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Characterisation of production, marketing and consumption patterns of farmed tilapia in the Nile Delta of Egypt

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ABSTRACT

Egypt has one of the world's largest aquaculture sectors which makes a significant contribution to income, employment creation and food security. However, there are very limited data available on the farmed tilapia value chain. The aim of this study therefore was to characterise production, marketing and consumption patterns of farmed tilapia in the Nile Delta of Egypt. A cross sectional study was conducted to collect data from tilapia producers (100), transporters (32), retailers (100), fish fry shops (20) and households (300) in three case study communities (fish producing, peri-urban and rural community). We conducted structured questionnaire interviews and participatory assessments for producers and consumers. Focus group discussions with mothers were also held to collect data for the availability, sources and consumption patterns of tilapia.

Results showed that, more than half of producers were small scale, having a farm size of 10 feddan or less (1 feddan = 4200 m^2). The main water supply for almost all farms was agricultural drain water, a potential source of contamination with chemical and biological hazards. The main production constraints were reported to be feed prices, water quality and availability, land rent, fuel and energy sources and environmental conditions. The farmed tilapia value chain was short with some value added in the form of marketing fresh and live fish as well as selling tilapia in fried or grilled form. The majority of produced tilapia was transported to retail sale and sold to consumers as fresh, while only a small proportion was processed by cleaning, grilling or frying. A lack of hygiene during transportation and marketing of farmed tilapia was found that could be potential sources for post-harvesting contamination. The availability and frequency of tilapia consumption were higher in the community in the production areas than in other communities. In non-producing areas, tilapia may be available in the market once a week during the village market day. Potential areas for further research in order to improve safety, quality and production of farmed tilapia were identified.

Introduction

Animal source foods (ASF) provide important sources of energy, micro and macro nutrients but are commonly associated with foodborne diseases. Livestock and fish value chains support the livelihoods of millions of rural and urban poor, for whom they can act as pathways out of poverty (ILRI, 2011). For more than 30% of the world population particularly in developing countries, fish and other aquatic products provide at least 20% of protein intake (Béné et al., 2007). In the poorest countries of Africa and South Asia, small-scale fisheries are considered critical for food security, as they supply more than 50% of the protein and minerals for over 400 million people (Richardson et al., 2011). Fisheries and aquaculture also provide direct jobs for more than 36 million people worldwide (98% of them in developing countries), and indirect jobs for about half a billion people (Richardson et al., 2011).

Egypt is the largest aquaculture producer in Africa and the 8th largest globally; in 2011 the aquaculture production was about 986,820 tonnes (FAO, 2013). According to the General Authority for Fisheries Resource Development (GAFRD) the aquaculture sector makes a significant contribution to income, employment

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creation and food security (Macfadyen et al., 2012). It is also a rapidly growing sector: fish consumption in Egypt rose from 8.5 kg to 15.4 kg/person/year between 1996 and 2008 (Macfadyen et al., 2012). A recent value chain analysis of the industry revealed that the farmed fish value chain in Egypt is mainly based on the production of tilapia with mullet the second most important species on private fish farms. Other species of fish such as carp and catfish are farmed in small quantities (Macfadyen et al., 2012).

To the authors' knowledge there are no data available that characterise the farmed tilapia value chain in Egypt. While available studies focus mainly on the financial performance of the farmed fish marketing and a few on the farmed fish sector in general, none of these studies evaluated the practices and perceptions of all value chain actors, including consumers (Norman-López and Bjørndal, 2009; Macfadyen et al., 2012, 2011; Kleih et al., 2013; El-Naggar et al., 2006). There is a need for research to understand the state of current tilapia production, marketing and consumption patterns as a basis to inform measures that ensure the availability and safety of tilapia. The aim of this study therefore was to characterise production, marketing and consumption patterns of farmed tilapia in the Nile Delta of Egypt. The objectives were to (1) characterise the production system of farmed tilapia and to identify production constraints, (2) describe harvesting, transportation and marketing of farmed tilapia in order to identify factors influencing its availability and safety, (3) determine the frequency of consumption of tilapia in different case study communities, and (4) to identify data gaps and areas for further research. The information obtained is useful to monitor the farmed tilapia production chain from production to consumption, identify critical control points and finally to suggest avenues to overcome production, quality and safety constraints along the chain.

Materials and methods

Overview

For the purpose of this study, questionnaire surveys were conducted among producers, transporters, retailers and households in the Nile Delta in Egypt. For producers, transporters and retailers a direct observation checklist was used. In addition, participatory rural assessments (PRA) for producers were conducted mainly to identify perceived tilapia production constraints in the study area. Moreover, PRAs or Participatory Urban Appraisals (PUAs) were held with consumers and focus group discussions (FGD) with mothers with children under five years of age to collect data for the availability, sources and consumption patterns of tilapia. The PRAs/PUAs and FGDs were held at health care centres during child vaccination days. For all surveys, questionnaires and checklists were developed in English and later translated to Arabic by two independent Egyptian native Arabic speakers for accuracy. The research objectives were fully explained to them before translation to make sure that they were familiar with these objectives. The interview protocols and questionnaires were discussed and explained to the enumerators. The interview team comprised six men (four veterinarians and two local people) and two women health visitors. The fieldwork was supervised by the first author. Questionnaires were pilot tested and changes were made where things were unclear and could be misunderstood by survey participants. In addition to questionnaires, enumerators were asked to register their observations of the environment in observation checklists and take photos when possible. All instruments are available upon request from the corresponding author. This study was conducted from October 2012 to May 2013 in order to cover both the production and marketing seasons.

Study sites

The target area for producers was Kafrelsheikh governorate, as this is the main fish producing area in Egypt with about 324,479 tonnes (55% of the national farmed fish production) and a total tilapia production of 259,583 tonnes (44% of the national farmed tilapia production) (Macfadyen et al., 2011). For consumption surveys, three case study sites were identified based on demographic characteristics and proximity to fish-farming areas. Purposive sampling was used to be able to compare non-tilapia producing and tilapia producing areas as well as urban and rural areas. The following communities were included: Community A, village in Kafrelsheikh governorate (close proximity to fish-farming areas), Community B, urban/peri-urban area in Gharbia governorate and Community C, village in Monofya governorate (geographically removed from fish-farming area), Fig. 1. Fish retailers and street vendors were interviewed also in these communities. Fish transporters and wholesalers were interviewed at the main wholesale fish market in Kafrelsheikh, *Alborsah*.

Surveys and questionnaires

Producers

In the absence of a database for all fish farms in Egypt, a list of fish farms in Kafrelsheikh governorate was compiled through government records of licensed farms and records of fines administered to farms without licenses. These lists were compiled and stratified into farms of different sizes, namely <5 feddan[1] (278), 5–10 feddan (194) and >10 feddan (287). The sample size was calculated to estimate the frequency of certain binary fish farm characteristics; 50% was chosen as an estimate of prevalence which was likely to apply to characteristics of interest (e.g. use of poultry manure in fish farms, use of commercial feed and other characteristics) with a 95% confidence interval and 10% precision, which resulted in a sample size of 97 farms. Farms were selected randomly from each group in numbers proportional to the percentage of farms in each group. Contact details for each farm were obtained from the government records, fish associations and/or fish feed factories. Visits were scheduled with the owner, manager, or a worker who was authorised to talk to the enumerators. Upon visiting fish farms, structured interviews were conducted to collect data about different production parameters, production inputs and outputs, farm management, water management and producers perception towards the quality and safety of farmed tilapia. Producers were also asked about the inspection or supervision of their production process by the government or any other organisation. In addition to questionnaires, four PRAs were conducted. For each PRA, enumerators with support from local key persons such as large scale farmers and feed producers invited a group of 10–15 producers to participate in the study. Participants were randomly selected from the list of the fish farms visited and key informants, including hatchery owners and feed factory owners. During the meeting, the aims and objectives of the PRA were described by the facilitators and informed oral consent was obtained from each participant. Different tools were used for collecting data, namely data show projector, seasonal calendar, chapatti diagrams, flow charts and problem opportunity matrix. Notes were taken by one of the facilitators in addition to audio-recording and photos. After the meeting, one person synthesised the notes, audio-records and the photos into a summary document. The PRA discussions mainly focussed on production constraints and producers' suggestions to overcome these constraints.

[1] Feddan is a unit of area used in Egypt and some other Arab countries, 1 feddan = 0.42 ha = 1.038 acres = 4200 m^2.

