Investigation of people's perception and proximate composition of tilapia

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Declaration

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The results presented in the thesis with the above mentioned title are entirely of the candidate's own investigations and no part of the results has been accepted for any degree nor is it being concurrently submitted for any degree.

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August, 2016

Dedicated to

My Beloved Parents

Acknowledgement

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Abstract

A study has been carried out to know about the public preferences for different types of tilapia and also to expose the proximate composition of these tilapia in order to find out any relationship between people's perception and fish nutrition status. It has been found from the structured questionnaires survey that most of the producers, sellers and consumers preferred reddish colored and oval shaped tilapia rather than the grey and elongated ones. The survey has also revealed that the producers and sellers demanded the highest prices for the large-reddish-oval tilapia than the other types. It has been found that the weight of tilapia varied significantly based on their body color, shape and size, while no variation was found because of reproductive stage.

Proximate composition analysis has been occurred some significant differences in protein, lipid, moisture and ash contents of various parts of different tilapia. The percentage of protein content in head region has varied significantly according to fish color (P=<0.001) and size (P=0.007), whereas this variation between elongated and oval fish is nearly significant (P=0.06). In case of lipid, the percentage in head region is highly significantly variable between elongated and oval fish (P=<0.001), and also among fish sizes (P=<0.001). It is also remarkable that lipid contents are significantly different in head (P=<0.001), abdomen (P=0.03) and tail (P=<0.001) regions based on fish shape where in all body parts, oval-shaped tilapia contain significantly higher amount of lipid than the elongated one. The study has also revealed that the reddish tilapia contained significantly higher amount of moisture contents in head (P=<0.018), abdomen (P=0.005) and tail (P=0.008) regions than the grey ones. In case of ash content, the percentages were significantly higher in abdomen region according to fish color (P=<0.001), shape (P= 0.006) and size (P=0.008). It has also been found that the ash contents were significantly variable in head (P=0.013), abdomen

(P=0.008) and tail (P=0.05) regions according to fish size. Thus, the findings of this study revealed that

producers, sellers and consumers preferred mostly the reddish colored, oval shaped and larger sized tilapia which usually contain vary significant amounts of proximate composition than other kinds of two tilapia and thereby, people are getting higher level of nutrients by choosing very special type of tilapia available in the local market.

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List of abbreviations

1. ANOVA - Analysis Of Variance
2. AOAC - Association of Official's Analytical Chemists
3. DoF - Department of Fisheries
4. FAO - Food and Agricultural Organization
5. FMRT - Fisheries and Marine Resource Technology
6. FMM - Fresh Minced Meat
7. gm - gram
8. HUFA - Highly Unsaturated Fatty Acids
9. MT - Metric Tons
10. ml - mili gram
11. SFA - Structured Fatty Acids
12. % - Percentage

CHAPTER ONE

Introduction

Chapter 1

1.1 Background of the study

Each day 200,000 people are added to the world food demand (UN population Division, 2007). To meet this demand, aquaculture became one of the fastest growing food production industries. According to FAO statistics, global fish production has grown steadily in the last five decades (figure 1). World capture production in 2000 was more than twice that of aquaculture, but it has already decreased by 1% compared to 1997, whereas aquaculture increased by 59%. In 2012, global capture production reached 86.6 million tons, a decrease of 2.6 percent compared with the previous year. Meanwhile, over-fishing is claimed to put marine ecology in danger (FAO, 2015). FAO concludes that the maximum wild capture fisheries potential from the world's oceans has probably been reached. Sustaining fish supplies from capture fisheries has not been able to meet the growing global demand for fish food. As a result, aquaculture has continued to provide fish as an alternative source of proteins (De Silva, 2004).

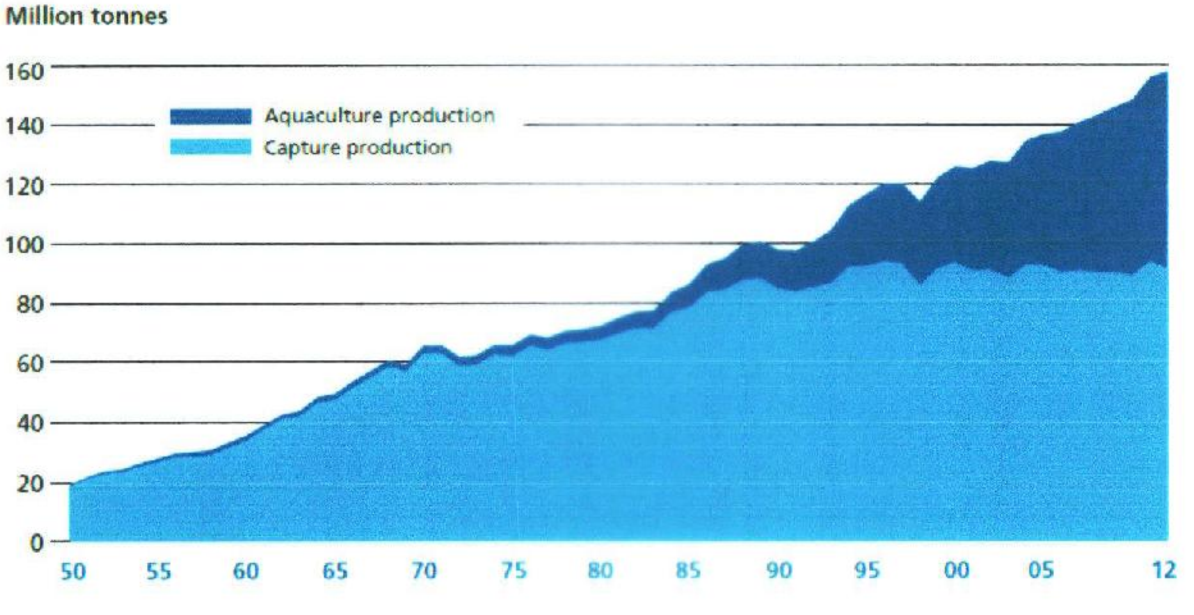

Figure 1. World capture fisheries and aquaculture production (Source: FAO, 2014).

Moreover, aquaculture production has continued to show strong growth, increasing at an average annual growth rate of 6.2 percent from 32.4 million tons in 2000 to 70.2 million tons in 2013. Out of 70.2 million tons of farmed food fish, two-thirds 63.3% (47.07 million tons) of total farmed food fish production were finfish species (FAO, 2015).The remaining is accounted from farmed crustaceans 9.7 % (6.7 million tons) and mollusks 22.8 % (15.5 million tons) of total farmed food fish production respectively (table 1).

Table 1. World Aquaculture production of food fish and aquatic plants in 2013 (FAO, 2015). (Unit: 1000 tons, live weight)

	Inland aquaculture	Mariculture	Subtotal
Finfish	41 292	5 778	47 071
Crustaceans	2 584	4 128	6 712
Molluscs	283	15 231	15 514
Other aquatic animals	525	368	893
Food fish total	***44 685***	***25 505***	***70 190***
Aquatic plants	82	26 896	26 978
Aquaculture total	**44 767**	**52 401**	**97 168**

It is now believed that aquaculture has the potential to make a significant contribution to the increasing food demand and to provide safe and high quality aquatic food. In addition to the total production, the diversity of aquaculture species has also increased. As in 2013, the number of species registered in FAO statistics was 575, including finfishes (354 species with 5 hybrids), molluscs (102), crustaceans (59), amphibians and reptiles (6), aquatic invertebrates (9), and marine and freshwater algae (37). It is estimated that more than 600 aquatic species are cultured worldwide for production in a variety of farming systems and facilities with different input intensities and technological sophistication, using either freshwater, brackish water or marine water (FAO, 2015). For most farmed aquatic species, hatchery and nursery technology have been established. Fish and fishery products play a critical role in global food security and nutritional needs of people in developing and developed countries. Fish is a key source of protein, essential amino-acids and minerals, especially in some densely populated countries where total protein intake may be low (Rice & Garcia, 2011; FAO, 2015). There are 100 million tons of fish eaten world-wide each year, providing two and a half billion people with at least 20 percent of their animal protein intake (FAO, 2015).The most common fish species raised by fish farms are salmon, carp, tilapia, European sea bass, and catfish.

Tilapias are significant food fish in many tropical and sub-tropical countries and one of the first fish species that was cultured in the world (Reza *et al.*, 2015). They are known to be a wild fish species originated from the Nile valley and later further spread to central and Western Africa (Nandlal & Pickering, 2004).They are mainly freshwater fish inhabiting shallow streams, ponds, rivers and lakes and less commonly found living in brackish water. In general, tilapias are macrophyte-feeders, feeding on a diverse range of filamentous algae and plankton. This reduces the cost of tilapia farming, reduces fishing pressure on prey species, avoids concentrating toxins that accumulate at higher levels of the food chain and makes tilapia the preferred "aquatic chickens" of the trade. Moreover, they are among the most widely cultured fish in the world, because of high tolerance to hostile environmental conditions, relatively fast growth (6 to 7 months to grow to harvest size) and easy to breed them (Reza *et al.*, 2015). 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 are the Nile tilapia *(Oreochromis niloticus*), Blue tilapia (*Oreochromis aureus*) and Mozambique or red tilapia (*Oreochromis mosambiques*) (Nandlal & Pickering, 2004). 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 (Kaliba *et al.,* 2006). Commercially grown tilapias are almost exclusively male. Cultivators use hormones, such as testosterone, to reverse the sex of newly spawned females. Because tilapia are prolific breeders, the presence of female tilapia results in rapidly increasing populations of small fish, rather than a stable population of harvest-size animals.

Global tilapia production has been growing rapidly along with demand. It has become the third most important fish in aquaculture and worldwide production about 5 million metric tons in 2014 shown in figure 2. At 1.7 million tons per annum, China is the largest tilapia producer in the world, followed by Egypt with 0.8 million (FAO, 2015).

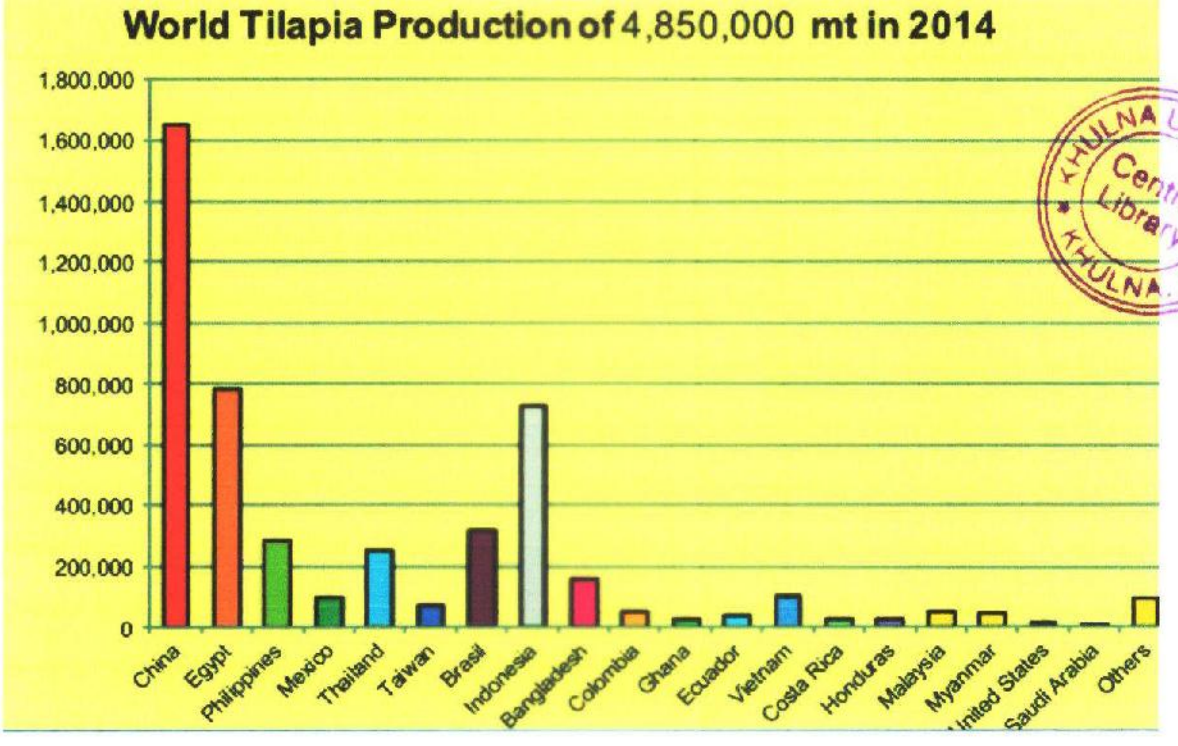

Figure 2: World Tilapia production in 2014 (Source: FAO, 2015).

The production of tilapia has been increasing rapidly in day by day. However, their culture faces problems including disease, and environmental pollution resulting from selective breeding programs focused only on growth and intensification. Disease resistance of tilapia has decreased as selection has been on growth and skin colour. In recent years, Streptococcus infection has contributed to severe economic losses in various countries, including the USA, Israel, Brazil and Thailand (Suanyuk *et al.*, 2008). In China, serious Streptococcus infection (S. agalactiae) has occurred in 2009, with a 20–50% infection rate, and 50–70% fish mortality in the main production area (Ye *et al.*, 2011). However, this impact very insignificant because it provides one of the most important sources of animal protein and income throughout the world (Sosa *et al.*, 2005). Tilapias are currently having important impacts on poor people in developing countries, both as cultured species in household-management systems and through access to fish produced in informal and formal fisheries (Little & Edwards, 2003). But the culture practice of tilapia varies to a great extent from country to country and even among the different farming systems. The cultivation of tilapia is a possible solution for communities who live in places where food is scarce. A fishpond with tilapia can provide these communities with a source of healthy, protein-rich food that can be produced by and for those who need this food most (Reza *et al.*, 2015).

Tilapias are generally appreciated as one of the healthiest and cheapest source of protein and it has amino acid compositions that are higher in cysteine than most other source of protein (Duffus, 1980). Tilapia meat contains significantly low lipids and higher water than beef or chicken and is favored over other white or red meats (Neil, 1996; Nestel, 2000). The nutritional value of this fish meat comprises the contents of moisture, dry matter, protein, lipids, vitamins and minerals plus the caloric value of the fish (Evangelos *et al.*, 1989; Steffens, 2006). It has lower cholesterol content when compared with meat (Harris, 1997) and thus is often recommended for consumption especially among the adult population. The quality of tilapia meat and its rapid growth are the main factors that have stimulated both consumers and producers interest in this species. The search for tilapia strains of superior performance by the producers along with the increasing demand for healthy food by the population of the world have required evaluations of this fish (Santos *et al.*, 2012).

The chemical composition of tilapia can be affected by many factors including species, environmental conditions, fish size, level of protein in the diet, and feeding rate (Ogata & Shearer, 2000). Numerous studies on tilapia show that body composition approximates the diet composition, but little information has been produced by comparing the entire and the fillet composition of different genetic groups (Lugo *et al.*, 2003).

The major constituents of tilapia are moisture, protein and fat with minerals occurring in trace amount (Holland *et al.,* 1993). Generally it contains very little carbohydrate, while the moisture content is very high. In tilapia fish species the moisture content is between 60 – 80 %, protein between 15 – 26 % and 2 – 13 % for fat (Olagunju *et al.*, 2012).

