sensory evaluation techniques were used to grade and score attributes of Nile tilapia fed on three different diets (Common feed, Norwegian feed and Tanzanian feed) and two tilapia species; Wami and Nile tilapia fed identical feed. No significant differences could be detected between Nile tilapia fed different feeds, with the implication that fish farmers may feed the most cost efficient feed, without jeopardizing sensory characteristics of young fish. Similarly, testing Nile tilapia against Wami tilapia did not result in any significant differences in quality traits, however, the numerical values were generally higher and in favor for the Nile tilapia.

In conclusion, the Nile tilapia has a great market potential in Morogoro given that the fish is fresh and weigh at least 250g, the proposed weight based on observation during this study. In reference to sensory characteristics, the farmers should chose the most cost efficient feed and species when farming tilapia.

ACRONOMY

EPINAV – Enhancing Pro- poor Innovation in Natural Resources and Agricultural Value chain

FAO – Food and Agriculture Organization

GDP – Gross Domestic product

HH – House Hold

MoLFD – Ministry of Livestock and Fisheries Development

NBS – National Bureau of Standard

NES – National Environmental Survey

RAS – Regional Administrative Secretary

SAS – Statistical Analysis Software

SRAC – Southern Regional Aquaculture Centre

SUA – Sokoine University of Agriculture

TABLE OF CONTENTS

ACKNOWLEDGEMENT IV
ABSTRACT VI
ACRONOMY VII
TABLE OF CONTENTS VIII
1. Introduction 9
2. Background 12
2.1 Fisheries and aquaculture in Tanzania 12
2.2 Tilapia fish species 13
2.3 Fish quality assessment 14
3. Materials and methods 15
3.1 Sensory perception and preferences of tilapia fish 15
3.2 Sensory evaluation 16
3.2.1. Fish material 16
3.2.2. Sampling 17
3.2.3 Sensory panelists 17
3.2.4. Sensory assessment of external features 17
3.2.5. Sensory assessment of cooked fillets 18
3.2 6. Data analysis 19
4. Results 20
4.1 Perception and preferences of tilapia fish 20
4.2 Sensory evaluation 22
4.2.1 Experiment 1 (same specie, three feed types) 22
4.2.2 Experiment 2 (two species, same feed) 23
5. Discussion 26
5.1 Perception and preferences of tilapia fish 26
5.2 Sensory evaluation 27
6. Conclusion 29
References 30
APPENDICES 33

1. Introduction

The current global population stands at approximately 7 billion and is expected to reach 9 billion by 2050 (FAO, 2009). This fast increase in population will undoubtedly increase demand for food and high quality protein. The Tanzanian population stands at approximately 47 million people, with the majority (80%) being dependent on agriculture for their livelihoods (NBS, 2012). In most cases a low input, integrated crop-livestock farming system predominates the Tanzanian agricultural sector (Liyama et al., 2007). The livestock sector comprises ruminant and none ruminant animals, poultry and fish. Traditionally fish activities have considered only practices with wild fish and not much attention has been given to aquaculture. Today, the fishery sector is among the agricultural sectors that are given more emphasis in the country. The sector is essential for the growth of the national economy, and contributes more than 1.4% to the GDP, equivalent to 195.17 (million) USD in 2010 (NBS, 2010). More importantly, the sector ensures food security and employs approximately 8% of the population. The general fish and fish-product market value chain in Tanzania extends from local to international coverage (MoLFD, 2013).

Fish has traditionally been an important source of nutrition (mainly protein) for both human and animal feeds (Tidwell and Allan, 2001). In Tanzania, fish contributes roughly 30% to peoples required protein consumption, which per capita fish consumption is equal to 8kg/year (NES, 2009). Among African countries, fish consumption is higher in the coastal countries as compared with land locked countries (Gordon et al., 2013). Studies show that within eastern and central Africa, per capita consumption varies within each country based on the availability of fish sources (Saleheet al., 2014). In the eastern and central African countries, there is a large volume of water sources for fish, including ocean, lakes, rivers, dam

and ponds. In total, there are about 54,337 km^2 of fresh and 64,000 km^2 of marine water bodies that can potentially be utilized for fish farming (Sobo, 2006).

Today in Tanzania, fish farming is more concentrated in freshwater, where small-scale farmers practice both extensive and semi-intensive farming (Chenyambuga et al., 2014). The predominant farmed fish species are various species of tilapia, mainly Nile (*O.niloticus*), Mozambique (*O. Mossambicus)*) and Wami tilapia *(O.urolepis hornorum)* (Chenyambugaet al*.,* 2014). African catfish (*Clarius gariepinus*) cultured by some small-scale fish farmers is second in popularity after the Nile tilapia. Of all current tilapia, more than 95% are Nile (*O.niloticus*), which is mainly farmed in earthen pond and under mixed-sex practice (Kalibaet al., 2006).

Currently, interest and demand for tilapia fish from the market has been increasing (Chenyambuga et al*.,* 2014). To meet this demand, different sources are involved in the supply of fish types, including those derived from; the rivers, ocean, lakes, dam/ponds, manmade and natural (MoLFD, 2013). As an exit strategy to the increasing demand of fish, expansion of aquaculture has become increasingly necessary. Moreover, because of the growing preference for fish products, different developmental partners have joined forces to support rural families through the introduction of fish farming technologies. For example, the Norwegian Government through the EPINAV program at Sokoine University of Agriculture (SUA) has initiated aquaculture projects in different rural areas that include Mgeta in Morogoro, Mbalali, Mbeya and Njombe areas. The main goal for these projects is to alleviate poverty and malnutrition among vulnerable groups such as women and children (EPINAV report, 2014).

Given to the fact that tilapia to a large degree contributes both to food security and to the economy in general, both at the household and national level, it becomes important to

consider aspects such as quality and customers preferences for the fish. These two characteristics are important factors because they define the long-run sustainability of the tilapia market value chain (Verbeke et al., 2007). Moreover, these attributes, if handled well, will help fish breeders to produce fish of high market value. Principally, the improvement and/or intensive production of fish should reflect the market needs.