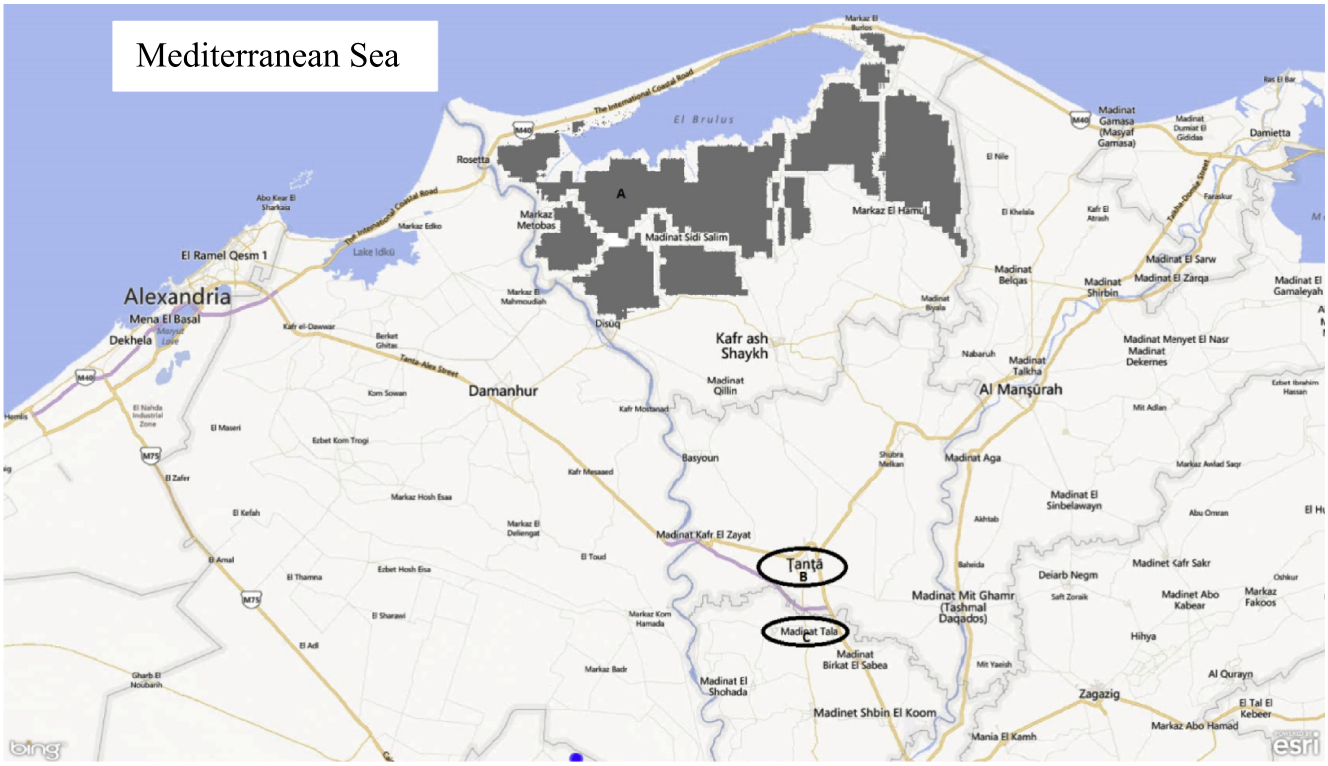

Fig. 1. Study sites: ■Areas with fish farms in Kafrelsheikh governorate, Community A, village in Kafrelsheikh governorate, Community B, Urban/peri-urban area in Gharbia governorate and Community C, village in Monofya governorate.

Transporters and retailers

Based on interviews of producers, the most convenient place to interview transporters moving tilapia was close to the wholesale market in Kafrelsheikh. Due to the lack of a sampling frame, it was decided to interview all transporters that were there at the time of the visit. Structured interviews with 32 transporters were conducted to collect data and direct observation using a checklist was also carried out. The target fish retailers and fish fry shops[2] were those serving the consumers in the study area; they were traced from consumers interviewed. Structured interviews were conducted with 20 wholesalers, 56 retailers, 24 street vendors and 20 fish fry shops to collect data about sources of tilapia, amount of tilapia sold per day, methods of transporting and keeping tilapia, frequency of cleaning and disinfection of utensils and different processing methods that may take place at retail level.

Consumers

Each community in the three selected study areas consists of approximately 2000 households (HH). The sample size was calculated using an expected prevalence of consuming tilapia (50%), 95% CI and 10% precision, which resulted in a sample size of 92 HH. From each community 100 households were selected by systematic random sampling using a sampling interval for each village that was calculated by dividing the number of HHs by the required sample size. PRAs/PUAs and FGD with mothers were also conducted to collect data on the availability, sources and consumption patterns of tilapia. The PRAs/PUAs and FGDs were held at health care centres during child vaccination days. Participants were invited for a meeting, the aims and objectives were clarified by the facilitators, after that informed oral consent was obtained from each participant. Different tools were used for collecting data, including a data show projector, seasonal calendars, chapatti diagrams, flow charts and problem opportunity matrix. Notes were taken by one of the facilitators in addition to audio-recording and photos. After the meeting, one person synthesised the notes, audio-records and the photos into a summary document.

Ethical approval

The present study received approval from the Ethics and Welfare Committee of the Royal Veterinary College, London, UK (reference number URN 2012 1191) and IREC clearance from ILRI which covers all countries in AU-IBAR. Oral informed consent was obtained from each study participant after reading the written consent form. The interviewers confirmed the participants' oral consent by ticking the relevant boxes on the hardcopies. The consent form mainly explained about the purpose of the study, the risks and benefits of participation in the study, conditions of confidentiality and the right to refusal or withdrawal from the study.

Data management and analysis

Data collected from the different surveys were translated back to English by the first author. Data from PRAs/PUAs were summarised. Quantitative data were entered into an electronic web-based data base and Microsoft Office Access 2007. Data were then extracted into Microsoft Office Excel 2007 for analysis. Statistical analyses were conducted to allow comparison between different study sites using IBM SPSS Statistics for Windows, Version 20.0. Armonk, NY: IBM Corp. A univariate ordinal logistic regression model, with frequency of consumption of tilapia as the response variable and community A as a reference was used for comparing the consumption patterns of tilapia in different communities. A univariate binary logistic regression model, with yes/no outcomes as responses after excluding "Don't know" and community A as a reference was used for comparing knowledge, attitude and

[2] Fish fry shops are those shops selling cooked and/or processed fish.

Table 1
Summary of demographic information for study participants for production, marketing and consumption of tilapia in the Nile Delta, Egypt.

Survey	Age/year				Sex (%)		Level of education (%)				
	Min	Max	Mean	SD	Male	Female	1	2	3	4	5
Producers	17	70	40	12.4	100	0.0	50	3.0	40	3.0	4.0
Transports	22	60	38	11	100	0.0	21	21	15.6	40.6	1.8
Retailers	18	60	38	9.6	62	38	40	11	18	23	8.0
Fry shops	19	50	36	7.0	65	35	50	5.0	5.0	40	0.0
Consumers A	24	77	45.8	11.2	86	14	17	1.0	3.0	53	26
Consumers B	23	90	40.7	12.5	92	8.0	18	4.0	5.0	59	14
Consumers C	25	70	47.7	10	91	9.0	22	1.0	9.0	46	22

1 = None, 2 = Primary, 3 = Middle school, 4 = Secondary, 5 = University, A = within the fish-farming area, B = peri-urban area away from the fish production, C = rural area away from fish production site.

practices (KAP) of consumers in different communities. Fisher's Exact test was used for the statistical analysis of other responses.

Results

In this study, 100 producers, 32 transporters, 100 retailers, 20 fish fry shops and 300 HHs were interviewed. The demographic data for all surveys are summarised in Table 1. In addition to questionnaire interviews and direct observation using checklists, four PRAs for producers, four PRAs/PUAs for consumers and four FGDs with mothers were conducted. The total number of participants in the producers' PRAs ranged from eight to 20, with no female participants. The total number of participants in the consumer PRAs/PUAs ranged from 14 to 17, with female participants dominating in all groups (the proportion of women was 64–86%). The number of women participating in the FGDs ranged from 8 to 12.

Characteristics of farmed tilapia production

Out of the 100 producers interviewed 69%, 30% and 1% were owners, workers and managers, respectively. Characteristics of farmed tilapia production are summarised in Table 2. The mean area of fish farms was 14.57 feddan (min 1.5, max 85, standard deviation-SD-14.96) and the mean quantity of branded fish feed used was five tonnes/feddan/cycle (min 2, max 10, SD 1.92). More than 90% of producers reported to buy branded fish feed from local fish feed companies and almost all farms reported using sinking feed. The size of the feed processing plants was indicated to range from small to large scale. More than 60% of producers reported that they stored fish feed for a short period of time (from 2 to 30 days) and all producers distributed fish feed in the ponds manually without wearing protective gloves. The main water supply for most fish farms (77%) was agriculture drainage canals, which contain water that has been used for agricultural activities. A minority of producers used water from clean agricultural irrigation canals and very few used ground water. Most producers (76%) stated that good quality water should be greenish, clear and not turbid. A few producers had water tested for ammonia, nitrate and nitrite by private veterinarians in private laboratories when there was a health problem in fish such as high mortality rate with unknown cause. None of the producers reported regular testing to monitor the water quality.

