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Short Communication

Sensory, morphometric and proximate analyses of Nile tilapia reared in ponds and net-cages

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ABSTRACT - The present study evaluated the sensory, proximate and morphometric differences of pond and net-cage-reared Nile tilapia (*Oreochromis niloticus*). Thirty samples from ponds and 30 samples from net-cages were used. Morphometric measurements were performed in fish and the fillets; proximate composition of the fillets was determined; and sensory analysis of the meat was performed. The fish reared in ponds exhibited similar weights and larger measurements than those reared in net-cages. Fillet measurement and weight were similar for both rearing techniques. The proximate composition analysis of the fillets showed that there was less lipid deposition (12.6 g/kg) and higher moisture retention (792.6 g/kg) in fish reared in the ponds compared with those reared in net-cages (31.7 and 767.8 g/kg, respectively). Although the amount of lipid in the fillets from fish reared in net-cages was higher, the fillets do not contain excessive fat. There was no difference in fillet protein or ash. The flavor of the fillet was moderately good to good and was similar in both farming systems. Fillets produced with the 2 farming systems have similar morphometric, proximate and sensory characteristics.

Key Words: fillet, lipid, *Oreochromis niloticus*, protein, farming system

Introduction

Fish rearing can be performed in different densities depending on the farming system employed (Souza et al., 2005). By the end of the 1990s, fish farming was based on a semi-intensive system in excavated ponds and dams (Filho et al., 2010) with or without water renewal. Typically, the nutrients are supplied by a combination of diet and chemical fertilizers and manure (Carmo et al., 2008).

Since 2000, there has been an increase in intensive net-cage fishing systems, especially in public waters and large hydroelectric reservoirs (Scorvo Filho et al., 2010). These systems are widely used in bodies of water unsuitable for other farming systems, such as ponds, lakes and river beds. The constant exchange of water with the environment is the main factor that enables high population density and a large biomass of fish per unit volume because it meets the high demand for oxygen and removes waste products (Carneiro et al., 1999; Signor et al., 2010).

Nile tilapia (*Oreochromis niloticus*) is the main species of fish reared in Brazil (FAO, 2007), and it is produced in both types of farming systems described above. Besides its animal performance traits, good acceptance of Nile tilapia meat enables the commercial breeding of this species; it has a firm texture, delicate flavor, low fat and caloric content and does not have an unpleasant odor (Santos et al., 2007). Nile tilapia is also an easy fish to fillet because it does not have Y-shaped intramuscular bones (Simões et al., 2007). Tilapia fillet is currently the main processed product derived from fish farming in Brazil, and the farming and processing of this species are multiplying around the country, due to the growing interest of domestic and foreign markets, mainly in Europe and The U.S. (Fulber et al., 2009).

Despite the growth of tilapia production in Brazil, there are no studies comparing the quality of fish produced in different farming systems (ponds and net-cages). Thus, the present study aimed to evaluate the sensory, morphometric and proximate differences of Nile tilapia reared in ponds and net-cages.

Material and Methods

Fish were collected from 6 commercial farms (3 ponds and 3 net-cages) located in the state of Espírito Santo, Brazil. On all of the farms, the fish are processed for fresh or fillet consumption.

Because they are commercial operations, the fish farms employed similar types of feed (extruded), dietary protein

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contents (320-360 g/kg), feed rates and frequencies (satiation, 3 times/day). The average duration of fattening was 5-6 months for all of the farms. The conditions of the 3 farms using each rearing system were similar with respect to the rearing unit size, final stocking density, water renewal rate, dissolved oxygen levels and temperature. The fish were reared in excavated ponds with sizes ranging from 800 to 1,000 m^2 with a density of 2 fish/m^2. The water renewal rate was 3% per day. During rearing, dissolved oxygen and water temperature ranged from 5.1 to 6.3 mg/L and 27.1 to 29.6 °C, respectively. The fish reared in net-cages were confined in 6 m^3 tanks installed in dams ranging from 3-5 acres. The final density was 125 fish/m^3. For net-cage rearing, dissolved oxygen and water temperature ranged from 4.8 to 6.0 mg/L and 27.4 to 29.8 °C, respectively.

A total of 60 male specimens (sex reversed) of Nile tilapia (Thailand) originated from the same hatchery station were used. To reduce the possibility of morphometric differences due to genetic characteristics, the animals were from the same lineage. A total of 30 animals from net-cages and 30 from ponds were used, all weighing between 500 and 650 g. The average age of fish from all farms was 8-9 months (1 month of larviculture, 2 months of rearing and 5-6 months of fattening).