When assessing tilapia in the Morogoro region, Tanzania, three specific objectives were chosen to describe the perceptions and quality preferences of tilapia fish.

- To evaluate perception and preferences of tilapia fish species in Morogoro region, Tanzania.
- To evaluate sensory quality differences of Nile tilapia fish fed on different diets.
- To evaluate sensory quality differences of two types of tilapia (Nile and Wami) fish species fed the same diet.

2. Background

2.1 Fisheries and aquaculture in Tanzania

Tanzania has a multitude of potential water bodies for fisheries activities. On the eastern side is the coastal zone along the Indian Ocean, and the inland shares lakes with other African countries, which includes the Victoria, Tanganyika and Nyasa lakes. Further, there are small lakes (e.g. Rukwa), dams (e.g. Mtera) and rivers (e.g. Rufiji) (MoLFD, 2011). Artisanal fisheries are dominant compared to industrial fisheries in all the country's water bodies. The type of fishing method mostly used is traditional, as such using simple fishing gear and methods, which results in marginal returns. Industrial activities are practiced in territorial water and beyond borders water bodies of economic zone (FAO, 2007).

The fish farming industry in Tanzania goes back to the trading history of the 1200s, yet the earliest experimental studies on tilapia farming occurred in the early 1950s (Balarin, 1985; Rice et al., 2006), and the earliest farming activities started in Mwanza, Ruvuma, Mbeya, Iringa and Arusha regions (FAO, 2005). Fish farming in these areas were initiated by international donor funded projects in the 1960s (Maar et al., 1966). The projects established large number of ponds (8,000-10,000) in these regions. However, reports show that by 2001 the number of live ponds dropped to less than 200 (FAO, 2001). Several reasons caused the decline in the number of the fishponds and their cultured fish. Poor yields, lack of fingerlings and lack of technical expertise in fish farming were the main limiting factors found (FAO, 2005). The Ruvuma Region alone hosted more than 50% of the country's fishponds in 2007 where the Nile tilapia (*O. niloticus*), Mozambique (*O. mossambicus*) and Zanzibar tilapia (*O.*

urolepis hornorum) were the main species farmed (FAO, 2007). The ponds are typically characterized by a small size, about (20m^2), and low productivity (FAO, 2005).

Strategies to revive fish farming in the country started in early 2002, through developmental partners or farmers own initiatives (FAO, 2005). In 2005, Tanzania estimated to have 14 100 freshwater fish ponds scattered across the mainland. Generally, the distribution of these ponds is based on several factors such as availability of water, suitable land for fish farming, awareness and motivation within the community on the economic potential of fish farming (Okechi, 2012). In addition, smallholder farmers with farm plots closer to water sources e.g. spring, rivers, ground water and streams benefited more with these initiatives (Okechi, 2012). Integrated fish farming was also a strategy, where farmers could feed fish using manure from domesticated livestock (Mdegela et al*.,* 2011). Further, cheap and locally available feed material was given priority, which varied from area to area depending on the availability. Supplementations for higher yields also use especially maize bran, rice bran, kitchen wastes and vegetables (Mdegela et al., 2011).

2.2 Tilapia fish species

Tilapia is an omnivorous fish species that thrive in warm tropical areas. The tilapia is known to be a wild fish species originated from the Nile valley and later further spread to central and Western Africa (Nandlal and Pickering, 2004). Moreover, tilapia is among the most widely cultured fish in the world, because of their rapid growth and simple reproduction. They also have resistance to physical handling and diseases; they tolerate poor (a wide range of environments and water quality) and eat a wide range of food types. The ability to perform in a wide range of cultured systems e.g. backyard ponds to intensively managed tanks/ponds, among others, is of importance (SRAC, 1999; Kalibaet al*.,* 2006; Wikipedia, 2012). The short

reproduction life and fast growth are beneficial for farmers, giving rapid turnover and often a faster payback period for the total cost of investment in tilapia fish production, compared to other aquaculture fish species (Salia, 2008). The most cultured species of tilapia worldwide is the Nile tilapia *(O.niloticus),* Blue tilapia *(O.aureus)* and Mozambique or red tilapia *(O.mosambiques)* (Nandlal and Pickering, 2004). From these three species, the Nile tilapia is the most popular farmed specie. In Tanzania *O. niloticus* is also a dominant species of tilapia in inland waters. The other tilapia species found in the country area*, are O. urolepisurolepis, O.urolepishornorum, O. jipe, O.ruvumae,O. leucosticus, Tilapia zillii, O. variabilis and O.esculentus* (Bwathondi, 1990).

In Morogoro, the endowment of perennial rivers, streams, natural dams, and constructed ponds makes it famous for economic fishing activities. For example, river Kilombero is an important source of in-river tilapia fishing. This river is stable in year round and the *O. niloticus* are plenty. However, the *Clarias gariepinus*, *Bagrus docmak*, *Hydrocynus vittatus*, *Distichodus petersii*, *Schilbe moebiussi*, *Labeo longipinnis*,*Alestes stuchlmanni*, *Anguilla spp*, *Mormyrus spp*, *Brycinus spp* and *Citharinus latus* fish species are equally important and found in the rivers. In addition, farmers are practicing small-scale fish farming in this river by constructing ponds (Chenyambugaet al*.,* 2014). Moreover, fish from Kilombero is important for outside market as well, like Iringa, Dar es Salaam and Tanga.

2.3 Fish quality assessment

Fish and fishery products are among of the most internationally traded food commodity so safety and quality improvement is essential (Huss, 2004). Further, a sustainable and properly functioning market needs monitoring of quality, because consumer awareness about the quality of fish and fishery products is currently increasing worldwide (Huss, 2004). Monitoring

quality of fish and fishery products involve a long chain from producer to the final consumer, hence it is crucial that everyone in the chain be aware of all factors influencing quality (Petersen, 2010).