The average amount of tilapia production was 3.2 tonne/feddan/cycle (Table 3). The time of harvesting depended mainly on the working hours of the wholesale market. However, most producers stated that they harvest their fish at night and/or early morning. The commonly used method of harvesting was draining water from ponds then catching tilapia using nets. In almost all farms water was pumped into draining canals that could be a water source for other fish farms downstream. The mean transportation time from farm to the wholesale market was 1.4 h (min 1, max 3, SD 0.9).

Table 2
Summary of the key characteristics for farmed tilapia production in Kafrelsheikh governorate, Egypt.

Survey question	% of producers
Fish farm with land area of 10 feddan[a] or less	60
Fish farm with land area >10–30 feddan	30
Fish farm with land area >30 feddan	10
Have one production cycle per year	94
Own fish hatchery	30
Keep cattle, buffalo, sheep, goat, donkeys, poultry and/or dogs at the fish farm	70
Have other fish farms nearby or adjacent to their site	97
Have agricultural land nearby the fish farms	4.0
Use branded fish feed	94
Use un-branded fish feed	4.0
Use home-made fish feed	5.0
Use poultry manure for fish	60
Treat poultry manure before its use	5.0
Use rice or wheat wastes as fish feed	15
Use other crop wastes as fish feed	7.0
Use bakery wastes and expired pasta as fish feed	5.0
Use fertilizers for fish farms	13
Use veterinary/chemical inputs on fish farm	30
Use antibiotics	66.7
Use growth promoters	16.7
Use probiotics	13.3
Use potassium permanganate	3.3
Buy veterinary/chemical inputs from private veterinarians	73.3
Buy veterinary/chemical inputs from pharmacies	20
Buy veterinary/chemical inputs from local shops	6.7
Change water in the fish ponds on a daily basis	95
Test water quality in the fish farm	10
Do not mix fish from different ponds during harvesting	90
Discard dead fish during sorting and grading after fishing	68
Sell tilapia through the wholesale market	100
Sell tilapia to traders/transporters	9.0
Sell tilapia to retailers	6.0
Sell tilapia directly to consumers	0.0
Transport tilapia in plastic boxes with ice	66
Transport tilapia in refrigerated trucks	24
Transport tilapia in plastic drums with an oxygen supply	6.0

[a] 1 Feddan = 0.42 ha = 1.038 acres = 4200 m^2.

Table 3
Grade and volume of farmed tilapia production in Kafrelsheikh governorate, Egypt.

Amount of production (tonne/feddan[a]/cycle)	Grade I[b]	Grade II[c]	Grade III[d]	Total
Minimum	0.5	0.2	0.1	1.4
Maximum	4.0	2.0	2.0	6.0
Mean	1.65	0.86	0.69	3.20
SD	0.64	0.43	0.35	0.84

[a] 1 Feddan = 0.42 ha = 1.038 acres = 4200 m^2.
[b] Grade I <3 fish/kg.
[c] Grade II from 3 to 5 fish/kg.
[d] Grade III > 5 fish/kg.

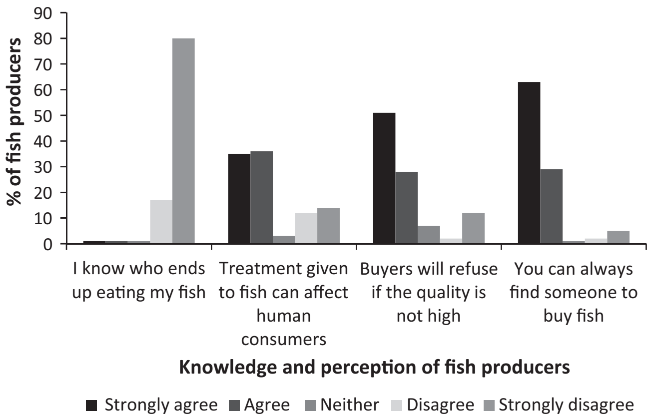

Fig. 2. Producers' perceptions towards the safety and quality of farmed tilapia and consumer behaviour in Kafrelsheikh governorate, Egypt.

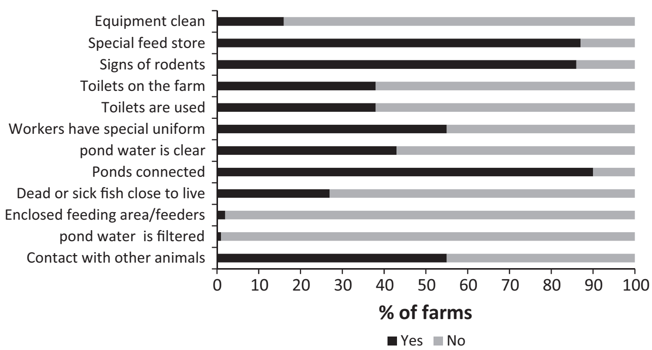

Fig. 3. Enumerators' observations of tilapia farms (biosecurity, workers and storage conditions) in Kafrelsheikh governorate, Egypt.

Producers' perceptions regarding the safety and quality of farmed tilapia and consumer behaviour are summarised in Fig. 2. Most respondents (80%) strongly disagreed with the statement that they know who ends up eating their fish, 35% strongly agreed that treatments given to tilapia may affect consumers' health and 50% strongly agreed that buyers would not buy tilapia if the quality was not high. All respondents stated that there was no inspection or supervision of the production process from either the government or the private sector. Enumerators' observations of fish farms' biosecurity, workers conditions and storage conditions are summarised in Fig. 3. In 55% of farms domestic animals had access to the ponds and there was no filtration of water in almost all fish farms. In more than 90% of farms, ponds were connected together, there was a feed store, and signs of rodents were observed.

Participatory rural assessments for producers

The aim of the PRA with producers was to collect information about the tilapia production cycle and the main constraints to tilapia production. The production cycle was described as usually starting in March/early April with either fingerlings or newly hatched tilapia from hatcheries (own or private). About 70–90% of producers start the production cycle with fingerlings (10–15 g body weight) and about 10–30% start with newly hatched fish (1–2 g body weight). Also farmers who have small tilapia (not of marketable weight) carried over from the previous season start feeding these. The number of tilapia fingerlings stocked per feddan is usually close to 10,000. Some farmers operate polyculture systems and stock 2000–5000 mullet fingerlings per feddan and/or other fish species in the same pond with tilapia. They continue feeding and harvesting until the end of October/early November. From late November/early December until end of February/early March, there is a decrease in tilapia production as tilapia stop feeding during winter and also the access to farms becomes difficult. About two thirds or more of producers have one production cycle per year and one third or less may have three cycles over a period of two years. The mortality rate was estimated at 10–15%, mainly due to diseases and cold stress. Harvested fish was sold without any value addition at the wholesale market. Fish consumption usually increases close to Easter and summer vacations and during the month of Ramadan and is low close to the Eid Al-Adha holiday, due to increased availability of meat from sacrifices. Producers reported that, some farmers arrange the harvesting time to be around these occasions. This practice has an influence on the prices of fish that could be sometimes negative, e.g. when there is too much fish offered in the market.

Size, weight, fattiness, gill colour, odour and firmness were considered indicators of tilapia quality and safety. Producers said they were very concerned about the quality and safety of tilapia as they receive higher prices for higher quality and safer tilapia. From the producers' point of view, the main factors affecting tilapia quality were water quality, source (locality) and the frequency of changing water in the ponds. Bad quality water would result in a poor food conversion ratio as well as stress on fish. In order to improve fish quality, they frequently changed the water and in some areas ground water was used. Farmers would like changes to the current legislation so they could have access to clean irrigation water for their fish farms. Feed quality was also identified as affecting fish quality; producers stated the protein content should not be less than 25%. The high price of fish feed and lack of cash sometimes forced producers to use low quality feed and other materials such as wheat flour mill, rice mill wastes, bakery wastes and out of date pasta for feeding tilapia. In one of the producer PRAs, participants stated that they buy small sized tilapia and use it as a substitute for fish meal after grinding assuming that it is cheaper than fish meal. Producers reported that diseases do not affect fish quality, as they usually remove diseased fish or those with lesions from the ponds and give these away. The weather conditions, especially in winter, may reduce the quantity of produced fish as it is difficult to access farms and tilapia normally stop feeding due to low water temperature. Although consumers prefer to purchase fish from the market during summer, producers believed the quality of fish harvested in the cold weather may be better as fish may have large amounts of feed in the stomach during hot weather. To address this issue, producers stop feeding before harvesting so that fish have empty stomachs or fish at night or early morning and add ice to fish boxes and transport to the wholesale market as soon as possible. Production constraints identified by producers and potential solutions they recommend are listed in Table 4. The major constraints were fish feed prices, water availability and quality, and the land rent for fish farms.