Protein is a major constituent, which has also been considered evaluating the nutritional value of the fish studied (Adeniyi *et al.,* 2012). The concentration of dietary essential amino acids is a major factor determining the nutritional value of food protein. Fish muscle contains an excellent amino acid composition and is an excellent source of nutritive and easily digestible proteins (Santos *et al.*, 2012). In different tilapia fish species protein content is between 15 – 26 % (Holland *et al.,* 1993). Olagunju *et al.* (2012) observed that the protein content of fresh water fish was lower than the marine fish. Protein content showed no change with the growth of the fish and was similar between different strains of tilapia (Santos *et al.,* 2012). The protein content of different parts of the tilapia showed no significant difference and no effect of feed on the protein content of tilapia (Muchiri *et al.*, 2015). Lupatsch *et al.* (2001) studied gilthead bream *(Spaurus aurata),* and reported that the protein level remained basically constant ranging from 15.7% to 19% with the growth of fish. The protein content of many species of fish increases slowly or remains more or less stable with the increase in body weight (Ramseyer, 2002). Heinsbroek *et al.* (2007) found a decrease in protein content with the increase the size of eel (*Anguilla anguilla*). The relatively high to moderate percentage crude protein may be attributed to the fact that fishes are good source of pure protein, but the differences observed in values obtained could also be as a result of fish consumption or absorption capability and conversion potentials of essential nutrients from their diets or their local environment into such biochemical attributes needed by the organisms body (Adewoye & Omotosho, 1997).

Lipid is also very important component of fish body composition which includes fatty acids and triacylglycerol. Fish typically require fatty acids of the omega-3 and omega-6 (n-3 and n-6) families (Karapanagiotidis *et al.,* 2006). Fatty acids can be a) saturated fatty acids (SFA, no double bonds), b) polyunsaturated fatty acids (PUFA, >2 double bonds), or c) highly unsaturated fatty acids (HUFA; > 4 double bonds) (Karapanagiotidis *et al.,* 2006). The fat content in most of the fish species is between 2 – 13 % (Pearson, 1976). According to Ackman (1989), generally fish can be grouped into four categories depending on their fat content, such as lean (< 2 %), low fat (2 to 4 %), medium fat (4 to 8%), and high fat (> 8%) fish. Lipids serve as a source of energy during starvation and fasting (Olagunju *et al.,* 2012). Marine fish typically require n-3 HUFA for optimal growth and health. The two major Essential Fatty Acid of this group are eicosapentaenoic acid (EPA: 20:5n-3) and docosahexaenoic acid (DHA: 22:6n-3). Freshwater fish do not require the long chain HUFA, but often require an 18 carbon n-3 fatty acid, linolenic acid (18:3-n-3). Tilapia requires fatty acids of the n-6 family (Osibona *et al.,* 2009).This fatty acid cannot be produced by freshwater fish and must be supplied in the diet. Many freshwater fish can take this fatty acid, and through enzyme systems elongate (add carbon atoms) to the hydrocarbon chain, and then further desaturation (add double bonds) to this longer hydrocarbon chain. Through these enzyme systems, freshwater fish can manufacture the longer chain n-3 HUFA, EPA and DHA, which are necessary for other metabolic functions and as cellular membrane components.

The lipid content in fish tends to increase with age (and size), decline during the winter, migration and spawning and reach its maximum value at the end of the primary feeding period of the year. Genetic origin is another factor that affects lipid content (Fauconneau *et al.,* 1991). Fresh water fishes (such as- tilapia, cat fish etc.) contain less lipid content than marine fishes (mackerel and herring) in their body composition (Olagunju *et al.,* 2012). This indicates that the marine fishes are better sources of lipid in the body when consumed. The low concentrations of lipid in the muscles of the fresh water species could be due to poor storage mechanism and the use of fat reserves during spawning activities (Osibona *et al.*, 2009). According to Huss (1995), lipid content is seasonal and is highest in fish just before spawning. The lipid content of different parts of the tilapia showed significant difference and had effect of feed on the lipid content of tilapia (Muchiri *et al.*, 2015). The head had significantly higher lipid content than the middle and tail portions of tilapia fish (Muchiri *et al.*, 2015).

The moisture is also a good indicator of its relative content of energy, protein and lipid (Adeniyi *et al.*, 2012). The moisture in fresh fish muscle is tightly bound to the proteins in the structure in such a way that it cannot readily be expelled even under high pressure. In the living fish, the moisture content usually increases and the protein content decreases as spawning time approaches (Adeniyi *et al.*, 2012). The moisture content of different parts of the tilapia showed significant difference and the middle portion had higher moisture content than the tail portion (Muchiri *et al.*, 2015). Tilapia fed on different diets had no effect in changing of moisture content (Muchiri *et al.*, 2015). There was an inverse relationship between moisture content and the size of different types of tilapia fish (Santos *et al.*, 2012). The high moisture content is a disadvantage in that it increases the fishes' susceptibility to microbial spoilage, oxidative degradation of polyunsaturated fatty acids and consequently decreases in the quality of the fishes for longer preservation time (Omolara & Omotayo, 2008).

Ash is another important component of fish body composition and a measure of the mineral content of food item. It is the inorganic residue that remains after the organic matter has been burnt off. Minerals are important for vital body functions such as acid, base and water balance. Calcium is good for growth and maintenance of bones, teeth and muscles (Turan *et al.*, 2003). Normal extra cellular calcium concentrations are necessary for blood coagulation and for the integrity, intracellular cement substances (Okaka & Okaka, 2001). Sodium is an activator of transport ATP-ases in animals and possibly also in plants (Adeyeye, 2005). There is also direct relationship of sodium intake with hypertension on human (Dahl, 1972). Iron is an important constituent of heamoglobin (Onwordi *et al.*, 2009). The presence of zinc in the fishes could mean that the fishes can play valuable roles in the management of diabetes, which result from insulin malfunction (Okaka & Okaka, 2001). The ash content in marine fish species was generally higher (Mackerel 1.79 %) than that of the fresh water samples (Tilapia 1.17 %) (Olagunju *et al.*, 2012). However, there was no significant difference between the values. It indicates that the tilapia fish species is a good source of minerals such as calcium, potassium, zinc, iron and magnesium (Olagunju *et al.*, 2012). Moreover, there was no variation of ash content in different body parts of tilapia and was no effect of different diets on ash content of tilapia (Muchiri *et al.*, 2015). A good source of instant energy that comes to the mind is carbohydrate. Carbohydrate helps in the body's development and growth. The carbohydrate content in fish is generally very low and practically considered zero. Carbohydrates have generally been ignored, as they appear in a small percentage of body weight (approximately 0.5%), in the form of glycogen (Payne *et al.*, 1999).

In addition, most developing countries like Bangladesh are faced with major challenges of alleviating hunger and malnutrition, which affect about one fifth of the world population (FAO, 2000). Due to food-deficit, countries are faced with the major challenge of introducing and sustaining ways of increasing availability of safe and nutritious food, especially protein source. Demand for animal protein in developing countries has been gradually increasing due to rapid growth of human population. This has progressed faster in Bangladesh, where the status of hunger and poverty is high (FAO, 2010). Thus the cultivation of tilapia is a possible solution for communities who live in places where food is scarce. Moreover, the farming of consumer preferred tilapia species is another solution for poverty alleviation through earning foreign currency in most of the developing countries. There are two types of tilapia (*niloticus & mossambicus)* species to be cultured in Bangladesh for commercial purpose. Since only a very few studies were carried out to investigate the public perceptions about fish quality (Pohar, 2011, Lofstedt & Schlag, 2010), the present study has been conducted to explore more details about this issue that will provide information to our farmers about which specific kind of tilapia has a very high market demand comparing with other types.

Therefore, the present study has been taken to find out whether people make their fish choice based on their phenotypic traits or proximate composition and also investigate whether people's preferences are correlated with proximate components of different tilapia species.

1.2 Objectives of the study-

The study has the following objectives to be achieved:

- To investigate the people's perception about tilapia consumption;
- To determine the proximate composition of different tilapia species;
- To find out how people's preferences are correlated with tilapia's phenotypic traits and proximate composition.

CHAPTER TWO

REVIEW OF LITERATURE

Chapter 2

2.0 Review of Literatures

In many of the developing and developed countries of the world, the demand for fish has continued to grow. Given population growth, expanding urbanization, and rising incomes in the developing world, this trend is expected to continue. Because levels of capture fish production have stagnated over the past decades (FAO, 2015), the world will thus be more dependent on aquaculture in the coming decades. According to the latest available statistics collected globally by FAO, world aquaculture production continued to grow, reaching 97.2 million tons (live weight equivalent) in 2013 (US$157 billion), including 70.2 million tons of food fish (US$150.3 billion) and 27 million tons of aquatic algae (mostly seaweeds, US$6.7 billion) (FAO, 2015).In addition World food fish aquaculture production expanded at an average annual growth rate of 6.2 percent from 32.4 million tons in 2000 to 70.2 million tons in 2013. Out of 70.2 million tons of farmed food fish, two-thirds 63.3% (47.07 million tons) of total farmed food fish production were finfish species (FAO, 2015). It is now believed that aquaculture has the potential to make a significant contribution to the increasing food demand and to provide safe and high quality aquatic food.

Bangladesh is a developing country which is blessed with vast aquatic resources and offers suitable climatic conditions for growing fish and other aquatic organisms of economic importance. It ranked 5th as aquaculture producing country in the world (FAO, 2015).The total aquaculture production is 2.06 million metric tons in 2014 which is covered 55.15% of total fish production in Bangladesh (DoF, 2015).The average growth rate of fisheries is 5.4% in last ten years where as aquaculture shows the growth performance of 8.2%. It is a well enriched country in fish biodiversity including fresh water fishes (260 species), exotic fish (12 species), marine fish crustaceans (486 species), fresh water shrimp (24 species) and marine shrimp (36) (DoF, 2015). At present, aquaculture production accounts for about half of the total fish production in Bangladesh (DoF, 2015).

Therefore, in developing countries like Bangladesh, fish is one of the potential sources of animal protein and crucial nutrients for the maintenance of a healthy body. Fish contributes a significant amount of animal protein to the diets of people in Bangladesh, about 63% of which comes from aquatic animals (DoF, 2015). Demand for animal protein in developing countries has been gradually increasing due to rapid human population. This has progressed faster in Bangladesh, where the status of hunger and poverty is high (FAO, 2010). Different types of fish have been cultured in Bangladesh to fulfill the nutritional requirements. Tilapia is the most common fish species raised by fish farms in Bangladesh.

Tilapias are important food fish in many tropical and sub-tropical countries and one of the first fish species that was cultured in the world (Reza *et al.*, 2015). They are known to be a wild fish species originated from the Nile valley and later further spread to central and Western Africa (Nandlal & Pickering, 2004).They are mainly freshwater fish inhabiting shallow streams, ponds, rivers and lakes and less commonly found living in brackish water. In general, tilapias are macrophyte feeders, feeding on a diverse range of filamentous algae and plankton. This reduces the cost of tilapia farming, reduces fishing pressure on prey species, avoids concentrating toxins that accumulate at higher levels of the food chain and makes tilapia the preferred "aquatic chickens" of the trade (Nandlal & Pickering, 2004). Moreover, they are among the most widely cultured fish in the world, because of high tolerance to hostile environmental conditions, relatively fast growth (6 to 7 months to grow to harvest size) and easy to breed them (Reza *et al.*, 2015). 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 are the Nile tilapia *(Oreochromis niloticus)*, Blue tilapia (*Oreochromis aureus*) and Mozambique or red tilapia (*Oreochromis mosambiques*) (Nandlal & Pickering, 2004). Commercially grown tilapias are almost exclusively male. Cultivators use hormones, such as testosterone, to reverse the sex of newly spawned females. Because tilapia are prolific breeders, the presence of female tilapia results in rapidly increasing populations of small fish, rather than a stable population of harvest-size animals. Global tilapia production has been growing rapidly along with demand. It has become the third most important fish in aquaculture and worldwide production about 5 million metric tons in 2014. At 1.7 million tons per annum, China is the largest tilapia producer in the world, followed by Egypt with 0.8 million (FAO, 2015).

In recent years, fish has become favorite foodstuff for the majority of societies because of several health reasons (Ali and Kiumars, 2010). Tilapia provides one of the most important sources of animal protein and income throughout the world (Sosa *et al.*, 2005).The nutritional value of tilapia meat comprises the contents of moisture, dry matter, protein, lipids, vitamins, minerals as well as very low level of cholesterol content when compared with meat (Louka *et al.*, 2004). The nutritional composition of tilapia varies greatly from one species and individual to another, depending on age, feed intake, sex and sexual changes connected with spawning, the environment and season (Silva & Chamul, 2000).

Numerous studies on tilapia show that body composition approximates the diet composition, but little information has been produced by comparing the entire and the fillet composition of different genetic groups (Lugo *et al.*, 2003). The main categories of body components of tilapia fish are the same as those of other animals: Moisture content (with great predominance), lipids, protein and small amounts of carbohydrates and minerals (often called ash), which remain after the body is burned during calorimetry (Weatherley & Gill, 1987). Beside of these proteins, lipid and moisture contents are the major constituents, which have been considered in evaluating the nutritional value of tilapia studied.

Protein is a major constituent, which has also been considered evaluating the nutritional value of the fish studied (Adeniyi *et al.*, 2012). In different tilapia fish species protein content is between

15 – 26 % (Holland *et al.,* 1993). Nurullah *et al.* (2003) conducted a research on nutritional quality of mola (*Amblypharyngodon mola*), dhela (*Osteobrama cotio*), chapila (*Gudusia chapra*), punti (*Puntius stigma*), tengra (*Mystus tengra*) and kankila (*Xenentodon cancila*) showed that the protein content was in the range of 14.08 to 21.70% with highest value in kankila and a lowest in chapila. Olagunju *et al.* (2012) observed that the protein content of fresh water fish was lower than the marine fish. Santos *et al.* (2012) reported that, Protein content showed no change with the growth of the fish and was similar between strains. Muchiri *et al.* (2015) observed that the protein content of different anatomical parts of the tilapia showed no significant difference. There was no significant difference in protein content of the fish fed on different diets (Muchiri *et al.,* 2015). Lupatsch *et al.* (2001) studied gilthead bream *(Spaurus aurata),* and reported that the protein level remained basically constant, ranging from 15.7% to 19% with the growth of the fish. Shearer (1994) stated that the protein content of salmonid in the growing phase is determined only by the size of the fish and it is not affected by growth rate, diet or environmental factors. The protein content of many species of fish increases slowly or remains more or less stable with the increase in body weight (Ramseyer, 2002). Heinsbroek et al. (2007) found a decrease in protein content with the increase the size of eel *Anguilla anguilla.* The relatively high to moderate percentage crude protein may be attributed to the fact that fishes are good source of pure protein (Adewoye & Omotosho, 1997).