Sensory evaluation is among the methods that are used to determine the quality of fish and fishery products (Alasalvar and Taylor, 2002). This method measures the characteristics of fish and fishery product as perceived by human senses of taste, smell, sight and touch. Other methods used to determine quality of fish are instrumental and physico-chemical analysis to analyze quality characteristics including proximate and nutritional composition, texture and colour. The sensory method is performed under controlled condition to reduce the effects of environment and personal bias. For external assessment, eyes, gills, skin and texture are among of the attributes for grading freshness (Villarreal, 2007). According to Sea food (2015), fresh whole fish have bright clear eyes, gills should be red or pink, not brown, skin should be shiny, firm and elastic to the touch with tight adhering scales and a mild aroma. Tilapia being among the most cultured fish species worldwide is popular in the market due to their firm white, lean flesh, mild taste and ease of filleting (Freitas et al. 2012).

3. Materials and methods

3.1 Sensory perception and preferences of tilapia fish

Six wards in the Morogoro municipality; Mindu, Kihonda, Kingolwira, Area five, Bigwa, and Kilakala, were selected to give a representative image of tilapia preferences among the Morogoro population. In each ward, 14 households (HH) were randomly selected and in each HH, the person responsible for going to the market was asked to participate in the interview. All interviews were conducted in June 2013. A closed and open-ended questionnaire (See

Appendix 8.1) was designed, pre-tested and used to guide the respondents. In total 85 respondents were interviewed in this study.

3.2 Sensory evaluation

3.2.1. Fish material

Nile and Wami tilapias raised at the Magadu fish farm on Sokoine University of Agriculture (Morogoro, Tanzania) were used in this thesis. The Nile tilapias used in Experiment 1 originated from Lake Victoria and were fed three different feeds: A) Common feed B) Norwegian feed C) Tanzanian feed. The composition of feed according to Lemmens (2014) are shown (appendix 8.2). Experiment 2 compared Nile tilapia and Wami tilapia originating from Lake Victoria or the Wami River, respectively. Both species were fed identical feed (Tanzanian feed). Three experimental units/fish tanks were representing the various feeds or species, as presented in Table 1. The same fish material has previously been used to study growth performance in the fish tanks and chemical properties of the fillets post-harvest (Lemmens, 2014).

Table 1. Fish species, fish origin, feed types and days of feeding. Feeding experiment in 2013 at Magadu farm, Sokoine University of Agriculture, Tanzania.

Exp.	Species	Source	Feed type*	Days of feeding
1	Nile tilapia	Lake Victoria	Common (n=3)	88
			Norwegian (n=3)	88
			Tanzanian (n=3)	88
2	Nile tilapia	Lake Victoria	Tanzanian (n=3)	100
	Wami tilapia	Wami river	Tanzanian (n=3)	100

* n = replicate fish tanks

3.2.2. Sampling

The fish with an average weight of 25.3g weight were starved for 1 day prior to sampling, upon where three fish per tank were randomly selected, killed by percussive stunning, bled in a bucket of clean water, gutted, de-headed, de-scaled, and placed in plastic containers. Each fish was cut into four fillet parts of similar size, rinsed in tap water, and then boiled in unsalted water using a gas cooker for ten minutes. The cooked fillets were left to cool down at room temperature, and placed on labeled plates according to group, and served to panelists.

3.2.3 Sensory panelists

The recruited participants were of mixed sex, both students and staff from SUA, aged between 21–54 years, with no particular knowledge of the study. Prior to the experiments, the participants were explained the evaluation procedures. A total of 29 participants' evaluated fish in Experiment 1, May 2013, and 30 participants' evaluated fish in Experiment 2, June 2013. Each participant assessed both external and internal parts of the fish.

3.2.4. Sensory assessment of external features

The sampled fish were grouped according to feeds (Experiment 1) and species (Experiment 2). Fish and their fillets from the three diets were labeled A, B and C, respectively. Participants evaluated both external and fillet attributes by grading and scoring (Appendix 8.3 A & B). Grading aimed to evaluate quality attributes, while scoring aimed to scale level of liking the attributes (Table 2). The same procedure followed for the two species evaluation of tilapia.

3.2.5. Sensory assessment of cooked fillets

For cooked fillet evaluation, participants were asked to rinse their mouth with drinking water between each sample in order to neutralize mouth taste buds. The taste, color, texture and the overall acceptability were evaluated. Participants evaluated attributes by grading and scoring.

Table 2. Outline for grading and scoring quality attributes of tilapia fish

Attribute	Grading of quality		Scoring of liking
Raw fish:			
Skin color	Shiny	3	Like very much 5
	Bleached	2	
	Dull	1	Like somehow 4
			Neutral 3
Skin texture	Hard/firm	3	
	Medium	2	Dislike somehow 2
	Soft	1	
			Dislike very much 1
Eye color	Normal	3	
	Colored	1	
Odor	Normal	3	
	Neutral	2	
	Abnormal	1	
Cooked fillet:			
Fillet color	White	3	
	Light grey	2	Like very much 5
	Grey	1	
			Like somehow 4
Fillet taste	Strong	3	
	Medium	2	Neutral 3
	Little taste	1	
			Dislike somehow 2
Fillet texture	Hard/firm	3	
	Medium	2	Dislike very much 1
	Soft	1	
Fillet flavor	Normal	3	
	Neutral	2	
	Abnormal	1	

3.2 6. Data analysis

Data regarding perception and preference of the fish were coded into the SPSS computer program (IBM16V, 2014). Frequency procedure was used to get descriptive statistics. Results are shown in frequency tables.

