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Effect of Slaughter Weight on Meat Quality of Nile Tilapia (*Oreochromisniloticus*)

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ABSTRACT

A total of 375 Nile tilapia was subdivided into three groups (125 fish/group), based on weight (600, 800 and 1200 g, respectively). Fish were killed and analyzed for various traits describing meat characteristics. Data was subjected to analysis of variance. Protein percentage of the 600 g weighing Nile tilapia was the highest (P<0.05). Fat percentage of the 1200 g weighing Nile tilapia was higher than that of the 600 g weighing animals (P<0.05). Drip loss percentage of the fillet of the 600 g weighing Nile tilapia was the highest (P<0.05), whereas boiling loss percentage was the highest (P<0.05) in the 1200 g heavy fish. TBARS value on days 0, 1, 3, 6 and 9 were not different (P>0.05) between groups. Shear force values of raw and cooked fillets were highest with the 1200 g heavy fish (P<0.05. The total collagen content of the fillet of the 1200 g weighing fish was highest (P<0.05). Flavor, juiciness, tenderness and acceptability ratings were lowest with fish weighing 600 g (P<0.05). In conclusion, fat percentages and firmness were higher with increasing the slaughter weight. Also flavor was improved with higher slaughter weight. By modifying the slaughter weight, a certain target meat quality can be achieved.

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Keywords: Meat Quality; Nile Tilapia (*Oreochromis niloticus*); Slaughter Weight

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1. Introduction

Nile tilapia (*Oreochromis niloticus*) was introduced in Thailand in 1965 as an official gift from Prince Akihito of Japan to the King Bumipol Aduljadej. The fish was distributed by the Department of Fisheries to the farmers (Ko-anantakul, 1999). The Nile tilapia is considered as a herbivore, with high reproductive and growth performance, tolerance to varying environmental conditions, high disease resistance, and a high palatability of its meat. The fish species adapts well to culture systems, too. Fish raised for 8 month to 1 year has about 500 g of final weight and is about 30 cm long. The typical market weight of fillets is then 200 - 300 g as demanded by the consumers (Bureau of Agriculture Economic Research, 2009). However, weights are higher for fish exported with 600 g (to USA), 800 g (to EU) and 1200 (to China) depend on eating habit (Department of Fisheries (2009).

Nile tilapia (*Oreochromisniloticus*) has rapidly become an important species for aquaculture, although their intensive cultivation remains constrained by poor spawning synchrony and low fecundity, adding significant cost to hatchery production (Campos-Mendoza et al., 2004). Tilapia has become the preferred species in aquaculture with farms starting and expanding across the globe while consumption even exceeds the most ambitious farm building plans. In 2010, the farmed tilapia exceeded 3.2 million metric tons per annum, surging further ahead of the salmon and catfish industries (Fitzsimmons et al., 2011). In Thailand, it is common to have different sizes of tilapia depending on the purpose for cooking. However, information about the meat quality of Nile tilapia in dependence of slaughter weight is missing. It would be especially important to know whether the meat quality can be maintained when growing the fish to higher slaughter weights. The aim of this study was, therefore, to evaluate the meat quality of Nile tilapia at higher and different slaughter weights. The resulting findings should help producers and consumers to choose which slaughter weight is best in terms of meat quality and nutritional composition.

2. Materials and methods

A total 375 Nile tilapia were divided into 3 groups (125 tilapia/group) based on weight (600, 800 and 1200 g, respectively). Fish were killed and analyzed for various traits of meat quality. The carcasses were chilled at 4°C for 24 h then the samples were stored at -20 °C for the further analysis. The fillets were separated into a proximal and a ventral section and analyzed for the following properties: chemical composition (AOAC, 1995), collagen traits (Hill, 1969), cholesterol content (Chaudhry, 2004), thiobarbituric acid reactive substances (TBARS; Du et al., 2001), water holding capacity (Jaturasitha, 2008), firmness (TA.XT plus, Stable Micro Systems Ltd., London, UK) and sensory traits (according to Johanson et al., 2000).

This experiment was analyzed as 3×2 factorial in CRD with two muscle types (dorsal and ventral fillet) compared for three slaughter weight groups. The Statistical Analysis System (SAS Institute Inc., Cary, N.C., USA) was adopted to perform data analysis and statistical computations for analysis of variance (ANOVA) and Duncan's test was used for multiple comparisons among means. Significance of differences was declared at $P<0.05$.