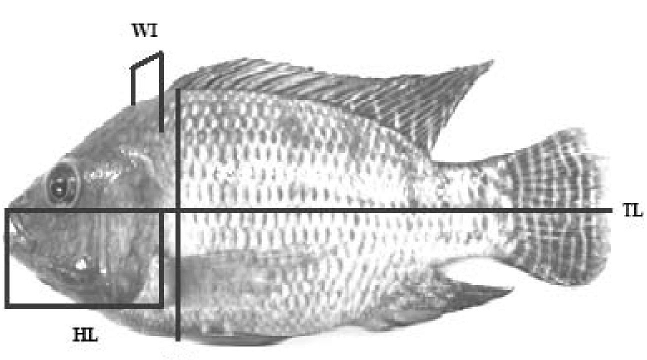
Ten fish were obtained from each farm; fish were stunned by hypothermia (cool boxes with ice and water) and sacrificed by cervical dislocation. After slaughter, the fish were weighed using a digital scale accurate to 1 g and packaged and placed on ice for 2 hours prior to being filleted (skin- and bone-free meat).

Measurement was conducted as described by Santos et al. (2007) and Crepaldi et al. (2008) (Figure 1) The measurements were as follows: total length (from the tip of the snout to the end of the caudal fin), head length (from the end of the head to the edge of the operculum); height (height of the body measured to the bottom of the 1st dorsal fin ray) and width (body width measured at the front of the 1st dorsal fin ray). Height and width measurements were performed with a caliper, and the other measurements were performed using a graduated ictiometer (mm).

Filleting was manually performed by a single, well-trained person. The fish were filleted whole with viscera, and the skin was subsequently removed from the fillet with a knife (Souza, 2002) . The following weights were measured: whole fish, fillet with skin, fillet without skin and carcass (represents the remainder of the fish, after filleting). Length, width and thickness of fillets were measured. The width was measured at 3 points transverse to the length of the fillet, with measurements performed every 3 cm; the first measurement was performed 3 cm after the start of the fillet (Figure 2). The assessments of fillet weight and length followed the method described by Souza et al. (2005).

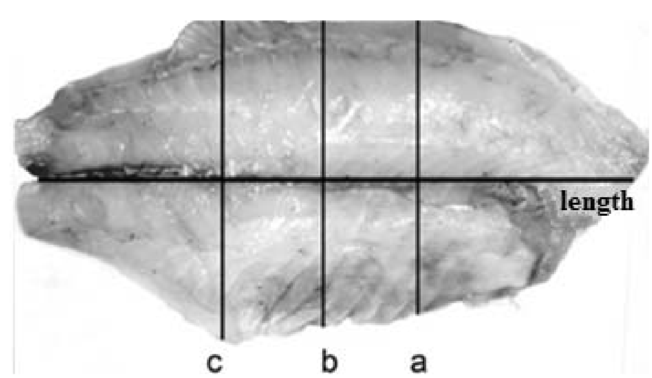
Once measured and weighed, fillets were washed, individually wrapped in plastic bags and frozen at -18 °C. The samples were thawed at the time for proximate and sensory analyses.

For the proximate chemical analysis, 4 fish per farm were used for a total of 12 fish from each rearing system. The analyses were performed according to the methods described in Association of Official Agricultural Chemists (AOAC, 1995). The moisture present in the samples was determined by drying at 105 °C until a constant weight was achieved. Total protein was measured by the Kjeldahl method, using the factor 6.25 for conversion of total nitrogen into total protein. The Soxhlet extraction method was used for total lipid determination. The percentage of ash in the samples



TL - total length; HL - head length; HE - height; WI - width.

Figure 1 - Morphometric measurements obtained in Nile tilapia from ponds and net-cages.



Measurements were performed at 3 points located at 3 cm (a), 6 cm (b) and 9 cm (c) across the length of the fillet.
Modified from Souza et al. (2005).

Figure 2 - Measuring points of Nile tilapia fillet: length, width and thickness.

was determined by burning them in a muffle furnace at 550 °C.

For sensory analysis, the acceptance method by hedonic scale and the paired-preference model test were used; both were previously described by Zenebon et al. (2008). A total of 18 samples were prepared (3 from each farm; 9 from each rearing method). Samples were cooked in an oven at 180 °C for 6 minutes and offered to the untrained tasters. Each judge had to taste all of the samples and avoid sensory fatigue; after, the judges rinsed their mouths with filtered water or ate pieces of apple to neutralize their sense of taste.