Lipid is also very important component of fish body composition which includes fatty acids and triacylglycerol. Fish typically require fatty acids of the omega-3 and omega-6 (n-3 and n-6) families (Karapanagiotidis *et al.,* 2006).Normally, lipids are soluble in ether hence they are ether extractable. They serve as source of energy during starvation and fasting. The lipid content in fish tends to increase with age (and size), decline during the winter, migration and spawning and reach its maximum value at the end of the primary feeding period of the year (Santos *et al.,* 2012). Genetic origin is another factor that affects lipid content (Fauconneau *et al.,*1991). As an energy stock, it tends to be in the form of neutral fats - triglycerides. Phospholipids, free fatty acids, sterols etc. comprise only a small fraction of lipids (Weatherley & Gill, 1987). The fat content in most of the fish species is between 2 – 13 %. According to Ackman (1989), generally fish can be grouped into four categories according to their fat content: lean fish (< 2 %), low fat (2 to 4 %), medium fat (4 to 8%), and high fat (> 8%). Lupatsch et al. (2001) studied gilthead bream *(Spaurus aurata),* and reported that the major changes occurred in lipid content, from 5.5% to 21.0%, with the growth of the fish. Nurullah *et al.* (2003) conducted a research on nutritional quality of mola (*Amblypharyngodon mola*), dhela (*Osteobrama cotio*), chapila (*Gudusia chapra*), punti (*Puntius stigma*), tengra (*Mystus tengra*) and kankila (*Xenentodon cancila*) showed that the lipid content was in the range of 2.82 to 6.28% with the highest value in tengra and lowest in kankila. Olagunju *et al.* (2012) observed that there was no significant difference between catfish and tilapia as was seen in mackerel and herring. The marine fishes (mackerel and herring) had a higher lipid content than the fresh water fishes hence their classification as high fat fishes. This indicates that the marine fishes are better sources of lipid in the body when consumed. The low concentrations of lipid in the muscles of the fresh water species could be due to poor storage mechanism and the use of fat reserves during spawning activities (Osibona *et al.*, 2009). According to Huss (1995), lipid content is seasonal and is highest in fish just before spawning. Muchiri *et al.* (2015) observed that the lipid content of different anatomical parts of the tilapia showed significant difference. The head had significantly higher lipid content than the middle and tail portions of tilapia fish. Oliver (2002) reported that the type of feed significantly affected the lipid content and fatty acids profile but not the overall proximate composition for the other constituents of sturgeon flesh.

The moisture is also a good indicator of its relative content of energy, protein and lipid (Adeniyi *et al.*, 2012).In tilapia fish species the moisture content is between 60 – 80 % (Holland *et al.*, 1993). Olagunju *et al.* (2012) observed that tilapia which is locally harvested has the highest percentage of moisture when compared to marine fishes. Nurullah *et al.* (2003) conducted a research on nutritional quality of some small indigenous fish species of Bangladesh. Proximate analysis of mola (*Amblypharyngodon mola*), dhela (*Osteobrama cotio*), chapila (*Gudusia chapra*), punti (*Puntius stigma*), tengra (*Mystus tengra*) and kankila (*Xenentodon cancila*) showed that moisture content in freshly caught fish ranged from 72.97 to 76.36% with the highest moisture content in chapila and the lowest in punti. Adeniyi *et al.* (2012) reported that, high lipid fishes (such as –Marine fishes) had less water and more protein than low-lipid fishes which is in-line with the report of Steffens (2006). Muchiri *et al.* (2015) observed that the moisture content of different anatomical parts of the tilapia showed significant difference. They also reported that the middle portion had higher moisture content than the tail portion. There was no significant difference in moisture content of the fish fed on different diets (Muchiri *et al.*, 2015). Santos *et al.* (2012) reported that, the moisture content of different size of tilapia showed significant difference. There was an inverse relationship between moisture content and the size of different types of tilapia fish. The high moisture content is a disadvantage in that it increases the fishes' susceptibility to microbial spoilage, oxidative degradation of polyunsaturated fatty acids and consequently decreases in the quality of the fishes for longer preservation time (Omolara & Omotayo, 2008).

Ash is another important component of fish body composition and a measure of the mineral content of food item. It is the inorganic residue that remains after the organic matter has been burnt off. Olagunju *et al.* (2012) observed that the ash content in marine fish species was generally higher (Mackerel 1.79 ± 0.89 %) than that of the fresh water samples (Tilapia 1.17 ± 0.06 %). There was no significant difference between the values. It indicates that the species is a good source of minerals such as calcium, potassium, zinc, iron and magnesium (Olagunju *et al.*, 2012). Muchiri *et al.* (2015) observed that the ash content of different anatomical parts of the tilapia showed no significant difference. There was no significant difference in ash content of the fish fed on different diets (Muchiri *et al.*, 2015). Santos *et al.* (2012) observed the difference in the percentage of ash content between Thai and commercial strains. They reported that, the fish in the 15-20cm class also had higher percentage of ashes than fish in the 5-10cm class, but similar to the fish in the 10-15cm class.

Furthermore, a good source of instant energy that comes to the mind is carbohydrate. It also helps in the body's development and growth. The carbohydrate content in fish is generally very low and practically considered zero. Carbohydrates have generally been ignored, as they appear in a small percentage of body weight (approximately 0.5%), in the form of glycogen (Payne *et al.,* 1999). The relatively low values of carbohydrate could be due to higher values of moisture and a relatively high value of protein content (Olagunju *et al.*, 2012).

In addition, most developing countries like Bangladesh are faced with major challenges of alleviating hunger and malnutrition, which affect about one fifth of the world population (FAO, 2000). Due to food-deficit, countries are faced with the major challenge of introducing and sustaining ways of increasing availability of safe and nutritious food, especially protein source. Demand for animal protein in developing countries has been gradually increasing due to rapid growth of human population. This has progressed faster in Bangladesh, where the status of hunger and poverty is high (FAO, 2010). Thus the cultivation of tilapia is a possible solution for communities who live in places where food is scarce. Moreover, the farming of consumer preferred tilapia species is another solution for poverty alleviation through earning foreign currency in most of the developing countries.

Furthermore, most consumers be aware of the health benefits of eating fish as part of their diet and stated fish consumption reduces the risk of heart diseases, increases intelligent quotient especially when taken by pregnant mothers and children, and has low fat content (Githukia *et al.* 2014). These consumer perceptions are consistent with findings of Nauman *et al.,* (1995) conducted in Malaysia where 44% of respondents consumed fish for health and nutrition reasons while 57% stated that taste was one of the major factors that influenced their decision to consume fish. Oomen *et al.,* (2000) also reported frequent consumption of fish, especially those with Omega-3 fatty acid which is reported to lower coronary heart diseases and stroke.

Relatively few studies have focused on consumers fish quality perception and public opinion towards the consumption of tilapia fish is poorly understood (Pohar, 2011). In addition, the public has often been presented with conflicting advice about consuming tilapia fish (Lofstedt & Schlag, 2010). Githukia *et al.* (2014) investigated the consumer preference of wild and cultured *O. niloticus*. It was observed that the higher preferences for captured compared to cultured Nile tilapia. Studies in some countries have shown that farmed fish species are perceived as of lower quality and less safe than their respective wild equivalents (Polanco & Luna, 2010; Meas & Hu, 2014). This situation calls for a special need to have basic information on people's perception of different tilapia fish species within the country that will drive development of desired products, marketing channels, processing and suitable transport system. Therefore present study has been taken to find out whether people make their fish choice based on their phenotypic traits or proximate composition and also investigate whether people's preferences are correlated with proximate components of different tilapia species.

CHAPTER THREE

Materials and Methods

Chapter 3

3.0 Materials and Methods:

3.1 Study area

The study was carried out at Dumuria Upazilla of Khulna District from February to May, 2016.

3.2 Structured questionnaires survey for human perception on tilapia consumption

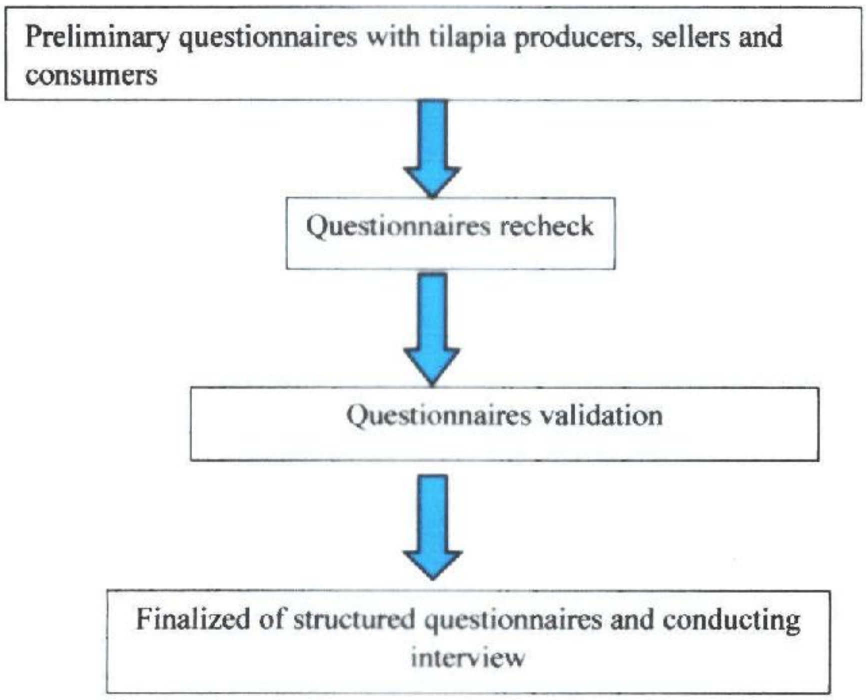

Figure 3: Flow-diagram about how the final questionnaires were finalized.

3.3 Sample collection

Mature tilapia were randomly collected from the same pond of Dumuria Upazilla, Khulna District and taken to the fish nutrition laboratory of Fisheries and Marine Resource Technology Discipline (FMRT) of Khulna University, Khulna to determine the proximate composition. The materials and methods used for proximate analysis are described below:

3.3.1.1Proximate component analyses

Sample size

Total number of samples: 360 samples

3.3.1 Reddish tilapia (*Oreochromis niloticus* – **Figure: 4**)

A. Oval: 30 fish * 3 body parts (Head, abdomen and tail)

B. Elongated: 30 fish * 3 body parts (Head, abdomen and tail)

3.3.2 Grey Tilapia (*Oreochromis mossambicus* – **Figure: 5**)

A.Oval: 30 fish * 3 body parts (Head, abdomen and tail)

B. Elongated: 30 fish * 3 body parts (Head, abdomen and tail)

3.3.1.2 Sample processing

The mature tilapia fish *(Oreochromis niloticus and Oreochromis mossambicus)* were purchased from a local fresh water pond and were transported within an hour in ice boxes to the fish nutrition laboratory of Khulna University. The fish (300-450 gm. in weight with length ranging from 25-28 cm) were prepared using the handling method; disemboweled, beheaded and skin removed before thoroughly washing with clean water to remove contaminants or unwanted particles. Fish muscle retrieved with care, separating the bones from the meat, chopped into pieces. A portion of the fresh fish meat was minced using a meat mincer and the pulverized fish meat (homogenate) was vacuum packed in polyethylene bags (100-250 g per unit) and was labeled as Fresh Minced Meat (FMM) sample. The fish samples were thoroughly washed with tap water and distilled water to remove any adhering contaminants and drained under folds of filter paper. The fish sample was dissected with a knife and the intestines, guts and bones were removed. The head was also discarded. The samples were then homogenized into a fine mesh with an electric food blender and thereafter, stored in a deep freezer (- 18 ^{0}C) prior to analysis.

The proximate compositions were analyzed for the content of moisture, crude protein, crude fat and ash according to the methods of Association of Official Analytical Chemists, AOAC (2000) which is described below:

3.3.1.3 Determination of protein

For protein determination micro kjeldahl method was followed. The systematic procedure of kjeldahl method for protein determination is presented below:

Apparatus

- Kjeldahl flask
- Kjeldahl nitrogen digestion apparatus
- Kjeldahl nitrogen distillation apparatus
- Burette
- Pipette
- Blender

- ❖ Conical flask
- ❖ Measuring cylinder
- ❖ Mortar and pestle

Reagent and its preparation

- ❖ Solvent: potassium sulphate and mercuric oxide in the ratio of 10 to 0.7 were mixed and crushed properly and preserved in colored bottle.
- ❖ Concentrated sulfuric acid was taken for the study.
- ❖ 2% boric acid solution: 20gm boric acid crystal was added with 1 liter distilled water.
- ❖ Tashiro's indicator, dissolving 80gm methyl red and 20 mg methylene blue in 95% ethanol and was made up to 100 ml with 95% ethanol.
- ❖ Sandy zinc or zinc powder.
- ❖ 33-40% caustic soda: 400gm NaoH and 10gm potassium sulfide was added with 1 liter distilled water.
- ❖ 0.1(N) HCl acid: 8.48 ml HCl was added with 1 liter distilled water.

Procedure

Sample preparation

A total number of samples collected from various areas of Dumuria and taken to the Fish Nutrition Laboratory of Fisheries Marine Resource Technology (FMRT) Discipline of Khulna University in Khulna. The samples were kept in incubator at 105 °c for 24 hours for determining the moisture. Then the dried samples were kept for further analysis.

Digestion

0.2-0.5gm of sample was weighed and inserted into a kjeldahl flask and 2gm of solvent and 5 ml of concentrated sulfuric acid (H_2SO4) were added into the flask. The content of the flask was digested by heating in a micro kjeldahl nitrogen digesting apparatus for 45 minutes till the clear color appears. After completion of digestion, the flask was transferred from digesting apparatus and let it be cooled for 10 minutes until the temperature decreased to about room temperature.

Distillation

15 ml of 2% boric acid (H_3BO_3) was taken in a conical flask and 2-3 drops of tashiro's indicator were added into the flask. The delivery tube of the apparatus was arranged with its tip below the surface of 15 ml boric acid. Then adding 70 ml of distilled water diluted the digested materials and 0.5gm of sandy zinc was added in the kjeldahl flask. About 25 ml of 33-40% caustic soda (NaOH) solution was poured slowly in the flasks along sidewall. The flask was then connected to the kjeldahl nitrogen distillation apparatus and distilled it for about 30 minutes to obtain 25-30 ml distilled solution. Distilled solution was stored in the conical flask through delivery tube.

Titration

The distilled solution stored in the conical flask was taken and titrated against 0.1(N) HCl solutions.