Farmed tilapia transportations

Fish transporters (32) were interviewed close to the wholesale fish market in Kafrelsheikh. The mean amount of fish transported per load was about three tonnes (min 1, max 13, SD 2.6). The median number of loads per day was one (min 1, max 3, SD 0.6). Transporters work from four to seven days per week and more than 70% of them transport fish all year. About 37% of transporters check the quality (size, colour and odour) of fish before transporting although 90% did not know if the fish supplier had a licence or not. Fish is usually transported in plastic boxes of 20–25 kg capacity with ice (62.5%) or in water tanks with oxygen supply for live fish (37.5%). Most transporters (75%) usually do not mix fish from different farms. The destinations of fish were traders/wholesalers (75%), retailers (22%) and restaurants (3%). The mean

Table 4
The main production constraints for farmed tilapia identified by participatory rural assessments (PRA) producers in Kafrelsheikh governorate, Egypt.

Constraints	Description	Suggestions
Feed prices	Considered as one of the most important constraints, producers complain that feed prices are continuously increasing, while fish prices are stable and sometimes decrease due to the large quantities of production	Government feed factories should be established with high production capacity. The government should facilitate loans with no interest until the end of the production cycle
Marketing	Producers stated that, the media sometimes play a negative role by reporting that farmed tilapia is contaminated and may contain public health hazards. This increases consumers' worries about farmed tilapia and makes them prefer wild tilapia and/or frozen imported other fish species with a perception that they are safer than farmed fish. Absence or lack of control on imported frozen fish that enters the markets and is sold as if it is fresh fish at a low price. The lack of export possibilities was another marketing constraint	Campaigns to build consumer awareness on the quality and safety of farmed fish Market legislations should be implemented
Fish diseases	Producers said they were not aware of specific fish diseases apart from some non-specific symptoms after fish were exposed to stress especially in winter; there can be a high mortality rate after very cold nights	Research towards genetic selection of resistant strains of tilapia. Also Best Management Practices (BMP) training programs
Water sources and quality	The main water supply for most fish farms is the agricultural drainage canals and lakes which can be heavily polluted with fertilizers and pesticide residues. Also the water flow depends on agricultural activities so it varies through the year. In farms close to the coastal zone at some times of the year the water level in the drainage canals can become lower than the sea allowing high salinity water to enter fish farms	Producers would like changes to the legislation so they can use clean irrigation water for fish farms
Land rent	The rent of the land is increasing yearly, and this together with high prices of fish feed decreases the profits	The government should reduce the rent and facilitate the payment for producers
Environmental conditions	Especially during winter season, heavy rainfall together with unpaved roads may make it impossible to access fish farms	The main roads for accessing farms should be paved
Mono-sex hormones	Hormones used for the production of mono-sex tilapia are sometimes of low quality and/or adulterated. Producers also complain about the high prices of hormones	The government should produce these hormones and control prices and quality
Knowledge and awareness	Lack of knowledge and awareness of producers of new fish-farming methods and the best management practices can be a constraint	Training programs should be implemented by government fish authorities in the region and/or by the university
Fuel	Fuel shortages and high price, particularly in the last two years for their tractors, water pumps and other vehicles	Alternative sources of energy such as electricity and/or solar energy should be explored

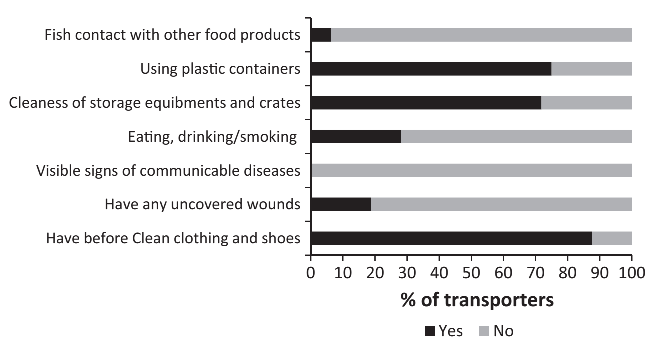

Fig. 4. Enumerators' observations of fish transporters and their equipment in Kafrelsheikh governorate, Egypt.

transportation time to different destinations in the country was estimated at 3.6 h (min 1, max 24, SD 4.3). Most transporters cleaned crates daily (68%), with fewer cleaning weekly (15.6%) or infrequently (15.5%). About 56% of traders used disinfectants for cleaning crates and equipment. Interviewers' observations for fish transporters are summarised in Fig. 4. Most transporters (87.5%) had clean clothing and shoes, 75% used plastic containers and more than 70% had clean storage equipment.

Farmed tilapia marketing

Of the 100 retailers interviewed, 85% were owners of the retailing business and 15% were workers (Table 1). The grade and volume of tilapia sold per day varied according to the type of retailer (Table 5). Only one respondent said there was inspection of fish by an official veterinarian, who usually took samples, but did not give feedback to the retailer. Most retailers buy tilapia from the wholesale market in Kafrelsheikh while a few said they sometimes have tilapia from their own farms and/or other farms (Fig. 5). More than 70% did not know if their fish supplier was licenced or not. A high proportion (62%) check the quality of fish before buying by examining the general appearance, colour, odour, stomach fullness and thickness of back muscles. They usually transport tilapia in plastic boxes with ice (87%), without ice (11%) or in water tanks with oxygen supply for live fish (2%). Most retailers (79%) clean their crates and other storage equipment on a daily basis. However, only 9% used disinfectants (Fig. 6). Most retailers (87%) sold fish directly to consumers (Fig. 7). About 30% cooked fish for their consumers, either by grilling (66.7%) or frying (33.3%). Interviewers' observations for retailers are summarised in Fig. 8. About 50% of retailers had a permanent structure, a source of electricity, access to running water, a concrete floor, separate rubbish bins and clean cloths. More than 50% used plastic storage containers.

Table 5
Grade and volume of tilapia sold per day for different types of retailers in the Nile Delta, Egypt.

Type of business	Mean volume (kg) of fish sold per day			
	Grade I[a]	Grade II[b]	Grade III[c]	Total
Wholesalers	1500	1650	1300	4450
Market sellers	44	51	47	142
Street vendors	18	42	44	104

[a] Grade I less than 3 fish/kg.
[b] Grade II from 3 to 5 fish/kg.
[c] Grade III >5 fish/kg.

Other than retailers, 20 fish fry shops were visited, in which 15 owners and five workers were interviewed (Table 1). The mean

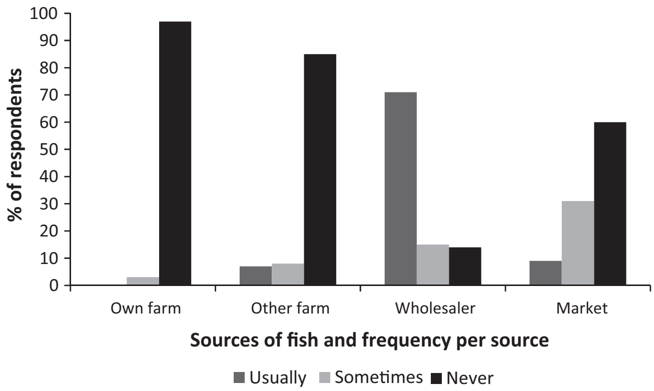

Fig. 5. Sources and frequency of farmed tilapia for retailers in the Nile Delta, Egypt.

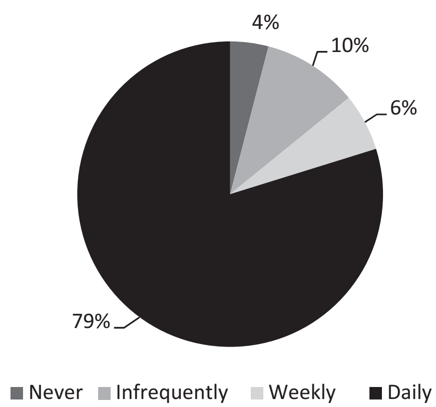

Fig. 6. Frequency of cleaning crates and/or storage equipment by fish retailers in the Nile Delta, Egypt.