In case of sensory evaluation, grading and scoring technique was used to obtain grades ranging 1, 2, 3 and scoring from 1, 2, 3, 4, 5 (Table 2). The excel computer program was used to summarize grades and score of sensors. Results of which were presented in tables. In addition, SAS computer program was used to test if there was any significance difference between feed and species.

4. Results

4.1 Perception and preferences of tilapia fish

The respondents in the preference survey consisted of 16% males and 84% female that were between 12 and 58 years of age, with an average of 35 years. The household size averaged five people, and the person who most frequently bought fish in the household was female. Tilapia was behind mackerel and Nile perch in purchasing frequency (Table 3), while African catfish, emperors and sardines were less frequently purchased.

Table 3. Fish species often bought in Morogoro Market

Specie				
English name	**Scientific name**	**Swahili name**	**N**	**Percent**
Mackerel	*Rastrelliger kanagurta*	Vibua	35	41.2
Nile perch	*Lates niloticus*	Sangara	21	24.7
Tilapia	*Oreochromis spp*	Sato/Perege	19	22.4
African cat fish	*Clariusgarie pinus*	Kambale	5	5.9
Emperors	*Lethrinus spp*	Changu	3	3.5
Sardines	*Rastrineo bolaargantea*	Dagaa	1	1.2
		Nguruka	1	1.2
Total			85	100.0

The majority of the respondents (59%) bought tilapia in Morogoro town markets, while some (41%) purchased the fish from other markets located close to their household. 95% of the respondents liked tilapia, and 76% reported to buy the fish at least once in a week. Among

the reasons for not consuming tilapia regularly was poor economy as revealed by more than 61% of the respondents.

Fish buyers in Morogoro market prefer fresh fish compared to processed form (Table 4); within the processed products, fried fish were favored as compared with smoked and sun dried fish.

Table 4. Common fish form sold in Morogoro market

Form	N	Percent
Fresh fish	64	75.3
Fried fish	18	21.2
Smoked fish	2	2.4
Sun dried	1	1.2
Total	85	100.0

Respondents reported the size of the fish to be the most determining feature when buying tilapia (Table 5), while smell, price, red eyes and gills were rated less important for fish buyers.

Table 5. Tilapia fish features preferred by buyers in Morogoro Market

Feature	N	Percent
Size	78	91.8
Smell of fish	3	3.6
Fish price	2	2.4
Fish with red eye	1	1.2
Fishes with red gills	1	1.2
Total	85	100.0

Price inflation and poor quality were the main off-putting aspects to fish customers (Table 6), while availability and distance to market were of less importance.

Table 6. Challenges associated in getting tilapia fish in Morogoro Market

Challenge	N	Percent
Price inflation	41	48.2
Not well preserved	21	24.7
No challenge	10	11.8
Fish availability	9	10.6
Market distance	4	4.8
Total	85	100.0

4.2 Sensory evaluation

4.2.1 Experiment 1 (same specie, three feed types)

Results in table 7. shows a relatively similar trend for both the grading (quality attributes) and scoring (liking) of the tilapia attributes (raw gutted and cooked fillet). No statistical significance differences ($p > 0.05$) were observed due to feed. Only some tendencies of slight variations in grades and score were observed, as follows: for grading of cooked fillet, an almost significant ($p=0.09$) less taste was noted for tilapia fed on the Norwegian diet. With both forms (raw and cooked fillet), the texture attribute shows that tilapia fed on Norwegian feed were graded and scored slightly higher than those fed on Common or Tanzanian feed. On the other hand, flavor was graded similarly across feed categories but scored relatively different. Here tilapia fed on Tanzanian feed scored most followed by Norwegian feed, and

then those fed on Common feed. Moreover, the overall acceptability shows that all tilapia fed on different diets were acceptable.

Table 7. Grading and scoring qualitative attributes of Nile tilapia fed on common, Norwegian, and Tanzanian feed

			Common feed	Norwegian feed	Tanzanian feed	P-value
GRADING						
	Raw, gutted					
	Skin	*Color*	2.6±0.1	2.6±0.2	2.4±0.3	0.86
		Texture	1.8±0.1	1.9±0.1	1.7±0.1	-
	Eye	*Color*	2.8±0.1	2.6±0.2	2.6±0.1	0.53
	Cooked fillet					
		Odor	2.7±0.1	2.6±0.1	2.7±0.1	0.86
		Color	2.3±0.1	2.3±0.1	2.1±0.1	0.36
		Taste	2.3±0.1	2.0±0.1	2.2±0.1	0.09
		Texture	*1.6±0.1*	*1.7±0.1*	*1.6±0.1*	*0.46*
		Flavor	*2.4±0.1*	*2.4±0.1*	*2.4±0.1*	*0.97*
SCORE (liking)						
	Raw, gutted					
	Skin	*Color*	3.7±0.2	3.6±0.2	3.6±0.2	0.81
		Texture	3.9±0.2	3.9±0.1	3.9±0.2	0.95
	Eye	*Color*	4.3±0.2	3.9±0.2	4±0.2	0.19
	Cooked fillet					
		Odor	3.9±0.2	3.7±0.2	3.8±0.2	0.76
		Color	3.6±0.2	3.7±0.2	3.5±0.2	0.71
		Taste	3.4±0.2	3.7±0.2	3.7±0.2	0.39
		Texture	3.6±0.2	3.8±0.2	3.4±0.2	0.23
		Flavor	3.4±0.2	3.5±0.2	3.9±0.2	0.22
Overall Acceptability			1.7±0.1	1.6±0.1	1.6±0.1	0.87

4.2.2 Experiment 2 (two species, same feed)

The sensory evaluation results on quality attributes (grading) and liking (scoring) of Wami and Nile tilapia are shown in Table 8. Although there were no statistically differences, the numerical values on score for taste (P-value =0.07) and texture (P-value=0.06) were higher

for the Nile tilapia. It seems that flesh color, taste, and texture attributes for both raw and cooked fillet of the Nile tilapia received higher scores than the Wami tilapia. Contrary, odor attribute of Wami tilapia received numerically both higher grading and higher scoring than the Nile tilapia (P-value =0.51 for grading and 0.25 for scoring). The overall acceptability was also numerically higher for the Nile tilapia than for the Wami Tilapia (P=0.12).