The percentage of gross portentous nitrogen was calculated out with the following formula (Pearson, 1976):

$$\% N_2 = \frac{0.1 \text{ x Burets reading x } 0.014}{\text{Sample weight (gm)}} \text{ x } 100$$

$$\text{Protein } (\%) = N_2 \% \text{ x } 6.25$$

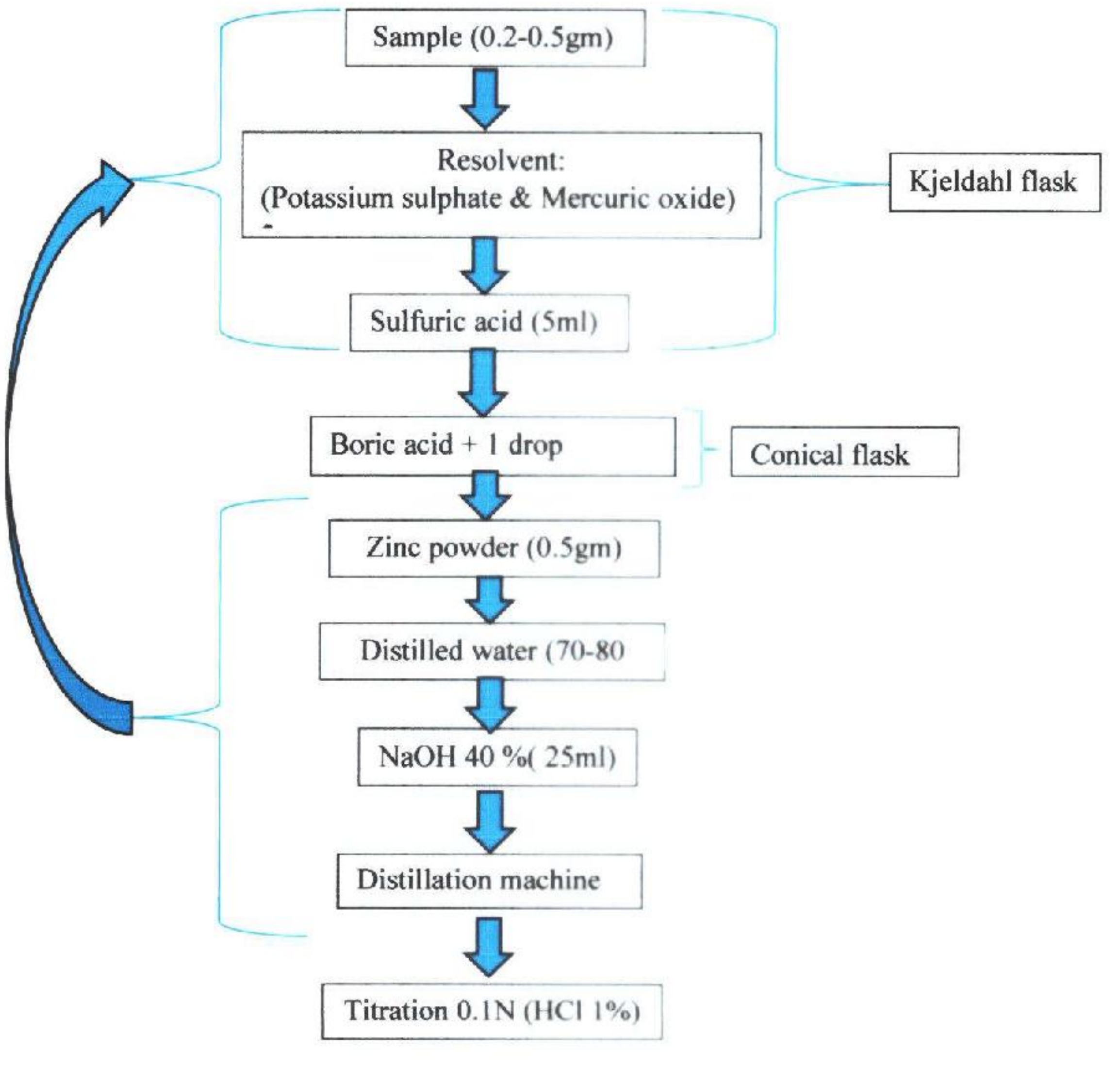

Figure 6: Flow chart of the procedure of protein content analysis.

3.3.1.4 Determination of Lipid

Most methods of measuring lipid content depend on extracting the lipid by dissolving it in a suitable solvent. In the method given the lipid was recovered from the solution by evaporating the solvent and is then weighted. By this procedure the fat content of the sample could be successfully extracted and measured.

Apparatus

- Separation funnel, Mixer, Blender, Beaker (250 ml), Mortar and pestle, Magnetic stirrer hot plate, Filter paper etc.

Chemicals

- Methanol, Chloroform, Distilled water

Procedure

Content of the sample could be successfully extracted and measured. Crude lipid of the sample was determined by extracting a weighted quantity of sample (2-5g) with methanol and chloroform (1:2) solution. At first the weighted sample was ground by using mortar. Then the sample was taken into a beaker, and chloroform – methanol (2:1)solution was added. After that, the sample was mixed by using a mixer. Then, the sample solution was filtered by a filter paper. About 50 ml water was added with the sample solution and sample solution turned into milky color solution. Then milky color solution was kept in separation funnel for 8 hours(minimum).Then three layers appear in the separation funnel. Another beaker was dried in the oven and weighted. Then the beaker was used for collecting the solution only the bottom layer of the separation funnel. After collection of the separated solution from separation funnel was kept in the hot plate for drying. After evaporating all of the chloroform a simple amount of sticky liquid left in the bottom of the beaker. Then it was taken out from the hot plate and allowed to cool down. After cooling down it was weighed and deducting the weight of the beaker that was measured earlier from the cooled beaker containing lipid, the amount of lipid is determined.

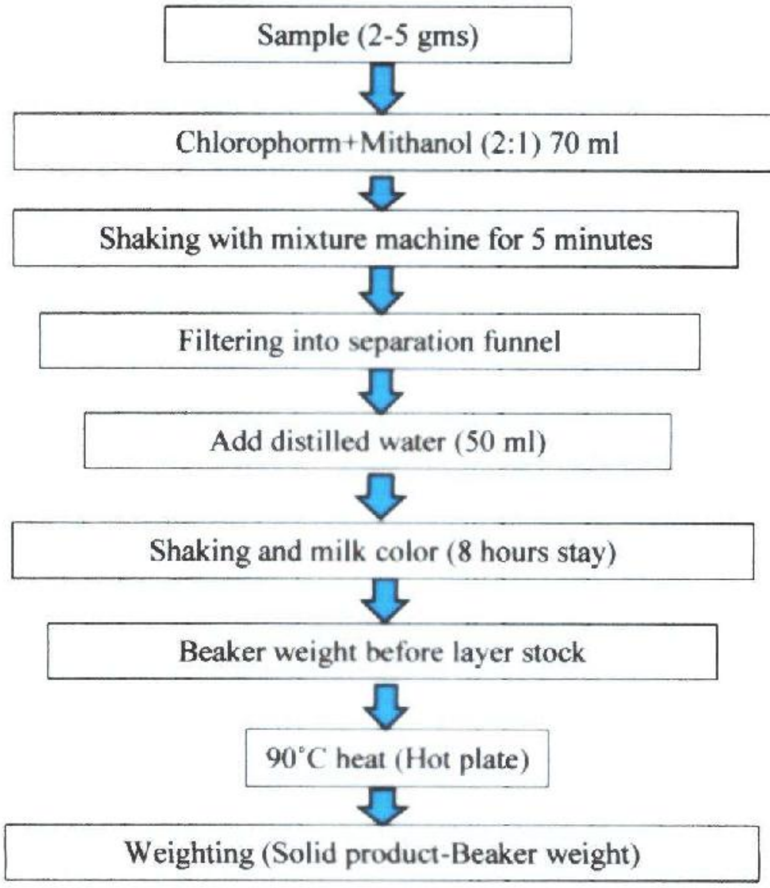

Figure 7: Flow chart of the procedure of lipid content analysis.

It was allowed to cool at room temperature, eventually vacuum packed in polyethylene bags. All samples were kept frozen at -20°C till when needed for the experiment. All chemical reagents used in the experiments were of analytical grade.

The percentage of lipid content was calculated by the following formula:

$$\text{Lipid (\%)} = \frac{\text{Weight of lipid}}{\text{Weight of sample}} \times 100$$

3.3.1.5 Determination of moisture

The main constituent of fish flesh is moisture, which usually accounts for about 80 percent of the weight of a fresh white fish fillet (Holland *et al.*, 1993).

Apparatus

- Oven, Porcelain crucible, Desiccator, Electric balance, Blender, Mortar and pestle.

Procedure

Moisture content of fish fillets was determined according to Association of Official Analytical Chemists, AOAC (2000). The samples were dried in moisture dish in an oven at 105°C until constant weights were obtained. The weight loss of the sample is the measure of moisture content. For determining the moisture, eight beakers were cleaned, dried and then the constant weight was taken. About 2-5 gm. of samples was taken into the beaker and weight was taken. The difference between the two weights (dried sample & crucible weight – crucible weight)gave the weight of sample. Then the beaker with sample was put in a controlled incubator and was dried at 105°C for 24 hours and weight several times till the constant weight was achieved.

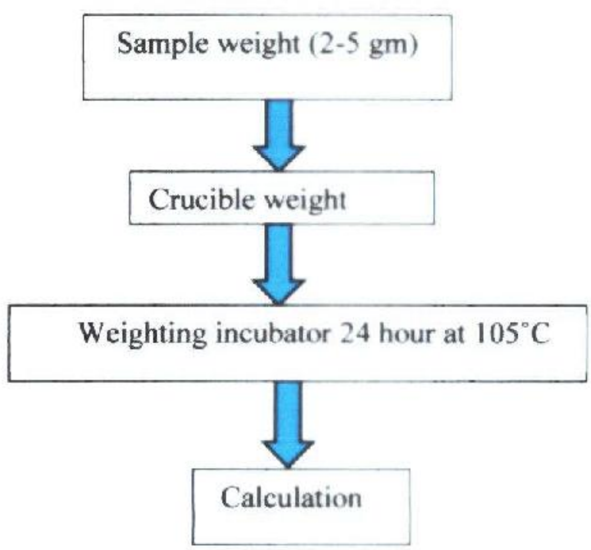

Figure 8: Flow chart of moisture content analysis

The percentage of the moisture content was calculated by the following equation:

$$\text{Moisture (\%)} = \frac{\text{Weight of the sample} - \text{Weight of the dried sample}}{\text{Weight of the sample}} \times 100$$

3.3.1.6 Determination of Ash

Ash Content Analysis:

The ash content of a sample is the inorganic residue left after complete removal of the organic residue by muffling at about 550°C. In a muffle furnace for 8 hours. Ash content of fish fillets was determined according to AOAC (2000). Pre-dried samples obtained from moisture content analysis were ashes in furnace at 550°C.

Apparatus

- Muffle furnace, Porcelain crucible, Desiccator, Electric balance, Blender, Mortar and pestle.

Procedure

At first, weight of the crucible was recorded. Then the sample with the crucible was weighed. Difference between the two weights gave the sample weight. After that each crucible with the sample was placed in the muffle furnace. The samples were muffled at 550^0C for 8 hours. Afterwards, the crucibles were transferred to the desiccator to cool down at room temperature for a few minutes. Finally ash with crucible was weighed. Ash weight was taken subtracting the crucible weight from ash with weight.

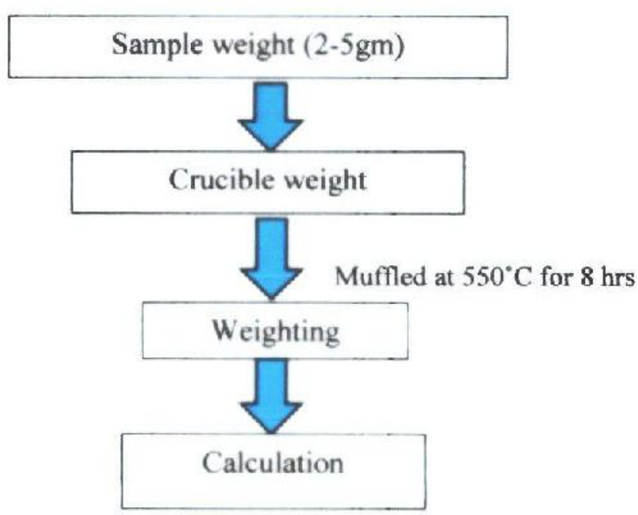

Figure 9: Flow chart of Ash content analysis.

The percentage of ash calculation was determined by the following formula (Pearson, 1976)

$$\text{Ash (\%)} = \frac{\text{Weight of Ash}}{\text{Weight of the sample}} \times 100.$$

3.3.1.7. Statistical analyses

All analyses were performed using 'R' version 3.2.0 (Please see: http://cran.r-project.org/). The descriptive statistics (means, SEs, ranges etc.) were calculated by using the 'pysch' package, normality was tested with the 'nortest' package.

The univariate analyses of variance (ANOVA) were performed to test for an overall effect of fish color, fish shape, fish size and reproductive stage on (a) different phenotypic traits, and (d) proximate composition. All analyses of variance models were run using the 'car'package of 'R' and all plots were prepared using the ggplot2.

CHAPTER FOUR

Results

Chapter 4

4.0 Results

After conducting the survey and finishing the laboratory experiments, all data were compiled, arranged and analyzed to explore how people make their choice to grow, sell and consume different types of tilapia, and how these tilapias are varied in terms of proximate composition.

4.1 Public preferences about tilapia:

It has been found from the structured questionnaires survey that most of the producers (63.3%), sellers (56.7%) and consumers (63.3%) preferred red-colored tilapia rather than the grey ones (figure 10). Similarly, majority of the producers (80.0%), sellers (60.0%) and consumers (66.7%) made their choice to oval-shaped tilapia rather than the elongated ones (figure 11). The survey has also revealed that most of the participants rated the reddish-oval tilapia highest, then they preferred grey-oval tilapia. The lowest number of participants gave their preferences on grey-elongated tilapia (see figure 12).

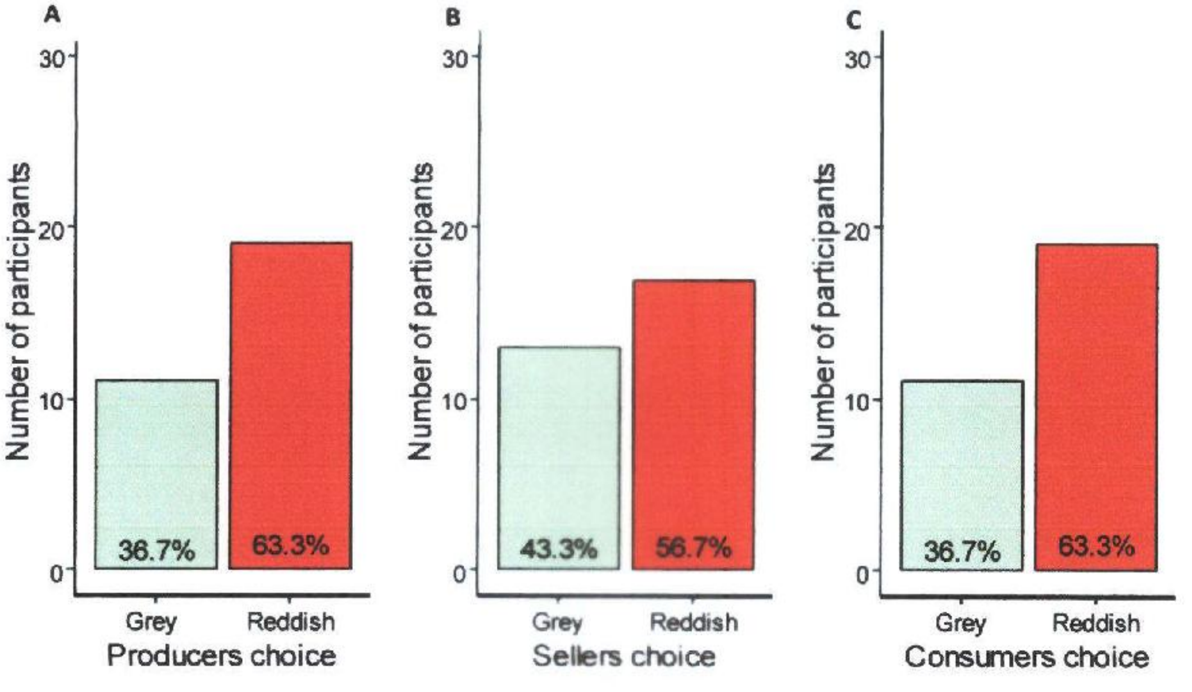

Figure 10: Number and percentage of (A) producers, (B) sellers and (C) consumers showing their preferences about grey and reddish tilapia.