For the acceptance test, a total of 11 tasters were used, with each expressing their degree of like and dislike. In this test, a 5-point hedonic scale was used, with 5 representing the highest score, "liked"; 4, "liked moderately"; 3, "did not like or dislike"; 2, "disliked moderately"; and 1 representing the minimum grade, of "really disliked".

For the paired-preference test, 9 fillets from each farming system were placed on 2 different trays (net-cage-raised fish tray and pond-raised fish tray), and each judge had to test all the fillets and choose the tray that had the sample they most preferred. A total of 22 tasters were used, with each taster choosing their preferred product.

The results were expressed as the mean±standard deviation. The morphometric and proximate results were compared between the farming systems by Student's t-test. The hedonic scale test was compared by the Mann-Whitney U test and the paired-preference test was evaluated with a chi-square test. All tests adopted $\alpha = 0.05$.

Results and Discussion

Of all the carcass characteristics evaluated, only total fish weight was not significantly different (Table 1). Similar weight was expected and was required to validate the comparisons because several studies have demonstrated the influence of slaughter weight on carcass and fillet yield in Nile tilapia (Souza et al., 2005). Fish age (8-9 months of age in all farms) was another important factor that was standardized to validate carcass and fillet yield comparisons.

However, significant differences (P<0.05) in carcass weight and measurements (total length, head length, dorsal width and height) were found, and these values were always higher in pond-reared fish. The pond fish had greater body measurements, due to the larger environment; fish reared in net-cages have less swimming mobility. This conclusion is supported by the fact that other factors that could influence body measurements, such as gender, age and growing period, were standardized.

According to Silva et al. (2009), tilapia weighing 550-600 g reared in ponds had a similar carcass yield (605.6 g/kg) to those found in the present study in the same farming system (648.7 g/kg). Higher yield reflects higher efficiency in carcass gain and has greater economic value than the other components that are not part of the carcass. The higher carcass yield in pond-reared fish may be related to visceral fat. Although this variable was not explicitly measured, it was visibly present in the pond-reared fish carcasses. Raising fish in net-cages produces high levels of biomass, optimizing the production unit in a small physical space compared with ponds; however, this method also prevents individual growth (Signor et al., 2010).

There were no significant differences in the analyzed fish fillet variables between the farming systems (Table 2). This finding suggests that although fish reared in net-cages exhibited lower measurements, this difference was not reflected in the fillet yield. This finding is confirmed by the results of the present study, where net-cage-reared tilapia had an average fillet yield of 300.8 g/kg, and the average pond-reared fillet yield was 281.8 g/kg. The values were lower than those of pond-reared tilapia reported by Souza (2002) and Silva et al. (2009), which were 336.6-365.8 g/kg and 351.4 g/kg, respectively.

Results may vary depending on the filleting method, especially in other species, such as pond-reared silver catfish (*Rhamdia quelen*), in which the fillet yield (cut initiated in the dorsal region, lateral to the fin, from the cranial region to the caudal extremity) was 314.5 g/kg (Carneiro et al., 2004), and for net-cage-reared pacu (*Piaractus mesopotamicus*), in which the fillet yield

Table 1 - Carcass yield of pond- and net-cage-reared Nile tilapia

Variable	Farming system		P-value
	Pond	Net-cage	
Total weight (g)	575±0.39	562±0.27	0.182
Carcass weight (g)	373±0.27	302±0.43	<0.001
Total length (cm)	30.52±1.37	28.82±1.35	<0.001
Head length (cm)	7.95±0.52	7.31±0.56	<0.001
Dorsal width (cm)	4.17±0.26	3.91±0.29	0.002
Height (cm)	10.78±0.42	10.29±0.37	<0.001

Table 2 - Fillet yield of pond- and net-cage-reared Nile tilapia

Variable	Farming system		P-value
	Pond	Net-cage	
Fillet weight with skin (g)	209±0.02	211±0.03	0.871
Fillet weight without skin (g)	162±0.02	169±0.02	0.277
Fillet length (cm)	15.92±1.3	16.46±0.8	0.093
Height a (cm)	6.82±0.8	6.85±0.7	0.883
Height b (cm)	7.68±0.7	8.07±1.1	0.151
Height c (cm)	8.33±0.7	8.69±1.0	0.143

Heights: a - 3 cm; b - 6 cm; c - 9 cm across the length of the fillet.

(cut from the dorsal side of the fish) was 235.3 g/kg (Bombardelli et al., 2007).

There are many factors that affect fillet yield, including the degree of mechanization, the filleting method (removal order of the skin and fillet, removal of the head and fins for filleting, type of cut made during beheading) and the skill level of the person performing the filleting (Souza, 2002).