Table 8. Grading and scoring of qualitative attributes of Wami tilapia and Nile tilapia, fed on the same diet (Tanzanian feed)

		Wami Tilapia	Nile Tilapia	P-value
GRADING				
Raw, gutted				
Skin	*Color*	2.7±0.1	2.8±0.1	0.62
	Texture	2.1±0.1	1.9±0.1	0.18
Eye	*Color*	2.7±0.1	2.5±0.2	0.25
Cooked fillet				
	Odor	2.7±0.1	2.6±0.1	0.51
	Color	2.2±0.1	2.5±0.1	0.09
	Taste	2.1±0.1	2.0±0.1	0.60
	Texture	1.8±0.1	1.8±0.2	0.87
	Flavor	2.5±0.1	2.7±0.1	0.25
SCORE (Liking) (1-5)				
Raw, gutted				
Skin	*Color*	3.9±0.2	4.1±0.1	0.42
	Texture	3.9±0.2	4.1±0.2	0.40
Eye	*Color*	4.2±0.2	3.9±0.2	0.18
Cooked fillet				
	Odor	4.2±0.2	3.9±0.2	0.25
	Color	3.9±0.2	4.2±0.2	0.28
	Taste	3.3±0.2	3.8±0.2	0.07
	Texture	3.4±0.2	4.0±0.2	0.06
	Flavor	3.7±0.2	3.8±0.2	0.61
Overall Acceptability		1.4±0.1	1.6±0.1	0.12

Interestingly, when looking at the evaluations made by male and female in the sensory panel, statistically significant differences were observed. As shown in figure 1a and b, the sex of the panelist had a strong influence scoring of the fish attributes. Especially, female scored higher for fillet taste (P=0.04) and color (P=0.03), while males scored higher for fillet odor (P=0.02).

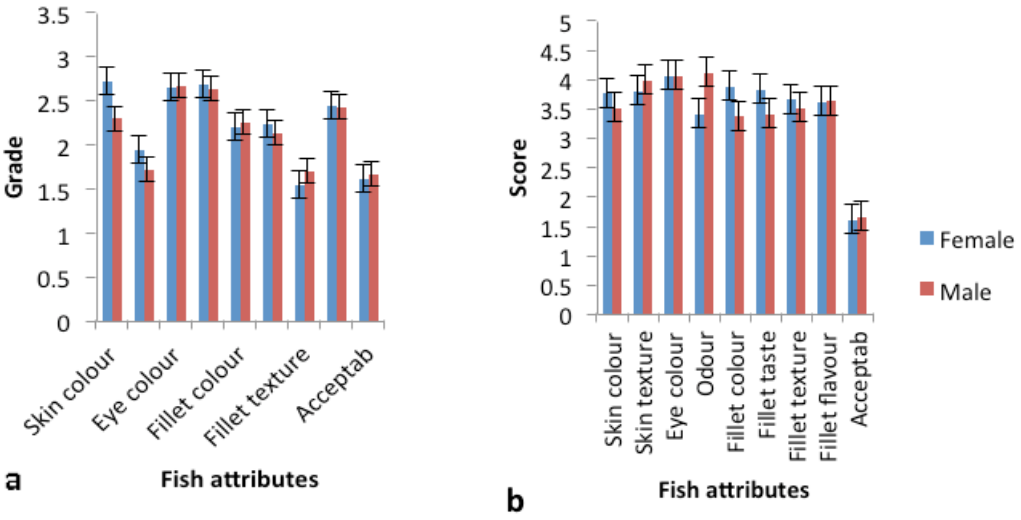


Figure 1. Grade (a) and score (b) of Nile tilapia fish attributes fed on different diets by male and female panellists.

5. Discussion

5.1 Perception and preferences of tilapia fish

Tilapia ranked third in preference after mackerel and Nile perch. These results are probably connected with the relative availability and lower prices of the two later species (Table 3). Contrary to mackerel, Nile perch and tilapia species predominantly originate from Lake Victoria, which is located 986 km from Morogoro. From a fish farmer's point of view, the long distance needed to transport competing species may be considered positive. Tilapia can be produced closer to the market, and hence reduce transportation cost and distance, making the fish more sustainable, both economically and environmentally. This is in agreement with the study of Reynolds (1993) who reported that transportation of fish over long distances is a problem in Tanzania, as it results in higher fish prices at the point of destination, and therefore only higher income groups can typically afford it. Based on this rationale, increasing fish production in the Morogoro region will also be beneficial for food security both locally and nationally. Moreover, due to shorter transportation distances between supplier and market, increasing the tilapia production closer to Morogoro may also meet consumers' desire of buying fresh (unprocessed) fish (Table 4), as the need for food preservation would be less. Along with high consumer acceptance, fresh fish has the additional benefits of being less likely to pose a food safety risk compared with the processed products as far as African hygiene conditions are concerned (Muchiri et al. 2015).

The size of the fish featured as the first criteria used by buyers in Morogoro market when buying fish (see table 5). Most consumers prefer fish of desirable size of up to 250g (Muchiriet al., 2015), because of the assumption, that such a fish has enough fillets and is easier to prepare than fish of a smaller size. This is similar to the study of Reynolds (1993) who observed

that fish of a larger size such as tilapia and Nile perch are mostly preferred by Tanzanian's. Therefore, with aquaculture development it is possible to produce fish of quality according to consumers' preference.

Price inflation is seen as a challenge affecting tilapia consumption in Morogoro (see table 6). This challenge is due not only to increased demand but also seasonal variation in the availability of the fish, as Lake Victoria is the major source. Based on the aforementioned factors development of fish farming in Morogoro, Tanzania is argued to be a viable and existing opportunity. This development also suggests a reduction of pressure on capture fisheries, where in most cases productivity is low (Salehe et al., 2014).