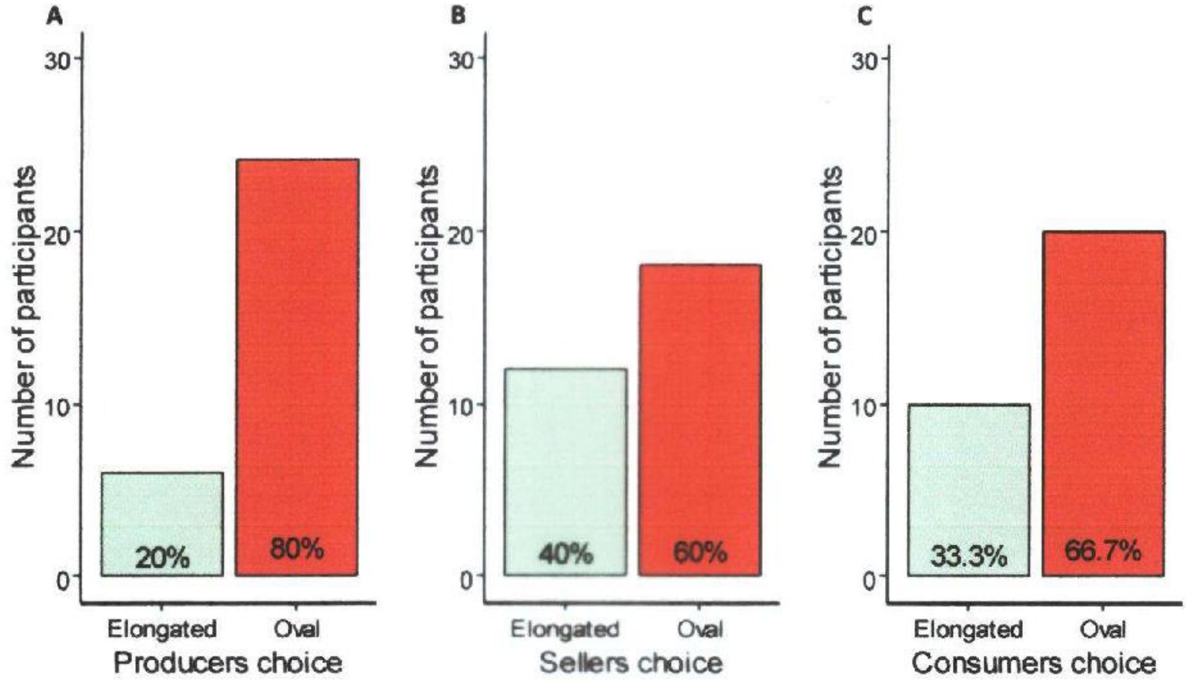

Figure 11: Number and percentage of (A) producers, (B) sellers and (C) consumers showing their preferences about elongated- and oval-shaped tilapia.

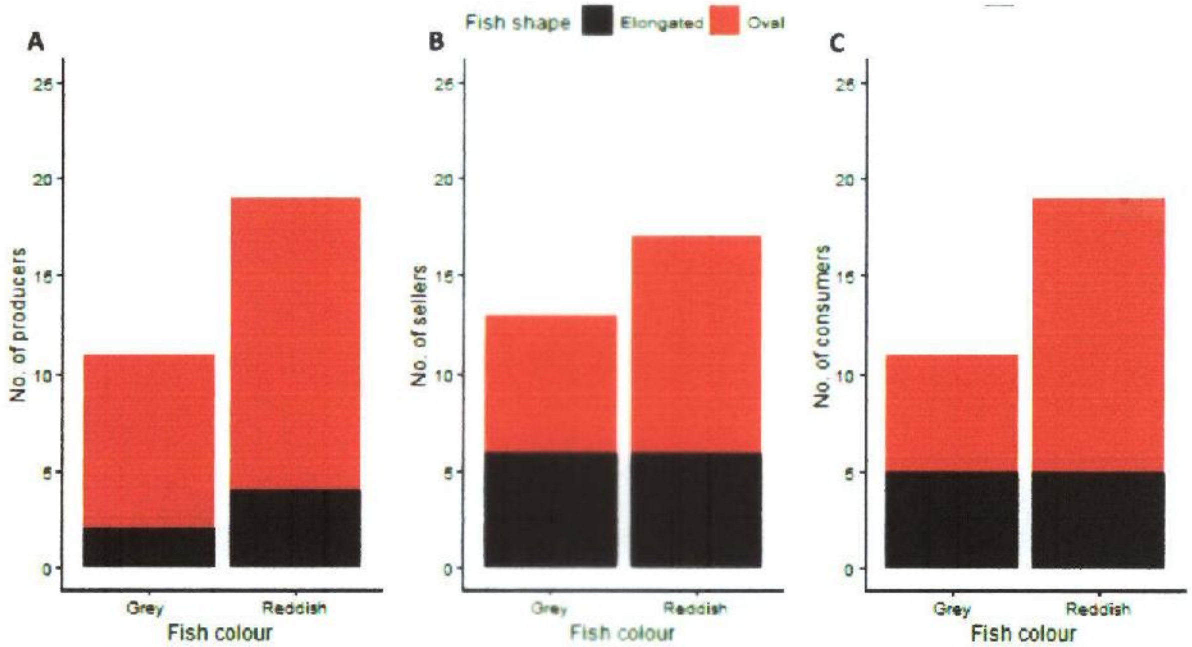

Figure 12: Number of (A) producers, (B) sellers and (C) consumers showing their preference on grey-oval, grey-elongated, reddish-oval and reddish-elongated tilapia.

4.2 Phenotypic variations:

Table 2 shows all the details about the differences in length and weight of various tilapia. It has been found that the length of tilapia does not vary according to their body coloration, shape and reproductive stage (table 2), while the weight varies significantly based on their ornamentation, shape, size, but no variation because of reproduction (figure 13).

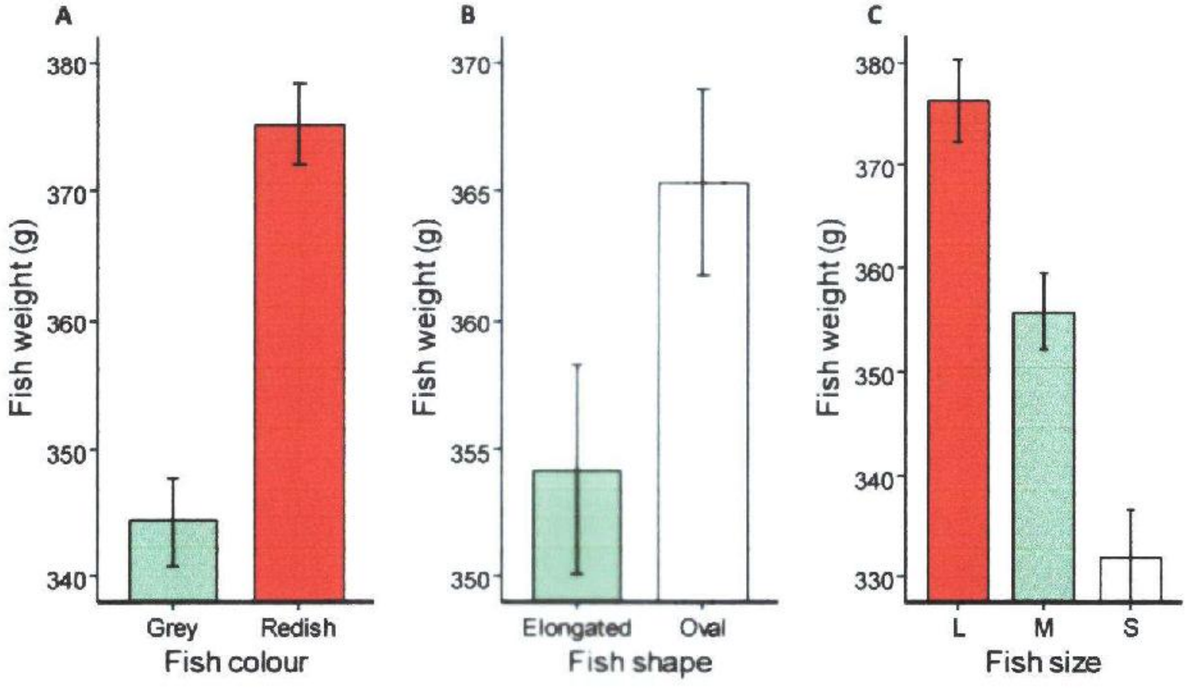

Figure 13: Variation in weight of tilapia (mean±SE) according to their (A) body color, (B) shape and (C) size.

Table 2: The ANOVA for tilapia size, price and proximate composition. Means and associated standard errors (SE) for each trait, *F*-ratios and associated *P* values are presented for each model (significant values are highlighted in bold and italic font).

Response	Fish color (Mean±SE)				Fish shape (Mean±SE)			
	Reddish	Grey	*F*	*P*	Oval	Elongated	*F*	*P*
Length (cm)	25.44±0.16	25.25±0.19	0.21	0.651	25.41±0.2	25.28±0.16	0.61	0.439
Weight (g)	375.18±3.17	344.35±3.56	56.04	***<0.001***	365.33±3.59	354.2±4.11	4.45	***0.03***
Producer price (BDT)	112.25±0.82	108.67±0.77	14.11	***<0.001***	112.33±0.84	108.58±0.74	11.13	***0.001***
Sellers price (BDT)	126.17±0.63	122.5±0.77	15.92	***<0.001***	125.5±0.65	123.17±0.81	4.49	***0.04***

Protein in head (%)	19.43±0.19	18.54±0.13	13.80	***<0.001***	19.23±0.19	18.74±0.15	3.39	0.06
Protein in abdomen (%)	20.04±1.04	18.02±0.13	3.17	0.08	19.63±1.04	18.43±0.15	1.42	0.24
Protein in tail (%)	20.13±1.01	18.32±0.13	2.66	0.11	19.83±1.02	18.62±0.13	1.48	0.23
Lipid in head (%)	1.55±0.05	1.61±0.05	2.16	0.14	1.72±0.04	1.45±0.04	18.64	***<0.001***
Lipid in abdomen (%)	1.56±0.04	1.62±0.04	1.73	0.19	1.65±0.04	1.53±0.04	4.78	***0.03***
Lipid in tail (%)	1.35±0.04	1.4±0.03	1.43	0.23	1.47±0.03	1.28±0.03	15.39	***<0.001***
Moisture in head (%)	79.59±0.29	78.26±0.41	5.75	***0.018***	79.01±0.41	78.85±0.32	0.05	0.83
Moisture in abdomen (%)	81.27±0.27	79.78±0.44	8.22	***0.005***	80.55±0.46	80.5±0.27	0.00	0.99
Moisture in tail (%)	79.59±0.23	78.44±0.34	7.23	***0.008***	78.82±0.34	79.22±0.25	0.96	0.33
Ash in head (%)	1.56±0.04	1.43±0.04	3.32	0.07	1.52±0.04	1.46±0.04	0.79	0.38
Ash in abdomen (%)	1.44±0.04	1.14±0.03	36.16	***<0.001***	1.23±0.03	1.35±0.04	7.87	***0.006***
Ash in tail (%)	1.34±0.03	1.27±0.04	1.92	0.17	1.34±0.03	1.28±0.04	1.49	0.22

Table 2 (continued): The ANOVA results for tilapia size, price and proximate composition. Means and associated standard errors (SE) for each trait, *F*-ratios and associated *P* values are presented for each model (significant values are highlighted in bold and italic font).

Response	**Fish size (Mean±SE)**					**Fish reproductive stage (Mean±SE)**			
	Large	**Medium**	**Small**	***F***	***P***	Egg bearing	No egg bearing	***F***	***P***
Length (cm)	26.64±0.09	25.08±0.07	23.07±0.22	203.2	***<0.001***	25.95±0.15	25.05±0.16	0.51	0.48
Weight (g)	376.33±4.02	355.93±3.65	331.84±4.89	25.72	***<0.001***	352.13±4.2	363.44±3.5	0.025	0.87
Producer price (BDT)	114.56±0.92	108.84±0.71	105.53±0.85	23.89	***<0.001***	110.38±0.9	110.49±0.73	0.027	0.87
Sellers price (BDT)	127.56±0.65	123.57±0.74	118.95±1.05	21.57	***<0.001***	124.36±0.8	124.32±0.68	0.51	0.47
Protein in head (%)	19.4±0.2	18.92±0.18	18.2±0.25	5.14	***0.007***	18.72±0.16	19.12±0.17	0.17	0.68
Protein in abdomen (%)	18.9±0.21	19.58±1.12	17.77±0.22	0.52	0.59	18.21±0.18	19.43±0.78	0.015	0.90
Protein in tail (%)	19.14±0.2	19.7±1.09	18.03±0.23	0.46	0.63	18.55±0.16	19.55±0.76	0.05	0.83
Lipid in head (%)	1.73±0.06	1.55±0.04	1.32±0.06	10.41	***<0.001***	1.73±0.05	1.51±0.04	3.09	0.08
Lipid in abdomen (%)	1.64±0.05	1.59±0.04	1.47±0.07	1.98	0.14	1.7±0.04	1.54±0.03	4.21	***0.04***
Lipid in tail (%)	1.43±0.04	1.36±0.03	1.27±0.08	2.17	0.12	1.47±0.04	1.33±0.03	4.50	***0.04***
Moisture in head (%)	79.29±0.43	79.16±0.36	77.39±0.65	2.87	0.06	78.52±0.48	79.12±0.31	0.16	0.69
Moisture in abdomen (%)	80.78±0.55	80.44±0.34	80.15±0.34	0.33	0.72	79.72±0.62	80.91±0.24	0.52	0.47
Moisture in tail (%)	79.02±0.37	79.17±0.27	78.58±0.6	0.20	0.82	78.39±0.36	79.32±0.25	0.55	0.46
Ash in head (%)	1.56±0.06	1.51±0.04	1.28±0.06	4.48	***0.013***	1.5±0.05	1.49±0.04	0.61	0.44
As in abdomen (%)	1.33±0.05	1.32±0.04	1.09±0.05	5.01	***0.008***	1.16±0.04	1.35±0.04	2.60	0.11
Ash in tail (%)	1.35±0.04	1.32±0.03	1.17±0.09	2.88	***0.05***	1.31±0.04	1.31±0.03	0.17	0.68

4.3 Price variations:

It has been found that the price of tilapia varies according to different phenotypic traits. The survey has reported that the producers would like to demand the highest money for the large-reddish-oval tilapia rather than the others (figure 14). Similarly, sellers asked the highest prices for the large-reddish-oval tilapia than the other types (figure 15).