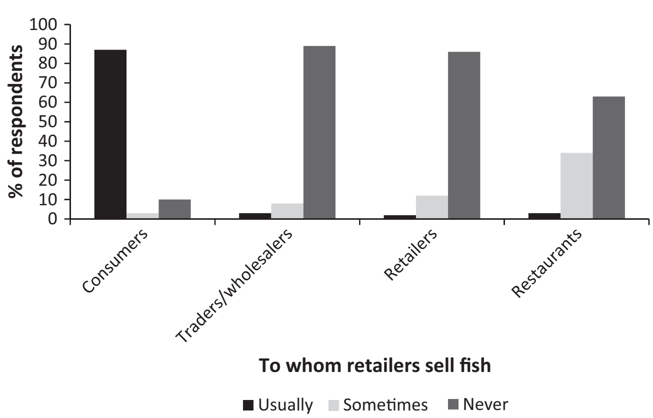

Fig. 7. Farmed tilapia customers and frequency for retailers in the Nile Delta, Egypt.

amount of tilapia sold per fry shop per day was 47 kg (Table 6). All respondents stated that there was no inspection of tilapia and that they usually buy it from wholesale markets, mainly from Kafrelsheikh and they did not know if the supplier was licenced or not. About 30% check the quality of tilapia (colour, odour, and size) before buying, 40% transported tilapia in refrigerated trucks and 65% keep it on ice during transportation. All respondents clean fish crates and storage equipment daily and 85% use disinfectants. The mean transportation time from retail to the fry shops was about 3.5 h (min 1, max 5, SD 0.94). Tilapia was usually kept on ice during the day (75% of respondents) and usually sold the same day; those

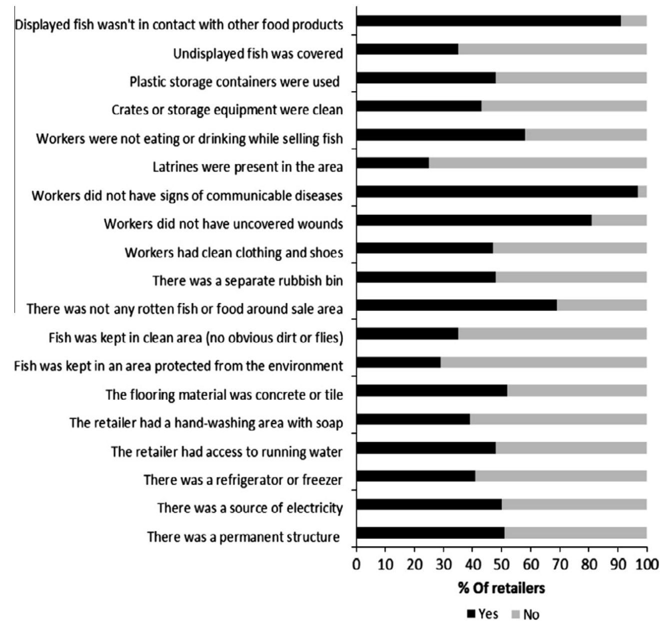

Fig. 8. Enumerators' observations of fish retailers (facilities, workers/retailers conditions and storage conditions) in the Nile Delta, Egypt.

Table 6
Grade and volume of tilapia sold per day in fish fry shops in the Nile Delta, Egypt.

Amount of tilapia (kg/day)	Grade I[a]	Grade II[b]	Grade III[c]	Total
Minimum	10	10	5.0	25
Maximum	30	50	40	120
Mean	13	19	14	47
SD	4.9	10.4	9.6	22.1

[a] Grade I less than 3 fish/kg.
[b] Grade II from 3 to 5 fish/kg.
[c] Grade III >5 fish/kg.

who have tilapia leftover for the next day kept it overnight in refrigerators. All respondents usually cleaned surfaces where fish was placed once a day using tap water (90%) or water from water tanks (10%). Respondents reported to use bar soap (80%), detergents (20%), disinfectants (65%) and only water (20%) for cleaning surfaces. Regarding the hygiene of fish fry shops, 90% had a hand washing area, 40% reported to wash hands after using the toilet, and 60% to wash hands regularly during the day. About 50% used the same knives and boards when preparing different foods at the same time. All respondents always sold tilapia directly to consumers and the most commonly used preparing methods were frying for 10–25 min or grilling for 15–20 min. Interviewers' observations (Fig. 9) showed that about 90% have a permanent structure, a source of electricity, access to running water and separate rubbish bins. Almost all fish fry shops had a hand washing area, clean clothes and clean equipment.

Consumption patterns of tilapia

Three hundred HHs were visited in the three different case study communities; characteristics of participants are summarised in Table 1. The mean number of inhabitants per HH was 5.0, 4.1 and 4.2 in fish-farming, peri-urban and rural communities, respectively. A high proportion of HHs (79%) in the fish-farming community were involved in the process of fish-farming and production throughout the year, either by having a fish farm, trading in fish or fish feed, working in fish markets or performing other work related to fish production. Working in fish farms and/or other

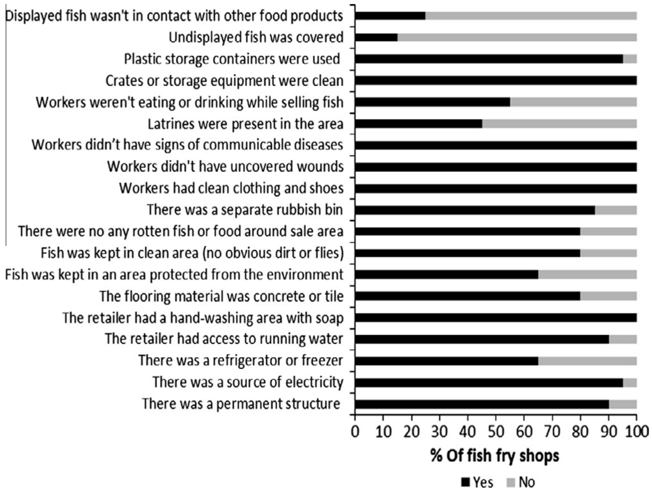

Fig. 9. Enumerators' observations for fish fry shops (facilities, workers/retailers conditions and storage conditions) in the Nile Delta, Egypt.

Table 7
Frequency of consumption and sources for purchasing tilapia in the Nile Delta, Egypt.

Survey question		% of households			P value
		A*	B**	C***	
Frequency of consuming tilapia	<Once/week	0.0	16	31	<0.0001
	Once/week	19	56	60	
	Twice/week	75	19	8.0	
	>Twice/week	3.0	1.0	0.0	
Taking the decision to buy tilapia	Joint decision	50	24	40	<0.0001
	Head of the household	28	2.0	12	
	Wife	22	74	48	
Sources for getting tilapia	Purchase	97	97	98	
	Own farm	22	0.0	1.0	
	Workplace	19	1.0	0.0	
	Gift from workplace	8.0	0.0	0.0	
	Gift from others	94	0.0	0.0	
	Fishing	2.8	0.0	0.0	
Sources of purchasing tilapia	Wholesale market	2.8	1.0	0.0	
	Retail market	100	90	95	
	Supermarket	0.0	4.0	0.0	
	Street vendor	0.0	8.0	0.0	
	Fish fry shop	0.0	5.0	25	
	Restaurant	0.0	2.0	0.0	
	Workplace	2.8	0.0	0.0	

* A, within the proximity of fish-farming area.
** B, peri-urban area away from the fish production.
*** C, rural area away from fish production site.

related activities such as trading of fish and/or fish feed, represented the only income source, major income source and same importance as other income sources for 63.3%, 25.4% and 10.1% of the HHs involved in fish production, respectively. In peri-urban and rural communities, only 1% of HHs was involved in fish industry and working in the fish value chain was not considered as the only or major source of HH income in any of the HHs.

The frequency of tilapia consumption, the person deciding to buy tilapia and sources for purchasing tilapia are summarised in Table 7. The results showed that the frequency of tilapia consumption was significantly higher in fish-farming community than in other communities (OR = 25.53; 95% CI: 13.1–49.74, $p < 0.0001$). The decision to buy tilapia was mainly by the wife and husband jointly in the fish-farming community and made by the wife in the other communities. The only source of tilapia for consumers in the peri-urban and rural communities was purchasing. In the fish-farming community, consumers could get tilapia from different sources, such as their farms, markets, gifts from their work places or from relatives, but in all communities, almost all consumers purchased tilapia from retail markets. Tilapia sold in these markets was always packaged in plastic bags unless it was cooked by the seller; in which case it was packed in aluminium foil. The consumption of tilapia grade I was significantly higher in the peri-urban community than in other communities (OR = 7.33; 95% CI: 3.57–15.06, $p < 0.0001$), Table 8. Tilapia fillet was consumed by 3% of respondents in the peri-urban community but not in other communities. Tilapia was replaced by other fish species or frozen imported fish by 49%, 85% and 94% of the respondents in fish-farming, peri-urban and rural communities, respectively. The most common reasons were the lack of availability of tilapia in the market, high price of tilapia compared with other types, especially imported frozen fish, and sometimes consumer preference. Some consumers stated other reasons such as their financial inability to buy and/or the low quality of the available tilapia. Other ASF such as chicken, meat, offal or eggs were also consumed.