5.2 Sensory evaluation

No major (statistically significant) effects of either feed or fish species were observed in this study. This may have different reasons. First, the sensory panelists had no previous training in the topic, and secondly, the fish used in the feeding studies were all of wild stocks with no control of age. Some trends in the material that can be of interest for future studies were however, noted and are discussed below.

There were no statistical differences in grading or scoring between tilapias fed different feeds, yet from a commercial perspective the Norwegian or Tanzanian feed should be considered due to their higher growth performance (Lemmens 2014). However, for Tanzanians the feed type might not be an option for now due to high cost implications (Chenyambuga et al., 2014). Alternatively, since no major disadvantages to quality evaluation was observed, fish farming in Tanzania may start using Tanzanian or Common feed so as to allow farmers to have the purchasing ability required and to develop skills of fish farming while further studies on tilapia customers' preferences can take place in the country.

The high grades and score attributes observed in fillet color for Nile tilapia as compared to Wami tilapia (see table 8) for color coincide with Lemmens (2014) who found that fillet of Nile tilapia was of white color and reddish yellow color for Wami tilapia. Perhaps the latter attributes might not be a preferred color of tilapia fillet. Higher values on taste and texture, along with the preference for Nile tilapia in the marked study, and higher growth performance (Lemmens, 2014) points to the Nile tilapia specie to be opted for fish farmers in Morogoro. Farming Nile tilapia in Morogoro should be possible, except that availability of fingerlings might be in question. Thus, government policies should play a role in facilitating farmers in Morogoro to acquire fingerlings at a reasonable price. In addition, training of farmers in fish farming techniques should not be left behind, as it will help to develop a knowledge base for productive aquaculture practices.

The analysis on the effect of panelists' gender, in the quality evaluation (see figure 1) should also be mentioned. The number of female to male panelist was approximately 50:50, and this is important since the current results suggest that gender is an important factor to consider in sensory evaluation studies. Other studies have shown that gender has been found to influence liking, attitude, affective response, choice, and perception toward food (https://wheatleyscholars.wordpress.com/2015/02/25/food-sensory-research-effects-of-gender-age-and-product-usage/). It is important also to be aware that the current sensory results might not reflect perfectly the quality of fish found at the market. They were experimental fish treated differently from the Lake Victoria tilapia and relatively small with an average weight of 25g. This is significantly less than the size of those sold at the market.

6. Conclusion

The most interesting observation made in this study is that Nile tilapia was found to be the most preferred fish species by consumers in Morogoro market and that the specie also scored and graded high in quality by sensory evaluation panelists.

The relatively small and not statistically significant differences in quality aspects observed when using the Tanzanian and the Common feed as compared to the more, expensive Norwegian feed indicates that the cheaper and more accessible Tanzanian feed can be used.

This study revealed that there is a potential market for the tilapia fish species in Morogoro region Tanzania; however, the current high price of tilapia is one of the limiting factors. This implies that Tilapia aquaculture should be expanded in the area, and this may be done through improving national policies which will ease producers access to the species.

References

Alasalvar and Taylor, 2002.Seafood-Quality, Technology and Nutraceutical applications. (Eds). Springer-Verlag, Berlin, Heidelberg, New York. Pp. 7-56. ISBN 3-540-42476-8.

Alda, M. and Salia, J., 2008. Economic analysis of small-scale tilapia Aquaculture in Mozambique. Final Project 2008. http://www.unuftp.is/static/fellows/document/alda08prfa.pdf .pp 1-39.

Balarin, J.D. 1985. National reviews for aquaculture development in Africa: Tanzania. FAO Fisheries Circulars (770.11). Rome, Italy -FAO.

Bwathondi, P.O.I. 1990. The state of fishing industry in Tanzania with particular reference to inland fishery. Proceedings of a Seminar on Prevailing Activities on the Lake Victoria Basin with Particular Reference to the Fisheries of the Lake, 8-9 March 1990. Mwanza, Tanzania. pp. 5-11.

Chenyambuga S. W., Mwandya A., Lamtane H. A., and Madalla, N. A., 2014. Productivity and marketing of Nile tilapia (*Oreochromis niloticus*) cultured in ponds of small-scale farmers in Mvomero and Mbarali districts, Tanzania. *Livestock Research for Rural Development.Volume 26, Article #43.* Retrieved February 21, 2015, from

EPINAV report, 2014. Enhancing Pro-poor Innovation in Natural Resources and Agricultural Value Chains (EPINAV) program grant No.1.1/06 at Sokoine University of Agriculture http://www.drpgs.suanet.ac.tz/index.php.

FAO, 2001.Database on Food and Agriculture for Eastern Africa. Global information on early warning systems (GIEWS)

FAO, 2005.Aquaculture production, 2003.Year book of Fishery Statistics - Vol.96/2.Food and Agriculture organization of the United Nations, Rome, Italy.

FAO, 2007.Fisheries country profile Tanzania. United Nations Food and Agriculture Organization, Rome, Italy.

FAO, 2007a. Fish stat Plus: Universal software for fishery statistical time series. Version 2. 3. 2000. Rome Italy: FAO Fisheries Department, Fishery information, Data and Statistics Unit.

FAO, 2009. How to feed the world in 2050.

Freitas D.G, Resende A.S, Furtado A.A, Tashima L and Bechara H.M. 2012. The sensory acceptability of Tilapia (Oreochromis niloticus) mechanically separated meat-based spread. Brazilian Journal of Food Technology.

Gordon, A., Finegold, C., Crissman, C. C. and Pulis. A., 2013.Fish Production, Consumption, and Trade in Sub-Saharan Africa: A Review Analysis.http://pubs.worldfishcenter.org/resource_centre/WF-3692.pdf.