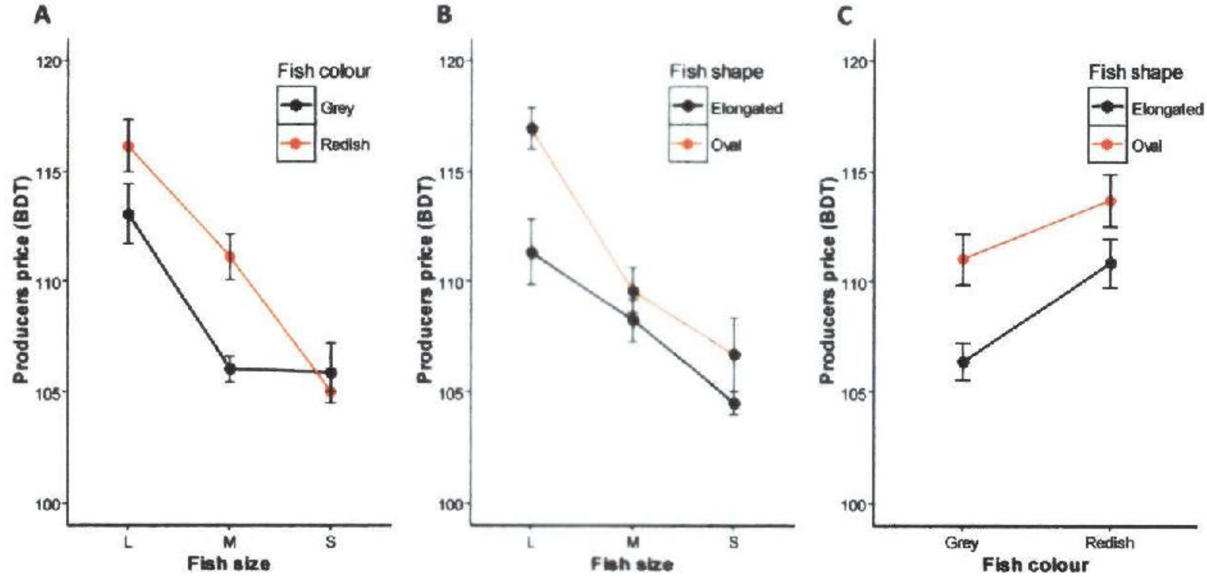

Figure 14: Variation in producers selling prices of tilapia (mean±SE) based on their body size, shape, color and their interactions.

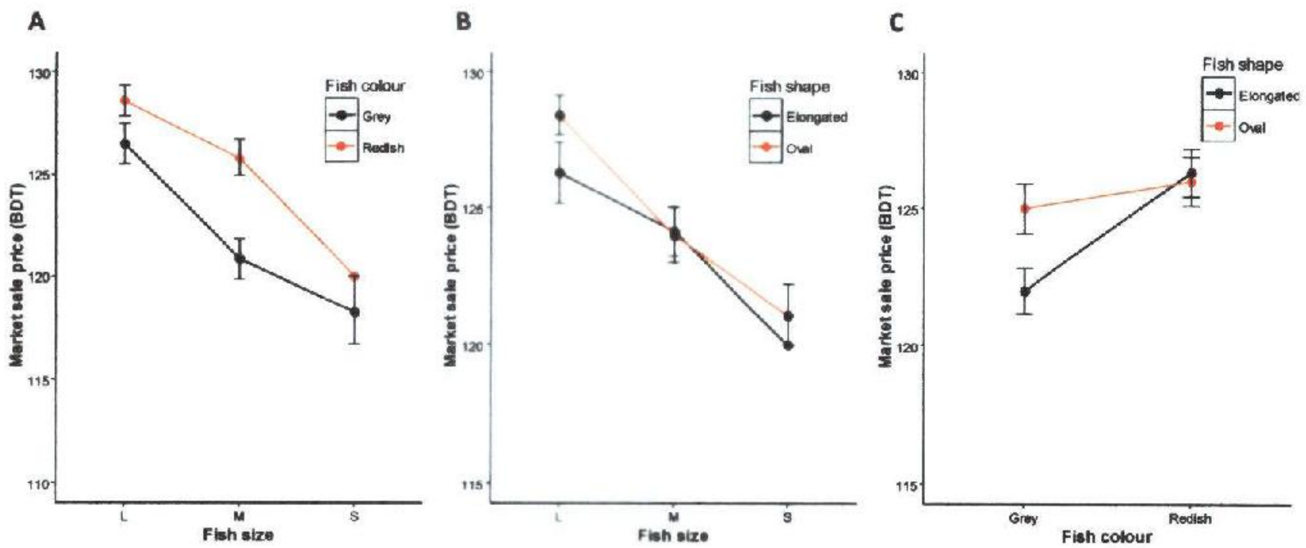

Figure 15: Variation in fish market sale prices of tilapia (mean±SE) based on their body size, shape, color and their interactions

4.4 Proximate composition analyses:

It has been found some significant differences in protein, lipid, moisture and ash contents of various parts of different tilapia (table 2). The percentage of protein content in head region has varied significantly according to fish color and size (figure 16) and also the variation of this between elongated and oval fish is nearly significant (F=3.39, P=0.06). Like protein, lipid content in head region does not differ significantly according to body color (F=2.16, P=0.14), whereas it is highly significantly variable between elongated and oval fish, and also among fish sizes (figure 17).

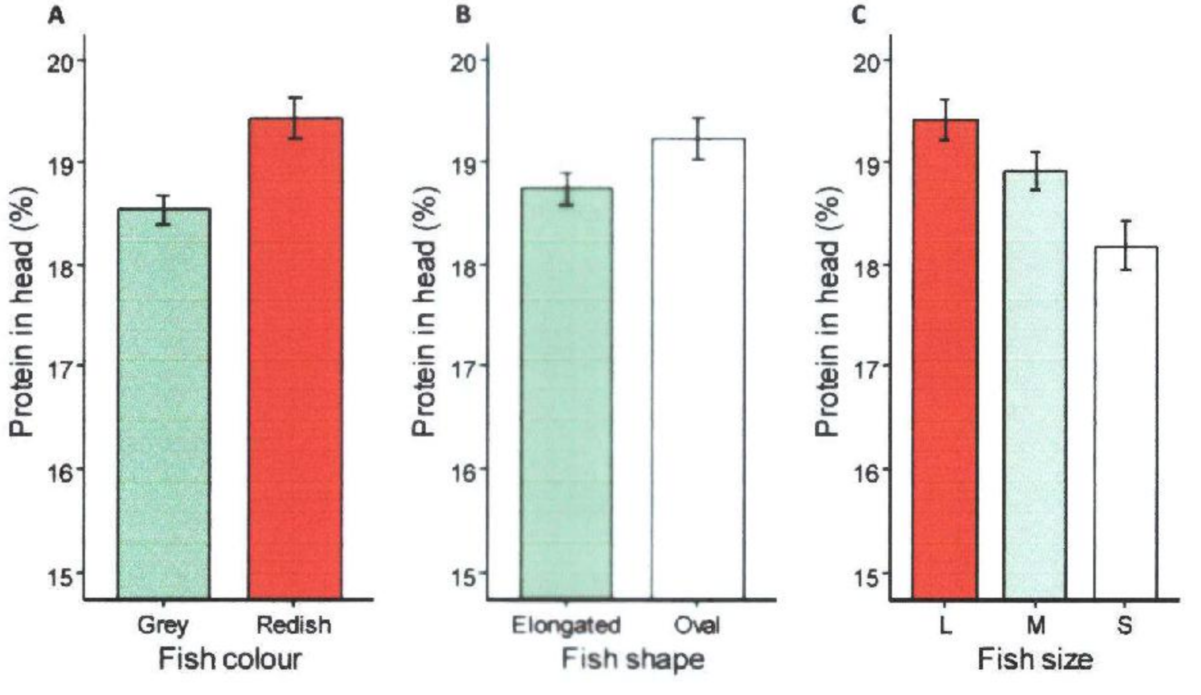

Figure 16: Percentage of protein content in head (mean±SE) according to (A) body color, (B) shape and (C) size

It is also remarkable that lipid contents are significantly different in head, abdomen and tail regions based on fish shape where in all body parts, oval-shaped tilapia contain significantly higher amount of lipid than the elongated one (table 2 and figure 20).

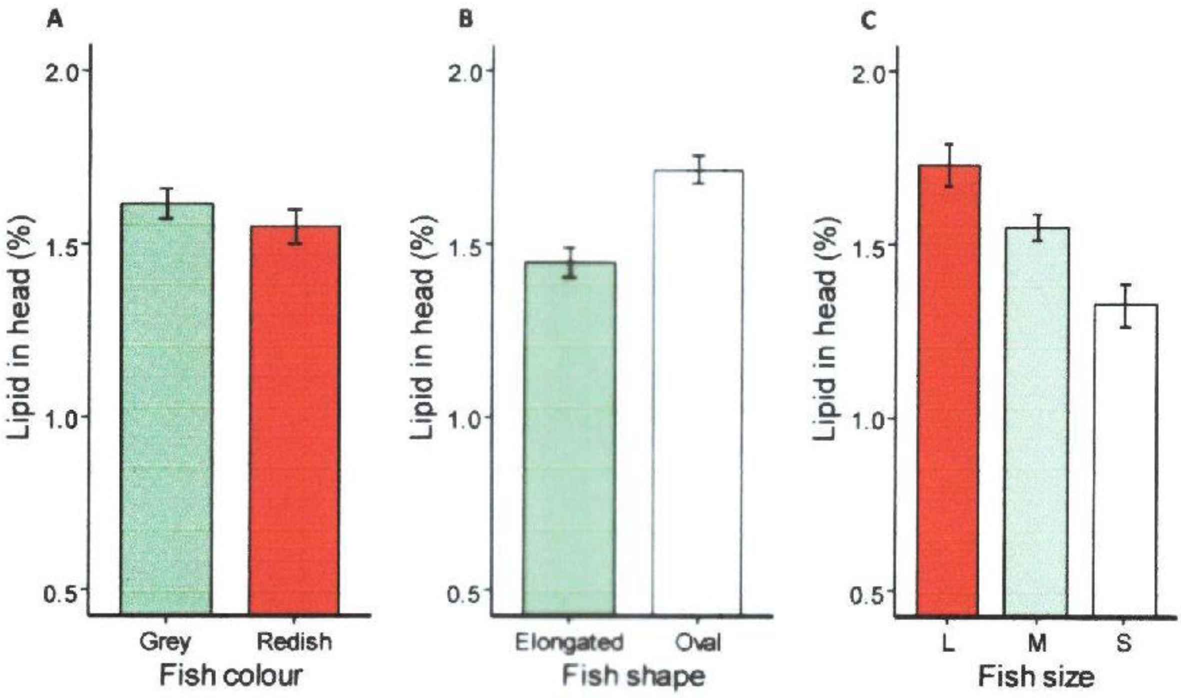

Figure 17: Percentage of lipid content in head (mean±SE) according to (A) body color, (B) shape and (C) size

The study has revealed that percentages of moisture content in head, abdomen and tails regions are significantly different according to fish color, i.e. in all parts of the body, reddish colored tilapia have significantly higher amount of moisture than the grey ones (figure 18). There was no significant variation in moisture content found according to fish shape and size (table 2).

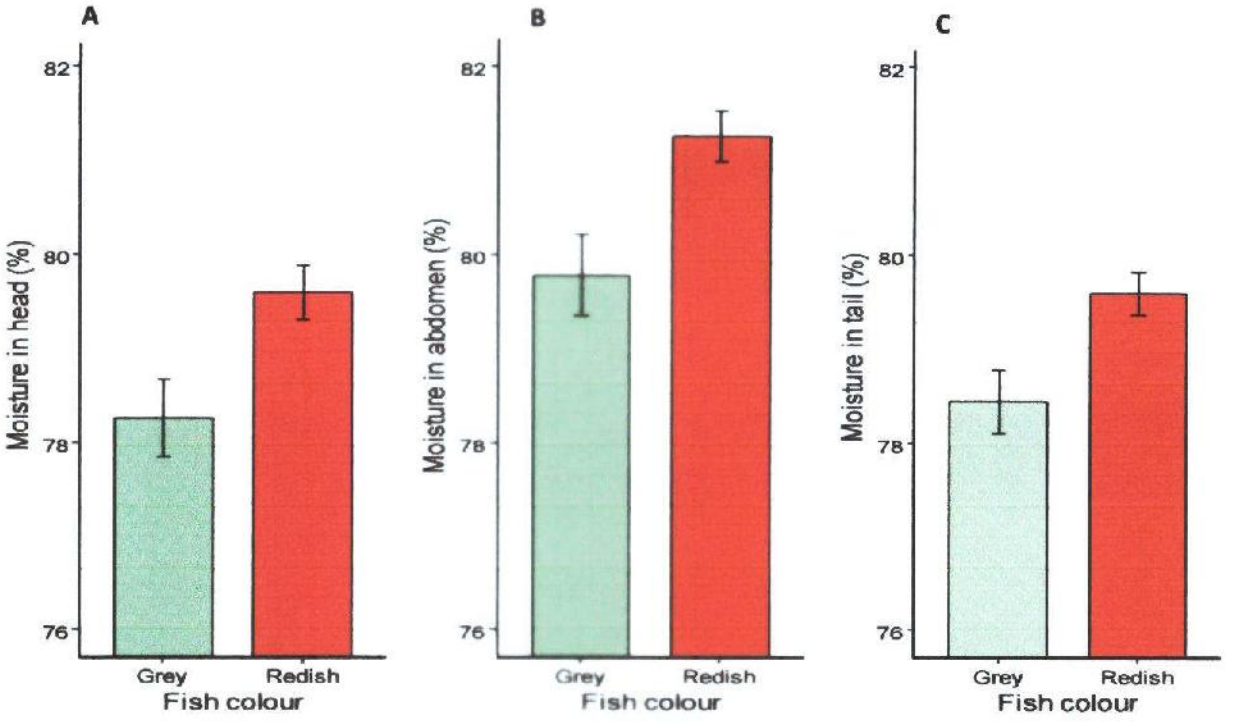

Figure 18: Percentage of moisture content (mean±SE) in (A) head, (B) abdomen and (C) tail regions according to body color.

In case of ash content, the percentages were significantly higher in abdomen region according to fish color, shape and size (figure 19). It has also been recorded that the ash contents were significantly variable in different parts of the body depending on fish size (table 2 and figure 22).