Access to retailers was considered an important factor influencing the purchase of tilapia by 28%, 30% and 75% of consumers in fish-farming, peri-urban and rural communities, respectively. The degree of cleanliness of the source was considered very important by most consumers in the three communities, as shown in Table 9. The mean time for transporting tilapia home after purchase was estimated at 15, 46 and 54 min for fish-farming, peri-urban and rural communities, respectively. The mean time of keeping tilapia at home before cooking was about 0.5, 1 and 1.5 h for fish-farming, peri-urban and rural communities, respectively (Table 10). During that period tilapia was mainly kept at room temperature in fish-farming community, and refrigerated or on ice in peri-urban and rural communities. In all communities, tilapia was usually cooked on the day of purchase, otherwise it was stored in freezers.

The most commonly used methods for cooking tilapia were frying (10–25 min) and/or grilling (about 30 min). Another method "*Samak singary*" is frequently used for preparing tilapia, especially in fish-farming community, in which tilapia is dressed with onion, spices and tomato sauce with/or without other vegetables and cooked in the oven for 30–40 min. More than 90% of respondents consume tilapia with fresh salads. Almost all respondents said they wash their hands with soap and water after using the toilet, after eating and before preparing food. Eighty per cent, 72% and 88% of respondents in fish-farming, peri-urban and rural communities, respectively, use the same knives and boards when preparing tilapia and other foods at the same time. Only some respondents stated that they reuse knives and boards after washing. It was noticed by enumerators in all communities that almost all HHs have a hand-washing area with soap in the kitchen.

Consumers' KAPs are summarised in Table 11. Almost all respondents agreed that eating tilapia was good for health and was a highly nutritious food and that safety can be judged by sight and taste. About 70% of respondents in peri-urban and rural communities would buy more tilapia if it was cheaper but the quality was the same. High proportions of respondents, especially in peri-urban and rural communities believed they would eat more tilapia in the future. More than 90% of respondents in peri-urban and rural communities believed that the quality of wild caught tilapia is better than the farmed one. On the other hand, 83% of respondents in the fish-farming community disagreed.

Participatory rural assessment for consumers and FGD with mothers

The PRAs/PUAs with consumers indicated that generally ASFs such as milk, dairy products, meat, poultry and fish were available in the three communities close to the year. However, tilapia was more available and accessible in the fish-farming community than

Table 8
Patterns of tilapia purchasing according to the grade in different study sites in the Nile Delta, Egypt.

Tilapia grade	Consumers' responses (%)			Univariate binary logistic regression			
	Community	Yes	No	OR[+]	SE[+++]	*P*-value	95% CI[++]
I (<3 fish/kg)	A[*]	50	50	1.0	–	–	–
	B[**]	88	12	7.33	0.37	<0.001	3.57–15.06
	C[***]	19	81	0.24	0.32	<0.001	0.12–0.44
II (3–5 fish/kg)	A[*]	100	0.0	1.0	–	–	–
	B[**]	26	74	–	–	–	–
	C[***]	73	27	–	–	–	–
III (>5 fish/kg)	A[*]	91	9.0	1.0	–	–	–
	B[**]	5.0	95	0.005	0.58	<0.001	0.002–0.016
	C[***]	8.0	92	0.009	0.51	<0.001	0.003–0.023

[*] A, within the proximity of fish-farming area.
[**] B, peri-urban area away from the fish production.
[***] C, rural area away from fish production site.
[+] OR = Odds ratio.
[++] CI = Confidence interval.
[+++] SE = standard error.

Table 9
Factors influencing purchasing tilapia considered by consumers in the Nile Delta, Egypt.

Factors	Community	Importance (%)/community				Univariate ordinal logistic regression			
		Very important	Important	Not important	Do not know	OR[+]	S.E.[+++]	p_value	95% CI[++]
Price	A[*]	53	42	5.0	0.0	1.0	–	–	–
	B[**]	54	45	1.0	0.0	0.91	0.27	0.71	0.531–1.542
	C[***]	31	38	30	0.0	3.79	0.29	<0.0001	2.157–6.640
Trust in seller/source	A[*]	61	31	8.0	0.0	1.0	–	–	–
	B[**]	35	62	1.0	2.0	2.22	0.29	0.005	1.273–3.881
	C[***]	87	12	1.0	0.0	0.22	0.36	<0.0001	0.106–0.437
Regular availability	A[*]	3.0	64	33	0.0	1.0	–	–	–
	B[**]	60	37	2.0	1.0	0.02	0.46	<0.0001	0.006–0.038
	C[***]	16	80	3.0	1.0	0.11	0.42	<0.0001	0.048–0.245
Packaging	A[*]	0.0	6.0	94	0.0	1.0	–	–	–
	B[**]	12	61	22	5.0	0.02	0.48	<0.0001	0.007–0.044
	C[***]	17	72	10	1.0	0.0	0.49	<0.0001	0.003–0.023
Safety	A[*]	50	33	17	0.0	1.0	–	–	–
	B[**]	60	35	3.0	2.0	0.51	0.29	0.018	0.288–0.889
	C[***]	49	51	0.0	0.0	0.75	0.28	0.286	0.433–01.280
Cleanliness	A[*]	72	11	17	0.0	1.0	–	–	–
	B[**]	99	1.0	0.0	0.0	0.03	1.03	<0.0001	0.003–0.186
	C[***]	93	7.0	0.0	0.0	0.18	0.45	<0.0001	0.074–0.432
Nutritional value	A[*]	22	72	6.0	0.0	1.0	–	–	–
	B[**]	67	29	2.0	2.0	0.14	0.32	<0.0001	0.075–0.259
	C[***]	73	25	1.0	1.0	0.11	0.32	<0.0001	0.056–0.200
Storage time	A[*]	85	13	1.0	1.0	1.0	–	–	–
	B[**]	90	7.0	2.0	1.0	0.62	0.45	0.283	0.253–1.495
	C[***]	14	72	7.0	7.0	29.02	0.39	<0.0001	13.434

[*] A, within the proximity of fish-farming area.
[**] B, peri-urban area away from the fish production.
[***] C, rural area away from fish production site.
[+] OR = Odds ratio.
[++] CI = Confidence interval.
[+++] SE = standard error.

other communities. Moreover, in the peri-urban community, tilapia was available and easily bought in the nearby city whereas the rural area depended mainly on fish sellers at the village market, which was held once a week. Consumers in the three communities were aware of quality attributes. However, ranking differed by community and the presence or absence of some attributes was also different, depending on distance, and the time and method of transporting and keeping tilapia along the value chain. Consumers in all PRAs/PUAs agreed that smell, colour of tilapia and gills, firmness and degree of detached scales are the main quality attributes and they would not buy tilapia if these attributes were unsatisfactory, even if there were no other choices. However, consumers in community A rarely noticed these changes as the time between harvesting and selling was relatively short. In the three communities, tilapia was usually bought either from retailers in the village market (during the market day), fish shops in the village or in the nearby city. Most consumers asked the seller to clean, and eviscerate tilapia before taking it home for preparation. Also a high proportion of consumers asked the seller to cook it for them, either by frying or grilling. Results from FGDs indicate that, mothers in the three communities agreed that they usually start to introduce solid food to their infants at the age of four to six months. They

Table 10
Time for transporting tilapia home and method of keeping it between arrivals until cooking in the Nile Delta, Egypt.

		Community		
		A*	B**	C***
Time to transport tilapia home (min)	Min	5.0	10	5.0
	Max	30	180	240
	Mean	14.34	46.13	54.04
	Standard deviation	7.61	39.15	37.09
Time kept at home before cooking (min)	Min	5.0	15	15
	Max	180	720	360
	Mean	33.95	55.21	96.42
	Standard deviation	33.30	80.06	70.24
Method of keeping tilapia at home between purchasing until cooking (% of HH)	Room temperature	89	30	55
	Refrigerator	11	70	45
	Freezer	0.0	0.0	0.0

* A, within the proximity of fish-farming area.
** B, peri-urban area away from the fish production.
*** C, rural area away from fish production site.

begin with milk, yoghurt and/or egg yolk in small amounts. At the age of one year, they start to introduce meat, poultry and fish to the diet of children. Fish was usually consumed grilled or fried. They also believed that feeding children on ASFs will give them a balanced diet, rapid growth, a good source of minerals such as calcium and a good source of energy. It seems that there was no gender discrimination but the amount of ASFs consumed may be different with age; as for example an adult person may eat one or two tilapia per meal but a child under five may eat only a half. Mothers reported that in a few cases children may not consume some ASFs due to allergic reactions such as skin rashes, vomiting and/or diarrhoea upon milk consumption. Some mothers complained that their children refuse to eat fish due to a history of choking on fish bones.