The fillet from pond-reared fish had higher moisture and lower lipid concentration (Table 3). The protein and ash contents showed no significant differences between the farming systems. Given the larger area for swimming, fish reared in ponds might have higher metabolism, which reduces lipid content due to energy expenditure and increases the percentage of water in the tissue. Souza et al. (2002) reported this inverse relationship between lipid and moisture in pacu (*Piaractus mesopotamicus*) when testing feeding restriction.

The moisture values obtained were 790.6 and 767.8 g/kg for pond and net-cage fish, respectively (Table 3). Souza et al. (2005) reported similar results for moisture in tilapia (799.9 g/kg); Leonhardt et al. (2006) described the fillet composition of 2 lineages (Nile tilapia and red tilapia), providing values of 784.3 and 792.0 g/kg moisture and Lazzari et al. (2006) reported 740 to 768 g/kg moisture in silver catfish (*Rhamdia quelen*).

Souza et al. (2005) and Oliveira et al. (2008) both assessed tilapia fillets and found lipid contents of 14.1 and 23.3 g/kg, respectively. These are similar to our values of 12.5 and 31.7 g/kg lipid in fillets of fish reared in pond and net-cages, respectively. The lipid compositions observed in fish reared in net-cages do not mean that the animals have excess fat, which usually occurs at concentrations greater than 10% (Contreras-Guzman, 1994).

According to Kubota & Emanuelli (2004), lipid composition may vary due to factors such as species, animal age, gender, season, environmental factors and especially feeding in the case of farm-raised fish. As the feeding protocols applied to all farms studied were notably similar, it is believed that variables related to feeding were not the reason for the difference in lipid concentration. The main explanation for this result is greater confinement and less space for fish reared in net-cages, which leads to less movement and less energy expenditure and results in lipid accumulation.

Table 3 - Proximate composition of pond- and net-cage-reared Nile tilapia

Variable	Farming system		P-value
	Pond	Net-cage	
Protein (g/kg)	166.7±14.4	162.7±16.1	0.660
Humidity (g/kg)	790.6±15.3	767.8±16.1	0.031
Ash (g/kg)	9.4±0.90	10.5±1.10	0.085
Lipid (g/kg)	12.5±5.40	31.7±13.0	0.008

In the present study, the amounts of protein in the fillets were 166.7 and 162.7 g/kg for pond- and net-cage-reared fish, respectively. These values are slightly lower than those found in Nile tilapia reared in ponds (18% protein) by Oliveira et al. (2008) and Omena et al. (2010). The values obtained in the present study are similar to the 164-184 g/kg protein found in silver catfish (*Rhamdia quelen*) (Lazzari et al., 2006). Pereira (2003) confirms these values, suggesting that fish meat protein should be approximately 150-200 g/kg, which is comparable to levels detected in eggs and steak.

The mean levels of ash found in the present study were 9.4 and 10.5 g/kg in pond and net-cage fish, respectively, which are within the range described in the literature for this species. According to Oliveira et al. (2008) the mean level of ash was 1.7 g/kg, while Omena et al. (2010) reported 12.3 g/kg.

The values obtained in the proximate analysis of tilapia reared in the 2 systems tested are in agreement with those described by Ogawa & Maia (1999) for fish in general, in which the chemical composition of fish ranged between 600-850 g/kg moisture, 10-20 g/kg ash, 6-360 g/kg lipids and 200 g/kg protein. The results from the present study are also similar to those reported by Souza et al. (2005) for the same species: 799 g/kg moisture, 175.1 g/kg protein, 14.1 g/kg lipids and 10.9 g/kg ash.

In the hedonic scale test, no significant difference in taste was found between the 2 rearing systems ($P>0.05$). Fish reared in both systems were rated "liked moderately" (grade 4). In the paired-preference analysis, pond-reared fish were preferred by 15 tasters, and net-cage-reared fish were preferred by 7 tasters. These results were not statistically significant ($\chi^2 = 2.91$; $P>0.05$; df = 1). This result may be related to increased lipid deposition in the fillets from fish reared in net-cages; fat concentration influences fillet flavor, due to deleterious effects on the organoleptic properties of the fillets.

Conclusions

Nile tilapia (*Oreochromis niloticus*) reared in net-cages exhibit smaller morphometric measurements; however, this difference does not influence the fillet weight or size. The fish produced in both farming systems can be easily used for filleting because the flavor of the meat is similar, and the elevated amount of lipids in fish reared in net-cages does not produce a fillet with excess fat.

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