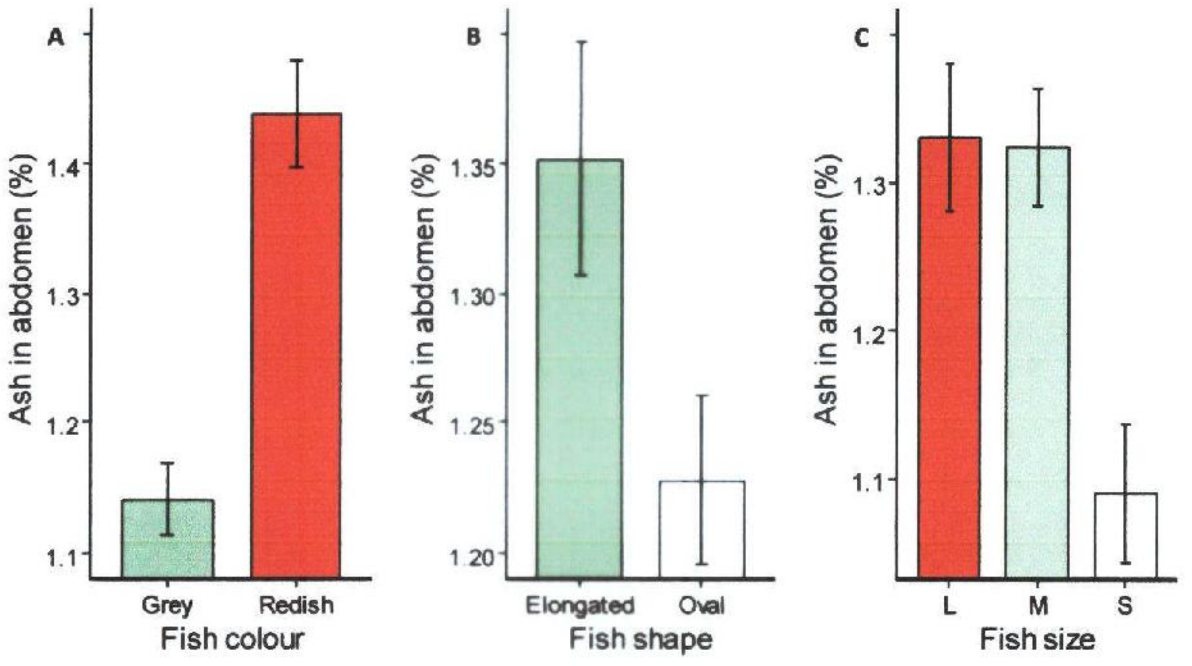

Figure 19: Percentage of ash content in abdomen (mean±SE) according to (A) body color, (B) shape and (C) size

It is noticeable that the color and shape of fish depend on fish size (figure 23), where medium sized tilapia group has higher number of reddish and oval shaped fish than larger and smaller groups, while smaller sized group has the lowest number of reddish as well as oval tilapia. Therefore, most of the people may prefer to buy not only the reddish-oval shaped tilapia, but also the bigger ones. But it is confirmed from the findings of this study that not only the bigger tilapia but also the smaller ones possess reddish and grayish body color, and also different shapes which prove that these are completely different tilapia which have different body colors and shapes even though they are same and/or different in sizes and reproductive stages (table 2 and figure 23).

CHAPTER FIVE

Discussion

Chapter 5

5.0 Discussion

The major objectives of the present study were to identify which kinds of tilapia people may prefer to produce, sell and eat, and also to determine whether the proximate compositions of different tilapia may vary because of their different phenotypes. Finally, the study correlated whether the public perceptions (fish phenotypic traits) have any link with the proximate composition of these fish.

5.1 People's perceptions

This study has shown that most of producers, sellers and consumers preferred reddish colored tilapia (figure 10) and similar kind of results was found from a study of Githukia *et al.,* (2014) who revealed that people made their choice for wild reddish tilapia than farmed reddish tilapia fish.

The present study has also revealed that most of the participants rated the reddish-oval tilapia highest, then they preferred grey-oval tilapia (table 1 and figure 12). The study has reported that producers demanded highest for large reddish oval tilapia than others similarly sellers seek higher price for reddish oval shaped tilapia due to people's choice and consumer choice this types due to its ornamental coloration. So, demand and price of reddish-oval shaped tilapia is comparatively higher than the other ones. In consistent with Githukia *et al.,* (2014) who observed that the people's perception and consumer preferences to consume wild and cultured reddish tilapia were affected by nutritional value, quality of the fish, size, color, taste, appearance and smell of the fish. Ahmed *et al.,* (2011) studied the determinants of fresh fish purchasing behavior among Malaysian consumers and found that 68.6% of the respondents reported price to be the most important factor, 67.8% indicated quality of fish, 44.1% alluded to taste while 41.6% agreed that nutritional value is the most important factors when purchasing fish. A further 38.4% indicated availability as a reason affecting purchasing of fresh fish while ease of preparation and/or cooking and the color of fish were not very important factors when considering purchasing fresh fish. Elsewhere, Quagrainie *et al.* (2008) reported that 80% of the respondents specified that appearance of fish was very important. Price and size were also indicated as important and somewhat important respectively while the origin of fish was the least important factor to the consumers.

Since only a very few studies were carried out to investigate the public perceptions about fish quality (Pohar, 2011, Lofster, R., & Schlang, A.K.,2010), the present study has been conducted to explore more details about this issue that will provide information to our farmers about which specific kind of tilapia has a very high market demand comparing with other types.

5.2 Proximate composition

As proteins, lipid, moisture and ash contents were the major constituents (Adeniyi *et al.*, 2012), the present study has considered these components in evaluating the nutritional value of studied tilapia.

It has been observed from the present study that the percentage of protein content in head region was varied significantly according to fish color and size (figure 16) and no significant variation has been observed between elongated and oval shaped tilapia fish. The present study was lined with Santos *et al.* (2012) who reported that protein content showed no change with the growth of the fish and was similar between strains. Muchiri *et al.* (2015) also observed that the protein content of different anatomical parts of the tilapia (head, middle and tail) showed no significant difference. There was no significant difference in protein content of the fish fed on different diets (Muchiri *et al.*, 2015). Lupatsch *et al.*, (2001) studied gilthead bream *(Spaurus aurata),* and reported that the protein level remained basically constant ranging from 15.7% to 19% with the growth of the fish which was line with present study. The protein content of many species of fish increases slowly or remains more or less stable with the increase in body weight (Ramseyer, 2002). Heinsbroek *et al.*, (2007) found an opposite result from present study and observed that decrease in protein content with increase the size of eel *Anguilla anguilla.*

The lipid contents were significantly different in head, abdomen and tail regions based on fish shape where in all body parts, oval-shaped tilapia contain significantly higher amount of lipid than the elongated one (table 2 and figure 20). In consistent with Muchiri *et al.* (2015) who observed the significant variation of lipid content in different anatomical parts when compare to wild and farmed tilapia. They also reported that the head had significantly higher lipid content than the middle and tail portions.

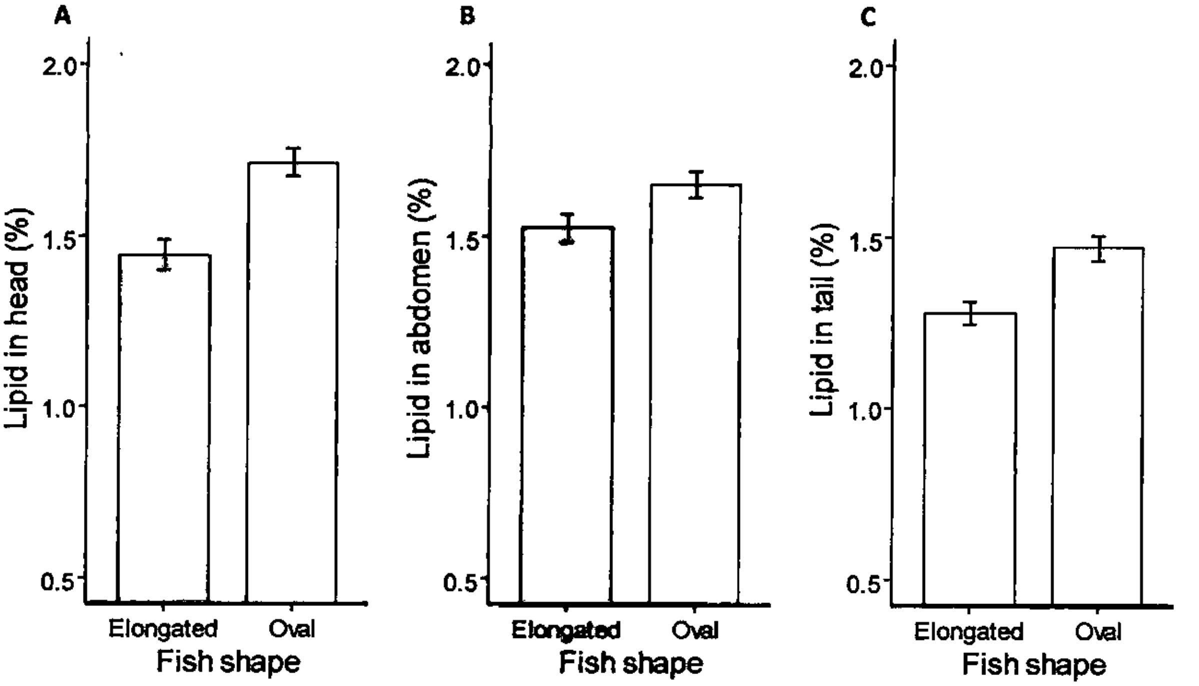

Figure 20: Percentage of lipid content (mean±SE) in (A) head, (B) abdomen and (C) tail regions according to body shape

The egg bearing tilapia showed significantly higher lipid content than non-egg bearing tilapia when compare to different body parts (figure 21). This indicates that the fishes are better sources of lipid in the body just before spawning. According to Huss (1995), lipid content is seasonal and is highest in fish just before spawning which is line with present study. The lipid content in fish tends to increase with age, decline during the winter, migration and spawning and reach its maximum value at the end of the primary feeding period of the year (Santos *et al.*, 2012). Genetic origin is another factor that affects lipid content (Fauconneau *et al.*, 1991). Oliver (2002) reported that the type of feed significantly affected the lipid content and fatty acids profile but not the overall proximate composition for the other constituents of sturgeon flesh.

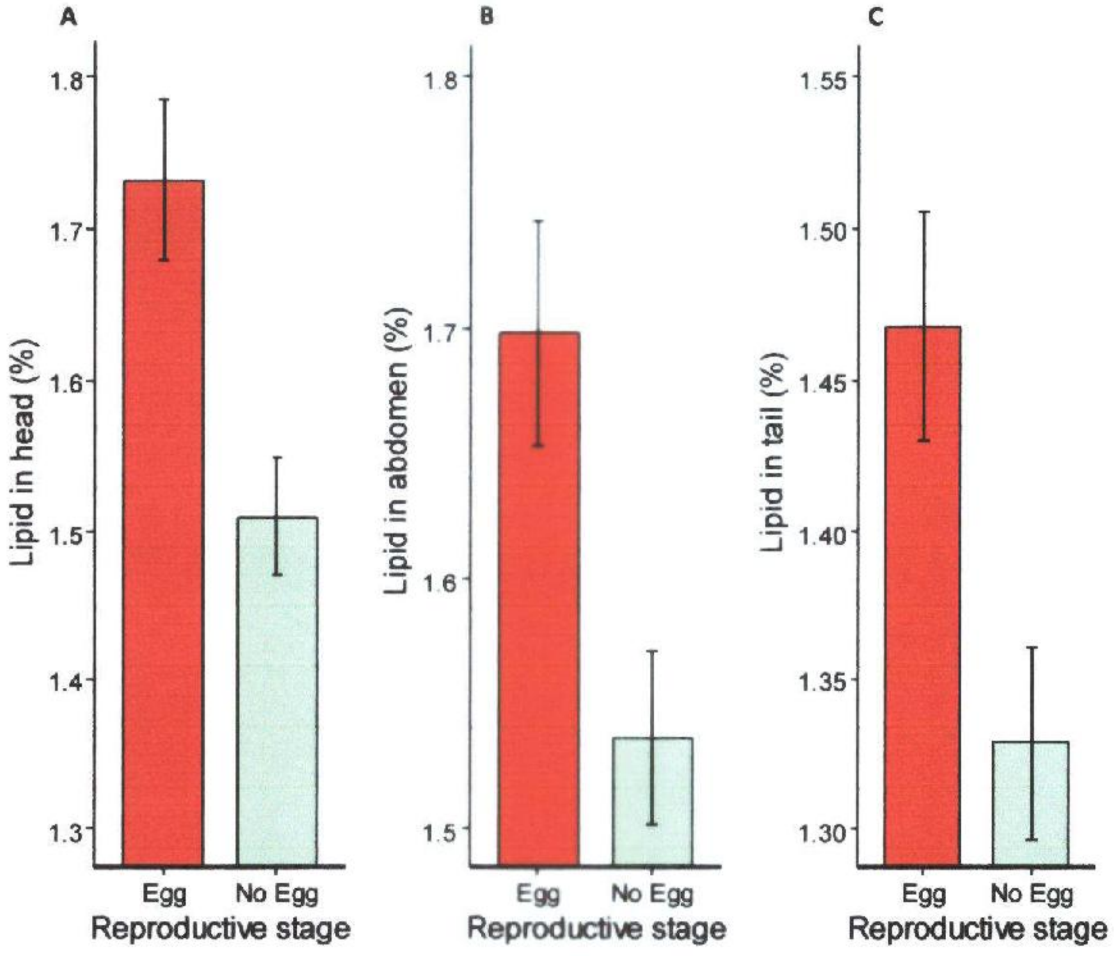

Figure 21: Percentage of lipid content (mean±SE) in (A) head, (B) abdomen and (C) tail regions according to reproductive stage of studied tilapia.

The present study has revealed that percentages of moisture content in head, abdomen and tails regions are significantly different according to fish color, i.e. in all parts of the body, reddish colored tilapia have significantly higher amount of moisture than the grey ones (figure 18). According to Muchiri *et al.* (2015) who observed the moisture content of different anatomical parts of the tilapia showed significant difference which was line with present study. They reported that the middle portion had higher moisture content (78.36 ± 0.24) than the tail portion (76.82 ± 0.22).They also reported that there was no significant difference in moisture content of the fish fed on different diets (Muchiri *et al.*, 2015). Furthermore, in the present study there was no significant variation in moisture content found according to fish shape and size (table 2). Conversely, Santos *et al.* (2012) reported that, the moisture content of different size of tilapia showed significant difference. There was an inverse relationship between moisture content and the size of different types of tilapia fish (Santos *et al.* 2012). The high moisture content is a disadvantage in that it increases the fish's susceptibility to microbial spoilage, oxidative degradation of polyunsaturated fatty acids and consequently decreases in the quality of the fishes for longer preservation time (Omolara & Omotayo, 2008).

Wide variation of ash content was observed in head, abdomen and tail regions. There was a significant difference in ash content in different size of the fishes with different parts of the body (figure 22). In consistent with Santos *et al.* (2012) observed the difference in the percentage of ash content between Thai and commercial strains of tilapia. They reported that, the fish in the 15-20cm class also had higher percentage of ashes than fish in the 5-10cm class, but similar to the fish in the 10-15cm class. Conversely, Muchiri *et al.* (2015) who observed, the ash content of different anatomical parts of the tilapia showed no significant difference. They also reported that there was also no significant difference in ash content of the fish fed on different diets (Muchiri *et al.*, 2015). Olagunju *et al.* (2012) observed that the ash content in marine fish species was generally higher (Mackerel) than that of the fresh water samples (Tilapia). There was no significant difference between the values. It indicates that the species is a good source of minerals such as calcium, potassium, zinc, iron and magnesium (Olagunju *et al.*, 2012).