Discussion

Although Egypt is considered the largest farmed tilapia producer in Africa and the second globally after China (FAO, 2013),

Table 11
Knowledge, attitudes and practices (KAP) of consumers regarding tilapia consumption in the Nile Delta, Egypt.

Agreement with the statements	Community	Responses (%)/community			Univariate binary logistic regression			
		Yes	No	Do not know	OR+	S.E.+++	p_value	95% CI++
Eating tilapia is good for health	A*	100	0.0	0.0	1.0	–	–	–
	B**	97	1.0	2.0	–	–	–	–
	C***	96	0.0	1.0	–	–	–	–
It is possible to get sick from eating gone off tilapia	A*	1.0	85	14	1.0	–	–	–
	B**	33	62	5.0	45.24	1.03	0.000	6.025–339.751
	C***	6.0	81	13	6.29	1.09	0.092	0.742–53.449
Tilapia is a highly nutritious food	A*	100	0.0	0.0	1.0	–	–	–
	B**	87	9.0	4.0	–	–	–	–
	C***	92	0.0	8.0	–	–	–	–
Worry more about chemicals in tilapia than germs	A*	5.0	58	37	1.0	–	–	–
	B**	29	61	10	5.52	0.52	0.001	1.999–15.215
	C***	21	17	62	13.53	0.566	0.000	4.463–41.042
Children <1 year should not eat tilapia	A*	86	8.0	6.0	1.0	–	–	–
	B**	77	13	10	0.55	0.476	0.210	0.217–1.400
	C***	44	45	11	0.09	0.426	0.000	0.039–0.210
Tilapia safety can be judged by sight and taste	A*	99	1.0	0.0	1.0	–	–	–
	B**	89	7.0	4.0	0.13	1.08	0.057	0.015–1.064
	C***	100	0.0	0.0	–	–	–	–
Would buy more tilapia if it was cheaper	A*	28	71	1.0	1.0	–	–	–
	B**	69	27	4.0	6.57	0.32	0.000	3.523–12.256
	C***	73	27	0.0	6.95	0.32	0.000	3.737–12.935
Would buy more tilapia if it was better quality	A*	19	80	1.0	1.0	–	–	–
	B**	74	21	5.0	14.84	0.36	0.000	7.394–29.772
	C***	98	1.0	1.0	412.63	1.04	0.000	54.061–3149.52
It is possible to get sick from well-cooked tilapia	A*	3.0	91	6.0	1.0	–	–	–
	B**	45	50	5.0	27.30	0.62	0.000	8.071–92.337
	C***	7.0	85	8.0	2.49	0.71	0.195	0.626–9.974
Eat poor quality fish because it is cheap	A*	6.0	93	1.0	1.0	–	–	–
	B**	54	42	4.0	19.93	0.47	0.000	7.952–49.945
	C***	33	67	0.0	7.63	0.47	0.000	3.028–19.249
Will eat more tilapia in the future	A*	63	19	18	1.0	–	–	–
	B**	85	10	4.0	2.56	0.43	0.027	1.115–5.892
	C***	83	8.0	9.0	3.13	0.45	0.012	1.287–7.609
Wild tilapia is better than farmed one	A*	10	83	7.0	1.0	–	–	–
	B**	91	6.0	1.0	125.88	0.54	0.000	43.835–361.510
	C***	95	1.0	4.0	788.50	1.06	0.000	98.842–6290.18

* A, within the proximity of fish-farming area.
** B, peri-urban area away from the fish production.
*** C, rural area away from fish production site.
+ OR = Odds ratio.
++ CI = Confidence interval.
+++ SE = standard error.

few published data are available on the tilapia value chain. This paper characterises production, marketing and consumption patterns of farmed tilapia in the Nile Delta of Egypt based on a comprehensive survey along the whole value chain. Outcomes from this study describe critical production, transport, retail and consumption practices, indicate trends and potential areas of risk and provide a basic understanding of the tilapia value chain. The findings are useful to inform the design of a quantitative food safety, nutritional security and risk assessment. In the following sections, findings from producers, retailers and consumer surveys as well as participatory assessments are discussed.

Farmed tilapia production and its constraints

More than half of producers (60%) are considered to be small scale, having a farm size of 10 feddan or less and 50% were non-educated. This could be a reason for not using new technologies of production and still using traditional methods. The average area of fish farms (14.57 feddan) was smaller than reported in other places in Egypt such as Behera (33.6 feddan) and Sharkia (38.4 feddan) governorates but larger than Fayoum (12 feddan) governorate (Nasr-Alla et al., 2012). The average amount of feed (5 tonnes/feddan/cycle) was lower than in Behera governorate (6.4 tonnes/feddan/cycle) (Nasr-Alla et al., 2012). Fish feed availability, quality and prices were major constraints for tilapia production. Producers sometimes were forced to use low quality feed or other alternatives to the expensive ingredients such as ground small size tilapia as a substitute for fishmeal with the assumption that it would be cheaper than fishmeal; however, as this contains 75% moisture, it is not actually cheaper. This practice could increase risks of transmission of fish diseases between farms as there was no heat treatment for this feed. About 60% of producers used poultry manure to fertilize fishponds which may also influence the consumption of tilapia in people's diets and their nutritional and food safety benefits and risks. The direct use of poultry manure without treatment, and the presence of excreta from other animal species on a high proportion of fish farms (which could contaminate fish ponds), are potential public health threats (Sapkota et al., 2008). Tilapia producers are looking for alternative and non-conventional feeds and would like the government to help by establishing new fish feed factories and/or giving them loans to buy feed and pay back after harvesting. Although the producers would like to rely on the government for solving production constraints, the government alone cannot solve these issues given the current economic status of the country after the 2011 revolution. There should be potential actions by all stakeholders along the chain and by other non-governmental organisations.

The average tilapia production (3.2 tonnes/feddan) was quite similar to other places in Egypt such as Sharkia and Fayoum governorates but lower than in Behera governorate (4.81); this may be due to water availability and/or quality (Macfadyen et al., 2012; Nasr-Alla et al., 2012). The main (and in some areas the only) water source for fish farms were agricultural drainage canals. The use of this water could be a potential source of pollution with heavy metals and/or pesticide residues particularly in the absence of water quality testing, connected ponds and no water filtration at the farm (Mansour and Sidky, 2002). It was found that concentration of pollutants in drainage water and fish organs was higher than the permissible limits (El-Sayed et al., 2011; Authman et al., 2013) and that the concentrations of some pesticide residues were higher in water drains than other sources (El-Kabbany et al., 2000; Mansour, 2009; Malhat and Nasr, 2013). However, results from analysis of tilapia samples from fish farms, indicated that the level of contamination of farmed tilapia from Kafrelsheikh fish farms with heavy metals and pesticides residues was below national and international maximum permissible limit (Eltholth et al., submitted for publication). This indicates that poor quality of the drainage water does not seem to make the tilapia unsafe. Access to ponds by domestic animals could be another potential source of water pollution that could affect the health and/or the quality of fish. Such pollutants can affect the growth and health of tilapia and may also impose health risks for consumers. Producers would like changes to the legislation and use clean irrigation water, however, this would be competing with the production of other crops unless used fish farm water could be redirected into the irrigation system after some process of cleaning. However, for fish farms in Kafrelsheikh, this is not possible as they are situated downstream from agricultural activities and it would be very difficult to reroute their water into agricultural zones. An alternative option would be to improve the water quality; however, potential methods to do this at reasonable cost should be investigated. The rent of the land belonging to the government was identified as another production constraint. In other studies in Egypt, the rent represents 62% of the fixed production costs (Macfadyen et al., 2012). The low productivity could also be attributed to the feed quality, amount of feed used per feddan and methods of feeding fish, manual versus automatic. Fish farm design and layout of ponds, knowledge of best management practices (BMPs) regarding feed and fish health management and low stocking density were considered as important constraints for tilapia production (Nasr-Alla et al., 2012).

Another constraint for tilapia production was the competition by the low price of imported fish and the lack of exportation. The main constraints to tilapia exports in Egypt are the absence of both a residue monitoring system and a disease testing framework required by EU and US authorities (Fitzsimmons, 2008). However, the production of tilapia in sub-optimal water conditions, lack of BMPs, lack of sufficient hazard analysis critical control point (HACCP) and International Standards Organization (ISO) approved processing plants, lack of value added capabilities (freezing, breading, packaging, etc.), and lack of by-product industries have also been put forward as limiting factors (Fitzsimmons, 2008; Nasr-Alla et al., 2012). Production costs, limited processing facilities and lack of expertise may be constraints for exportation as well.