Huss,H.H. 2004. Assessment and management of sea food safety and quality. Rome Italy: FAO Fisheries technical paper. No. 444.

Iiyama, M., Kaitibie, S., Kariuki, P., and Morimoto, Y. 2007.The Status of Crop-Livestock Systems and Evolution toward Integration. Annals of Arid Zone 46(4): 1-23.

Kaliba, A.R., Osewe, K.O., Senkondo, E.M., Mnembuka, B.V. and Quagrainie, K.K. 2006.Economic Analysis of Nile Tilapia (Oreochromis niloticus) Production in Tanzania. Journal of the World Aquaculture Society 37 (4): 464 – 473.

Lemmens, S.C. 2014. Effect of feeding supplementary diets containing soybean and Moringa leaves on growth and fillet quality of Nile tilapia (Oreochromis niloticus) and comparison of growth and fillet quality between Nile tilapia (O. niloticus) and Wami River tilapia (O.urolepishornorum). Master's thesis, Norwegian University of Life Science, Department of animal and aquaculture science.AS Norway.

Maar, A., Mortimer, M.A.E and Van der Lingen, I. 1996. Fish culture in Central East Africa. FAO cooperate Document No.20. Rome, Italy: Food and Agriculture organization of the United Nations.

Mary N. Muchiri, Jackin N. Nanua and David Liti, 2015. A comparative study on growth, composition and sensory quality between farmed and wild Nile tilapia(Oreochromis niloticus).

Mdegela, R.H., Omary, A.N., Mathew, C. and Nonga, H.E. 2011. Effect of pond management on Prevalence of Intestinal Parasites in Nile Tilapia (Oreochromis niloticus) under small-scale fish farming systems in Morogoro.

MoLDF, 2011. Investment opportunities in the fisheries industry in Tanzania.

MoLFD, 2013; Ministry of livestock and Fisheries development. Government Budget Assembly Speech for 2012/2013 financial year. http://www.mifugouvuvi.go.tz/category/speech

Nandlal, S., and Pickering, T. 2004. Tilapia fish farming in Pacific Island countries. Volume 1. Tilapia hatchery operation. Noumea, New Caledonia: Secretariat of the Pacific Community.

NBS (National Bureau of Statistics), 2012. National sample census of agriculture: smallholder agriculture volume III: Livestock sector. Pages 18–19 in National report, Government printer, Dar-es-Salaam, Tanzania

NES, 2009: National Economic survey. Ministry of Finance, Dar es Salaam Tanzania.

Okechi, J. 2012. Developing smallholder aquaculture in Kenya into viable enterprises: a case study of nyaguta fishponds in kisii, Kenya. IIFET 2012 Tanzania Proceedings.

Petersen, D. 2010. Sensory quality of seafood in the chain from catch to consumption. DTU Food, National Food Institute.

Reynolds, J.E.1993. Marketing and consumption of fish in Eastern and Southern Africa. Selected country studies.FAO Fisheries Technical paper.No.332 Rome. 194p.

Rice, A.M., Mmochi, J.A., Zuberi, L. and Savoie, M.R. 2006.Aquaculture in Tanzania. World aquaculture 37.4: 50-57.

Salehe M, Luomba J, Musiba M, Mlaponi E and Mghamba K. 2014. Consumer Preference on Value Added Products of Farmed Fish in Lake Victoria Basin, Tanzania. Asian Journal of Applied Science and Engineering.3:28-33.

Sobo, F. 2006. Overview of fisheries and aquaculture resources, Tanzania. Fisheries Division, Tanzania. Presented at the "Workshop on Fisheries and Aquaculture in Southern Africa: Development and Management" Windhoek, Namibia, 21st – 24th August 2006.

SRAC (Southern Regional Aquaculture Center), 1999. Tilapia Life History and Biology.

Tidwell H. J. and Allan, L.G., 2001. Fish as food: aquaculture's contribution Ecological and economic impacts and contributions of fish farming and capture fisheries. EMBO Rep. 2(11): 958–96.doi: 10.1093/embo-reports/kve236.

Verbeke, W., Vanhonacker, F., Sioen, I., Van Camp, J., and De Henauw, S.,2007. Perceived Importance of Sustainability and Ethics Related to Fish: A Consumer Behavior Perspective. AMBIO: A Journal of the Human Environment 36(7):580-585.

Villarreal, B. 2007. A practical guide for seafood product. AZTI-Tecnnalia, Spain.

Wikipedia, 2012. Aquaculture of Tilapia. http://en.ikipedia.org/AquacultureofTilapia

APPENDICES

Appendix 8.1. Questionnaire used for assessment of Tilapia fish preferences by consumers in Morogoro market.

Perception of people inhabited in Morogoro region on different characteristics of Tilapia fish

HH information

District:	Street/village		
Respondents name:	Age:	Marital status:	Household size:
	Education:	Main occupation:	

HH Fish information

1.	Who often buy fish for your home use	Father Mother Children Others			
2	Which fish species do you often buy? Mention them by ranking.				
3	Which form of fish do you often buy and why? (Please tell the quantity (amount per week) and price)		Quantity	Price	Give reason
		Fresh fish			
		Fried fish			
		Smoked fish			
		Sun dried			
4.	Where do you buy fish?				
5.	Do you like Tilapia fish (tick √):	Yes No			
6.	If yes, how often in a week/month do you have Tilapia fish in your meal?				
7.	If not consuming Tilapia fish frequently, why?				
8.	Are there different types of Tilapia in the markets? (tick √):	Yes No			
9.	If yes, mention the types of Tilapia you know				
10.	What are the characteristics of the different type(s) of Tilapia you mentioned above?				
11.	Which type (s) of Tilapia fish do you prefer most and why?	Type	Reasons to why prefer the type(s)		
12.	What are the key features you normally look when buying Tilapia fish?				
13	What feature of Tilapia fish you like to be improved				
14.	Are you aware that there are cultured Tilapia in ponds? (tick)	Yes No			
15.	If yes, is there any difference between cultured and non-cultured Tilapia? (tick)	Yes No			
16	If yes, mention the differences				
17.	Between cultured and non-cultured, which type do you prefer most? And why?)				
18	What are challenges in getting preferred Tilapia fish?				