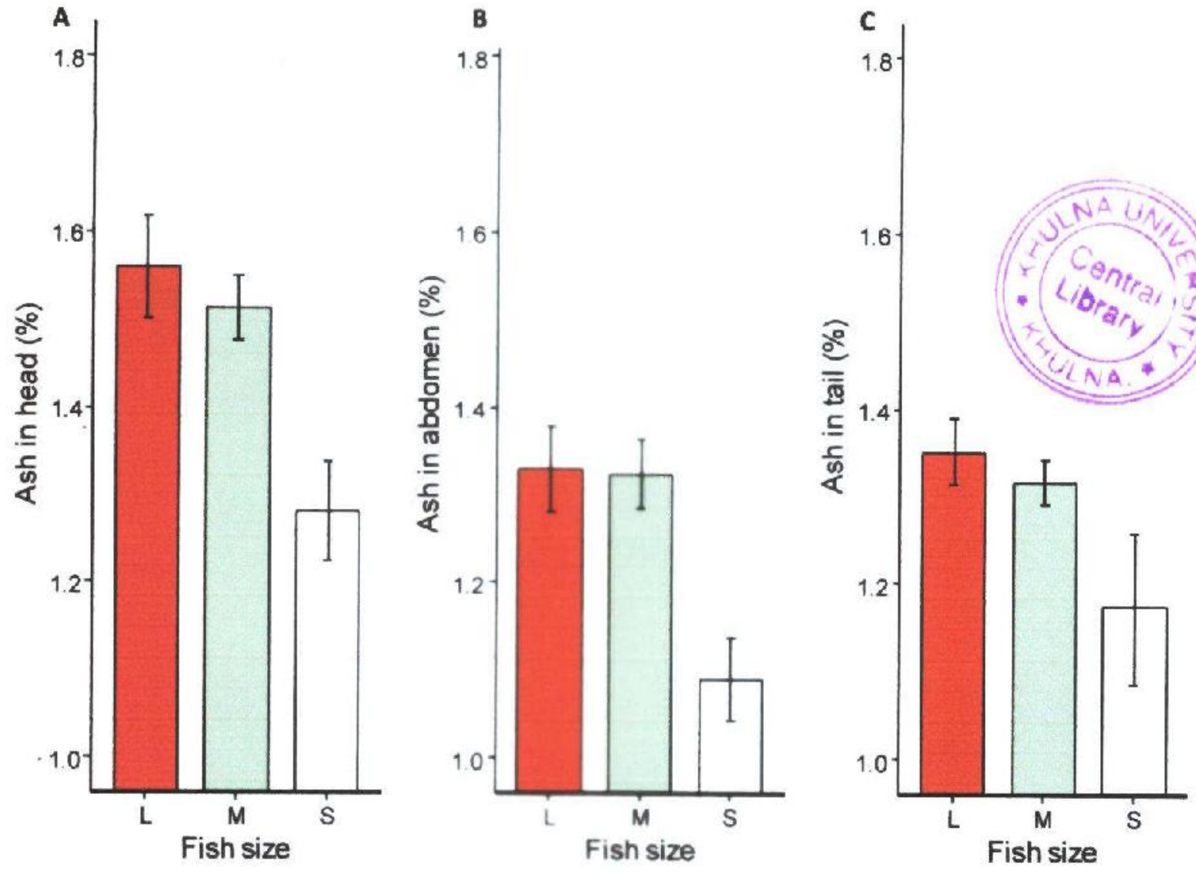

Figure 22: Percentage of ash content (mean±SE) in (A) head, (B) abdomen and (C) tail regions according to fish size (L=large, M=medium and S=small).

5.3 Relationship between public preferences and proximate composition

The findings of this study revealed that producers, sellers and consumers preferred mostly the reddish colored tilapia (figure 10 and 12) which contain significant levels of moisture in all body parts (table 2 and figure 18), high amount of ash in abdomen (table 2 and figure 19) and of course, have very high prices in all markets (table 2). Thus, people are getting high level of protein and bit higher amount of minerals by paying higher prices for these reddish tilapia.

In consistent with Githukia *et al.* (2014) who reported that the main factors influencing consumer purchasing behavior of reddish tilapia regarded as price with a median score of 92%, nutritional value at 88%, quality of fish product at 88%, health consciousness at 84% , taste of fish at 78% and processed fish (cut into pieces or fillets) at 52% .

Furthermore, the main reasons for consuming reddish tilapia by consumers were perceived for health benefits, good taste. Most consumers were aware about the health benefits of eating fish as part of their diet and stated fish consumption reduces the risk of heart diseases, increases intelligent quotient especially when taken by pregnant mothers and children, and has low fat content (Githukia *et al.* 2014). These consumer perceptions are consistent with findings of Nauman *et al.*, (1995) conducted in Malaysia where 44% of respondents consumed fish for health and nutrition reasons while 57% stated that taste was one of the major factors that influenced their decision to consume fish. Oomen *et al.*, (2000) also reported frequent consumption of fish, especially those with Omega-3 fatty acid which is reported to lower coronary heart diseases and stroke.

However, consumer's dislike of its 'mud taste' and health concerns among certain consumers who felt that cultured fish were produced with chemicals like growth hormones (e.g. 17 alpha Methyl testosterone) and pesticides.

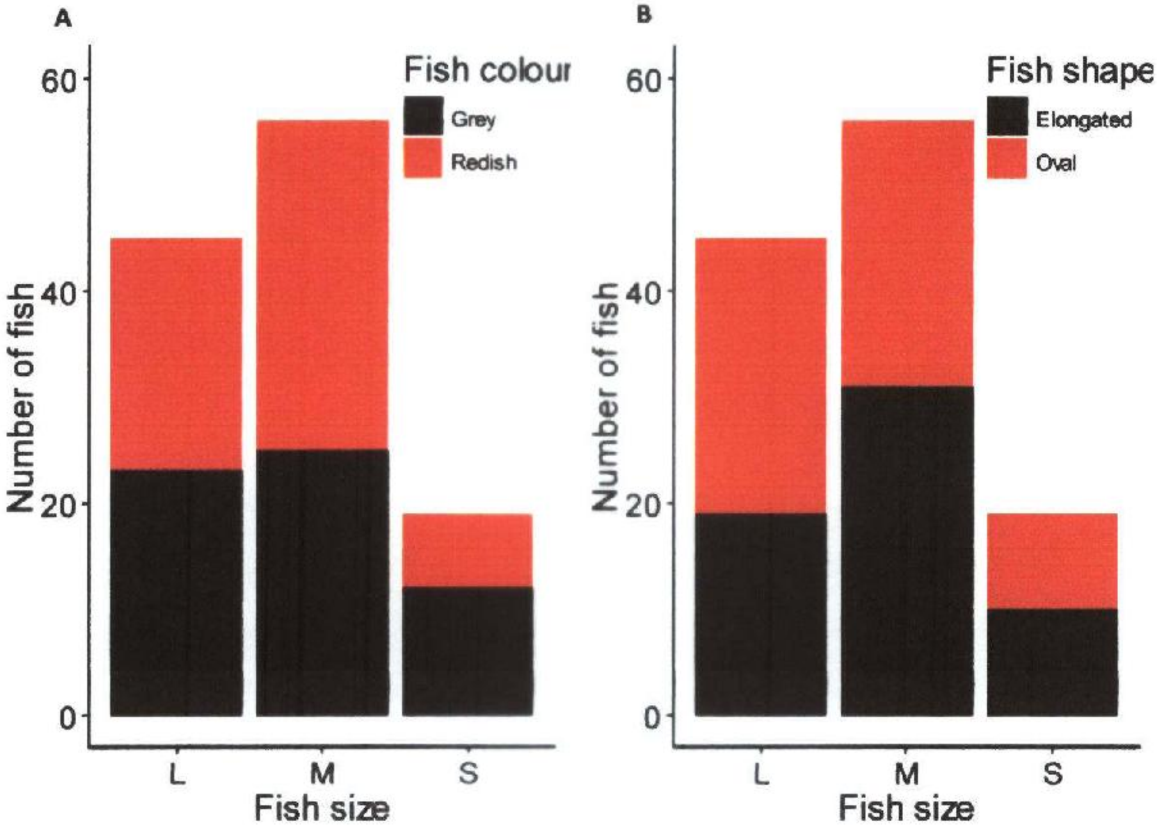

Figure 23: Number and size of studied fish according to (A) fish color and (B) fish shape (L=large, M= medium and S= small).

CHAPTER SIX

CONCLUSION

Chapter 6

6.0 Conclusion

Fish are very important sources of animal protein in diets for human beings. Freshwater and marine fish supply protein equivalent to other animal meat, but relatively low in fat content. Regular consumption of fish is therefore recommended for elderly and people with hypercholesterolemia and coronary heart disease (Oomen *et al.*, 2000). However, in Bangladesh, freshwater fish is costly and poor people are unable to get them and therefore, they are suffering from malnutrition and various chronic diseases (FAO, 2010).

The present study was undertaken to determine the nutritive value of tilapia fishes those are available in the local market. From the study it is clear that people usually prefer reddish-oval tilapia than other color and shape. Though it is colorful and attractive on desire. Mostly public perception on consumption depends upon choice i.e. color, size, shape of tilapia and their purchasing capacity. Taste of tilapia more or less similar for different coloration, size, shape etc. Producers demand highest for large reddish oval tilapia than others similarly sellers seek higher price for reddish oval shaped tilapia due to people's choice and consumer choice this type due to its ornamental coloration. So, demand and price of reddish-oval shaped tilapia is comparatively higher than the other ones.

People like oval shaped, reddish color and bigger tilapia. Reddish & grey color different species. Oval & elongated different species. People like reddish and oval shaped because they contain significant amount of proximate composition (protein, lipid, moisture and ash level high)Further research needed to investigate taste panel, fatty acid profile.

CHAPTER SEVEN

RECOMMENDATION

Chapter 7

Recommendation:

1 Tilapia is the first grown, easy culture able and short time crop comparatively other fishes. It is available in nearby market and compare the price variation, for local consumption peoples can easily mitigate their nutritive demand.

2 From the analysis it is clear that nutritive value on reddish-oval shaped tilapia contain higher protein and moisture content comparatively than other ones.

3 Tilapia culture is a possible solution for communities who live in places where food is scarce. Tilapia can provide these communities with a source of healthy, protein-rich food that can be produced by and for those who need this food most.

This study clearly indicates that the proximate values obtained would be useful to help the consumers in choosing fish based on their nutritional values besides providing an update to food composition database.

7

CHAPTER EIGHT

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Chapter 8

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Cecilia Muthoni Githukia*1, Kevin O. Obiero2, Julius O. Manyala3, Charles C. Ngugi4, Kwamena K.Quagrainie5. Consumer Perceptions and Preferences of Wild and Farmed Nile Tilapia (*Oreochromis niloticus* L.) and African Catfish (*Clarias gariepinus* Burchell 1822) in Urban Centres in Kenya

CHAPTER NINE

PICTURE GALLARY

Chapter 9

Picture Gallery

Picture-1 Tilapia Strain

Picture-2: Tilapia Nursery and pond

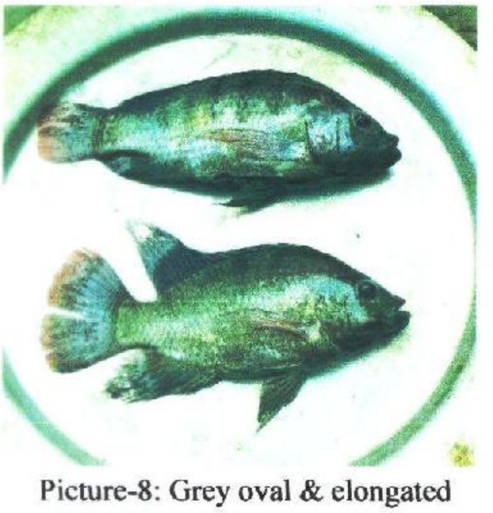
Picture-3: Tilapia Floating Feed

Picture-4: Tilapia Harvesting

Picture-5: Grey Tilapia

Picture-6: Tilapia Weighting

Picture-7: Reddish oval & elongated



Picture-8: Grey oval & elongated


Picture-9: Peoples interview on perception


Picture-10: Tilapia processed for cooking


Picture-11: Nutrition lab work


Picture-12: Nutrition lab work

CHAPTER TEN

Appendix

CHAPTER TEN

Appendix

Appendix-1

Investigation of people's perception and proximate composition of tilapia.

Fish Buyer/Consumer information (High/ Mid-level)

1. Name of entrepreneur:
2. Address:
3. Everyday which types fishes you have purchased:
4. How many times tilapia purchased for a week:
5. What pieces/kg you have sold:
6. Daily consumption for your family:
7. Do you know about types of tilapia:
8. Buyers interest on which type of tilapia (*Nilotica /Mossambicus*):
9. Level of buyers and types of tilapia

Level	Reddish tilapia			Grey tilapia			Quantity		
	Large	Medium	Small	Large	Medium	Small	Large	Medium	Small
Large									
Medium									
Small									

10. Size & Price of types of tilapia

Size	Reddish tilapia				Grey tilapia			
	Oval		Elongated		Oval		Elongated	
	Pieces	Taka/kg	Pieces	Taka/kg	Pieces	Taka/kg	Pieces	Taka/kg
Large								
Medium								
Small								

11. Which is priority based on price (Size, Shape, color...........)
12. What types of tilapia regular purchased from market:
13. Whose tilapia price and weight is high and your chosen:
14. Why buyer/consumer choice this types of tilapia:
15. Choice of cooking (Curry & Fry,):
16. What is your opinion for problems of tilapia marketing:
17. How this issue should be solved:
18. What is your suggestion to improve the conditions of tilapia market:
19. Which fishes buyer/consumer demand is high (Live, frozen , died):
20. Consumer choice(Curry & Fry):
21. Is there any different smell/taste depends on size, shape, types, curry & fry of tilapia:

Appendix-2

Investigation of people's perception and proximate composition of tilapia.

<u>Fish Producer/Farmers information</u>

1. Name of Farmers:
2. Address:
3. How many years involved for fish cultivation:
4. Why you were motivated on tilapia culture:
5. Do you know about types of tilapia:
6. What is the stocking density of tilapia strain/ 33 decimal area:
7. Every year which types of tilapia you have mainly cultured:
8. Why you have choice to culture this types of tilapia:
9. What hatchery is the source and price of tilapia strains:
10. Why you have choice Mono sex tilapia(Factors) culture:
11. Have you practiced on tilapia nursery system:
12. Which types of feed and feed quantity during nursery and grow out stage:
    A) Nursery:
    B) Grow out:
13. What types of feed & kgs and times you have used daily:
14. Are there any strain color difference between nursery and grow out stage:
15. How many times you have taken for 1st partial harvesting;
16. How many times you have taken for culture period:
17. What shape of tilapia you have preferred(Oval/elongated):why:
18. Your choice/observation about what color of tilapia culture feasible:
19. Which is priority based on culture (Shape, color...........)
20. Whose tilapia price and weight is high:
21. Why farmers choice this types of tilapia:
22. What is the problems of tilapia marketing and consuming :
23. How this issue should be solved, your suggestions:
24. What is your suggestion to improve the conditions of tilapia market:
25. Which fishes demand high (Live, frozen , died):