All these production constraints affect the quality and quantity of farmed tilapia production and consequently health and nutritional status of consumers. However, producers were aware of the quality and safety indicators of tilapia and paid attention to keep water quality as optimal as possible. They also removed dead tilapia and those with lesions prior to transport, added ice to fish and transported it to the wholesale market as soon as possible after harvesting.

Harvesting, transporting and marketing of farmed tilapia

The results from this study and previous studies (Macfadyen et al., 2012) indicated that the farmed tilapia value chain in Egypt has limited value addition, i.e. tilapia is transported as soon as possible after harvesting to the wholesale market then distributed to retailers and consumers. It is usually sold fresh, however, some retailers clean and/or cook (e.g. grill and/or fry) tilapia for immediate consumption. Marketing fresh tilapia, cleaning and/or cooking are considered as adding value. Although women were not involved in the fish-farming and transporting which may be due to the nature of the farming process and/or social constraints, a high proportion (38%) of fish retailers were women and some of them were owners of the shops. This indicates that women can still find job opportunities along the fish value chain. Globally, women represent 47% in primary and secondary sectors associated with small scale fisheries (Mills et al., 2011). In Vietnam and Nigeria, it was found that women had a key role in processing and marketing of aquaculture and less importance in production stages such as hatching and farming (Veliu et al., 2009).

The results indicated that tilapia is potentially exposed to contamination along the chain. Unhygienic handling of tilapia was observed during harvesting, where crates were thrown on the ground and in mud so even if they were cleaned earlier there was a potential risk of contamination at the farm level. The commonly used method of harvesting was by draining water from ponds then catching tilapia in very turbid and low quality water. Feed deprivation prior to catching, removal from water, handling, grading and transportation act as stressors for tilapia, as temperature, dissolved oxygen, pH, carbon dioxide, ammonia, and the salt balance of the fish's blood may be changed during this period (Conte, 2004; Ashley, 2007). All of these factors may affect the nutritional quality and safety of tilapia. Drained water could be a potential source of contamination for other fish farms and for the environment.

During transportation and retailing, cleaning and disinfection of fish crates was infrequent and the level of hygiene was low. Therefore contamination was likely to happen during these stages via unclean equipment and handling practices. Multiplication of microbial pathogens was also likely as there were no effective cold chains for preserving the quality of tilapia from harvest until reaching the consumers. The reported lack of hygiene increases the risk of contamination of tilapia and probably lowers the nutritional quality and safety. Under the current production and marketing systems, consumers rely on purchasing from sellers they trust and conducting sensory checks when purchasing fish to assure fish safety. However, while these sensory checks may give an indication of the freshness of the fish and indicate diseases that cause visible alterations, they do not provide any information about contamination with invisible contaminants, such as heavy metals or pesticide residues. Potential health hazards associated with tilapia are heavy metals, lipophilic organochlorine contaminants, persistent organic pollutants, polycyclic aromatic hydrocarbons and antibiotics residues (Chindah et al., 2004; Hastein et al., 2006; Yahia and Elsharkawy, 2014; Malik et al., 2010; Wu and Yang, 2010; Cole et al., 2009) and consumption purely based on trust and sensory checks could thus constitute a health risk for consumer. There should be an intervention for reducing risks of post-harvesting contamination with food-borne pathogens by providing cold chains and BMP training for producers, transporters and retailers along the chain. As a first step farmers should be advised to use clean crates and apply sufficient ice as soon as possible after harvesting to reduce the temperature of tilapia. Almost all producers, transporters and retailers stated that there is no inspection of their business. Therefore, implementing HACCP system for production and marketing of farmed tilapia would potentially improve the quality and safety. However, such systems would probably only be implemented if there were the right incentives for producers and retailers, such as a price bonus, improved market access, public legislation and enforcement, or subsidies. Also the willingness of consumers to pay more for safety-assured tilapia should be assessed.

Consumption patterns of tilapia

The frequency of tilapia consumption by consumers in the vicinity of tilapia producing areas was significantly higher than in other communities. This may be attributed to many reasons such as having many alternatives for getting tilapia and lower prices of tilapia compared to non-producing areas. On the other hand, in non-fish producing areas, the only source of tilapia or any other type of fish was by purchasing. These results were consistent with findings in other countries such as Nigeria where the consumption of fish was significantly higher in fishing than in non-fishing households (Gomna and Rana, 2007; Gomna, 2011). Also in China and Bangladesh, the consumption of fish was significantly higher in households in producing areas compared with both non-producers and the national average consumption (Dey et al., 2000). The replacement of tilapia with other types of fish, especially imported frozen fish, was higher in non-producing areas. This was due to the lack of availability of tilapia in the market (usually once a week), low quality, the high prices of tilapia compared with other types, and sometimes consumers' preference. Financial inability to buy tilapia was another reason. The low quality of tilapia in non-producing areas may result from improper and/or unhygienic conditions during transportation and storage of tilapia from the production area to the consumers. The results showed that, it may take 24 h or more for tilapia to reach consumers in non-producing areas taking into account the transportation time from farm to the wholesale, then to retailers, then to local retailers and/or street vendors. During this time, tilapia was not frozen but was in most of cases transported with limited amounts of ice. The frequency of consumption of tilapia was higher in the peri-urban area than in rural area as consumers in the peri-urban area can easily get tilapia from nearby city markets, usually have high income and have different dietary habits. Tilapia may also be more affordable in peri-urban areas than in the rural areas as there were higher proportions of salaried employees. It was also noticeable that tilapia grade I and II were more available and frequently consumed in non-producing communities. This means that higher grades of tilapia tended to be transported to non-producing areas and lower grade tilapia consumed locally.

Consumers were aware of the signs of good quality tilapia and for most of them the hygienic condition of the source was the single most important criteria for purchasing tilapia. However, as discussed before, sensory checks alone may give a false indication about the quality and safety of tilapia. There were potential food safety risks due to contamination and/or cross-contamination at home as a high proportions of consumers kept fish at room temperature. Many, especially in non-fish producing communities, thought that wild tilapia was better than farmed one. Most consumers in non-producing areas say they would buy more tilapia if it was better quality. This illustrates the impact unhygienic transporting and storage conditions and the resulting spoilage may have on consumers demand. The results also indicated that the demand for tilapia is increasing with more than 80% of households particular in non-producing areas would like to consume more tilapia in the future.

Conclusions and areas for further research

In conclusion the current farmed tilapia production chain in Egypt is short with little value addition; almost all produced tilapia are transported and marketed as fresh. Farmers considered the main production constraints were fish feed prices and quality, availability of land and its rent, water availability and quality, and fuel and energy sources. There are many potential sources for contamination of farmed tilapia with different pollutants along the production chain due to some current practices, low level of hygiene and lack of monitoring systems at farms, transporting and retailing. However, there was high awareness of hygiene and safety and many good practices along the value chain, despite limited awareness of international standards. In this study, the frequency of consumption of tilapia was higher by consumers living in the vicinity of fish farms than those away from fish production area. Public health may be promoted by creating an awareness of hygienic handling and healthy cooking of tilapia.

One of the important and urgent requirements is the development of a database for fish farms in Egypt. To improve the quality and quantity of farmed tilapia, the following studies are suggested: (1) assessing the quality of feed and feeding methods to identify the most efficient and cost effective way of feeding,

(2) assessing the impact of water pollution on both quantity and quality of tilapia production, (3) assessing the impact of traditional fishing methods and slow suffocation of tilapia on the nutritional quality and safety and (4) assessing the impacts of traditional processing and cooking methods of tilapia on the nutritional value, biological and chemical hazards. Future studies are also suggested to improve water quality, find alternative non-conventional fish feed, energy sources and genetic studies for selecting cold and disease resistant tilapia strains. Tilapia processing and value addition should be investigated as well in terms of profitability, nutrition and safety of the final products. Also consumers' perceptions for purchasing processed and/or semi-processed tilapia should be assessed.

This is the first study to look at practices and perceptions related to production, transport, retail and consumption of farmed tilapia in Egypt. This study presents results from case study communities on an important but poorly described food value chain; further studies are needed to characterise the national value chains and consumption patterns. While further research is needed, some recommendations can already be made to support the development of the farmed tilapia value chain in Egypt. At production level, farmers could benefit from private, public or collective action to improve infrastructure and inputs. The legislation prohibiting the use of irrigated water in fish-farming should be re-assessed. The functioning of the value chain could be improved by better integration and traceability. Publicity and awareness campaigns should credibly promote farmed tilapia as a healthy and safe product. Fish consumption needs to be carefully considered in light of the double burden: healthy cooking methods should be prioritised. Improving fish-handling in the household and encouraging fish and meat as complementary foods are important messages for consumers.

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