Appendix 8.2. Feed composition

Composition %	Common feed	Norwegian feed	Tanzanian feed
Fish meal		7.0	13.0
Soybean meal		19.6	
Sunflower meal		20.4	34.5
Pea meal		5.0	
Maize meal		8.0	12.0
Wheat flower		30.0	2.0
Sunflower oil		7.7	3.0
Di – calcium phosphate		1.5	
Lysine		0.2	
Methionione		0.6	
Vitamin C		0.03	
Maize bran	100		
Moringa meal			34.5
Mineral and Vitamin mix			1.0
TOTAL %	100	100	100

The mineral and vitamin mixture contained: Vitamin A, D3, E, K, B2, B6, B12, C, Biotin, Calcium Phantothenate, Nicotinamide, Iron Sulphate, Manganese Sulphate, Copper Sulphate, Potassium Chloride, Zinc Sulphate, Magnesium Sulphate, Sodium Sulphate, Sodium Chloride, Lysine and Methionine.

** Vitamin C used in the Norwegian diet was Vitamin C produced for human dietary.

Appendix 8.3. Quality assessment guide questions

(A) QUALITY DIFFERENCES OF TILAPIA FISH FED THREE DIFFERENT DIETS

Name …….....

Sex……

Age……..

Part A: External assessment of Nile Tilapia fish.

a). Raw whole Fish: Do you notice any difference: please score						
Feed	**Group A**		**Group B**		**Group C**	
Grade& Score	Grade	Score	Grade	Score	Grade	Score
Skin color: 3 =Shining 2 = Bleached 1 = Dull						
Skin texture: 3 = Hard/Firm 2 = Medium 1 = Soft						
Eye color: 3 = Normal 1 = Colored						
Odor: 3 = Normal 2 = Neutral 1 = Abnormal						

Part B: Internal assessment of Nile Tilapia fish:

b) Cooked fillet pieces of Fish: Sensory Evaluation of Cooked Nile Tilapia Fillet						
Grade& Score	**Grade**	**Score**	**Grade**	**Score**	**Grade**	**Score**

Color: 3= White 2=Light grey 1=Grey						
Taste: 3=Strong 2=Medium 1=Little taste						
Texture: 3=Hard/Firm 2=Medium 1=Soft						
Flavor: 3 = Normal 2 = Neutral 1 =Abnormal						
General acceptability						

Score: 1. Dislike very much2. Dislike somehow, 3. Neutral, 4. Like Somehow. 5. Like Very much
General acceptability: 3. Good 2. Moderate 1. Poor

(B) QUALITY DIFFERENCES OF TILAPIA FISH FED ON SIMILAR DIETS

Name …….....
Sex……
Age……..
Part A: External assessment of Tilapia fish.

a). Raw whole Fish: **Do you notice any difference: please score**				
Fish species	Tilapia A		Tilapia B	
Grade & Score	Grade	Score(√)	Grade	Score(√)
Skin color: 3 =Shining 2 = Bleached 1 = Dull		1.Dislike very much 2. Dislike some How 3.Neutral 4. Like some How 5. Like very much		1.Dislike very much 2. Dislike some How 3.Neutral 4. Like some How 5. Like very much
Skin texture: 3 = Hard /firm 2 = Medium 1 = Soft		1.Dislike very much 2. Dislike some How 3.Neutral 4. Like some How 5. Like very much		1.Dislike very much 2. Dislike some How 3.Neutral 4. Like some How 5. Like very much
Eye color: 3 = Normal 1 = Colored		1.Dislike very much 2. Dislike some How 3.Neutral 4. Like some How 5. Like very much		1.Dislike very much 2. Dislike some How 3.Neutral 4. Like some How 5. Like very much
Odor: 3 = Normal 2 = Neutral 1 = Abnormal		1.Dislike very much 2. Dislike some How 3.Neutral 4. Like some How 5. Like very much		1.Dislike very much 2. Dislike some How 3.Neutral 4. Like some How 5. Like very much

Part B: Internal assessment of Tilapia fish:

b) Cooked fillet pieces of Fish: **Sensory Evaluation of Cooked Tilapia Fillet**		
	Tilapia A	**Tilapia B**

Grade& Score	Grade	Score(√)	Grade	Score(√)
Color: 3= White 2=Light grey 1=Grey		1.Dislike very much		1.Dislike very much
		2. Dislike some How		2. Dislike some How
		3.Neutral		3.Neutral
		4. Like some How		4. Like some How
		5. Like very much		5. Like very much
Taste: 3=Strong 2=Medium 1=Little taste		1.Dislike very much		1.Dislike very much
		2. Dislike some How		2. Dislike some How
		3.Neutral		3.Neutral
		4. Like some How		4. Like some How
		5. Like very much		5. Like very much
Texture: 3=Hard/Firm 2=Medium 1=Soft		1.Dislike very much		1.Dislike very much
		2. Dislike some How		2. Dislike some How
		3.Neutral		3.Neutral
		4. Like some How		4. Like some How
		5. Like very much		5. Like very much
Flavor: 3 = Normal 2 = Neutral 1 = Abnormal		1.Dislike very much		1.Dislike very much
		2. Dislike some How		2. Dislike some How
		3.Neutral		3.Neutral
		4. Like some How		4. Like some How
		5.Like very much		5. Like very much
General acceptability				

General acceptability (√):
3. Good , 2. Moderate, 1. Poor

Norges miljø- og biovitenskapelige universitet

Postboks 5003
NO-1432 Ås
67 23 00 00
www.nmbu.no