3. Results and discussion

The fillets of the 600 and 800 g weighing Nile tilapia groups had a higher ($P<0.05$) moisture content than of the 1200 g weighing Nile tilapia group (Table 1). The fillets of the Nile tilapia with 600 g of weight were the highest in protein percentage ($P<0.05$). The fillet of the 1200 g weighing Nile tilapia was higher in fat percentage than that of the 600 g weighing Nile tilapia ($P<0.05$). The ventral fillet was lower in moisture percentage ($P<0.001$) and higher in fat percentage ($P<0.05$) than the dorsal fillet section. In a previous study, dry weight, protein, fat and ash percentages of tilapia meat were 22.1, 19.4, 1.29 and 1.21%, respectively (Wu et al., 1996). Osibona et al. (2009) found that tilapia meat had moisture, protein, fat and ash percentages of 80.4, 19, 1.1 and 1.2%, respectively.

Cholesterol was not significantly different between groups (Table 1). Freshwater fish was found to have cholesterol contents of approximately 41 and 53 mg/100 g of fat (Moreira et al., 2001). The ventral fillet in the present study had a higher cholesterol concentration than the dorsal fillet ($P<0.001$). There was a positive correlation between the cholesterol concentrations of the ventral fillet and the dorsal fillet. Freshwater fish has lower cholesterol concentrations in the meat than sea fish and may therefore be a particularly healthy food for human (Mathew et al., 1999; Luzia et al., 2003).

Water holding capacity was determined as drip, thawing, grilling and boiling losses. The drip loss of the fillet of 600 g weighing Nile tilapia was the highest (*P*<0.05). Thawing and grilling losses were not significantly different (*P*>0.05). Boiling loss of the fillets of the 1200 g weighing Nile tilapia was the highest (*P*<0.05). The ventral fillet had higher drip and thawing losses than the dorsal fillet (*P*<0.05). Alkobaby et al. (2008) revealed that the water holding capacity of tilapia meat correlated with pH: the fusion of water in filter paper was 7.41 cm^2 with pH 6.5, and when the pH was decreased to 6.3 water fusion decreased to 4.42 cm^2. The water holding capacity is important for consumer acceptance and sensory perception of texture and flavor (Pelicano et al., 2003).

Concerning the TBARS measured on days 0, 1, 3, 6 and 9 there were no significant differences between groups (*P*>0.05). The muscle portions were not significantly different on days 0 and 1. On days 3, 6 and 9 the ventral fillet had higher TBARS values than the dorsal fillet (*P*<0.05). As expected, the rancidity was increased with storage time, but also seems to have depended on fat percentage. Accordingly, fat accumulation in the muscle is associated with faster lipid oxidation and results in a faster accumulation of oxidation products in meat (Chaiyapechara et al., 2003). Biscalchin-Gryschek et al. (2003) found that TBARS on day 1 of tilapia and red tilapia meat was 0.15 and 0.25 mg malondialdehyde, respectively.

Table 1

Composition, water holding capacity and shelf life of fillets of Nile tilapia as depending on slaughter weight and fillet section

Criteria	Slaughter weight (g)			Fillet		SEM	*P*-value		
	600	800	1200	Dorsal	Ventral		Weight	Muscle	Interaction[1]
Chemical composition (%)									
Moisture	73.4^a	73.5^a	72.6^b	73.5^x	72.7^y	0.085	<0.001	<0.001	0.019
Protein	20.3^a	19.7^b	19.3^c	19.8	19.7	0.088	<0.001	0.792	<0.001
Fat	6.38^b	6.79^{ab}	7.87^a	6.47^y	7.55^x	0.244	0.044	0.031	<0.001
Cholesterol (mg/100g)	48.9	43.8	49.0	37.6^y	56.9^x	1.75	0.385	<0.001	0.022
Water holding capacity (%)									
Drip loss	5.07^a	3.71^b	3.55^b	3.23^y	4.99^x	0.227	0.015	<0.001	0.388
Thawing loss	4.92	4.11	4.29	3.06^y	5.82^x	0.504	0.787	0.010	0.550
Grilling loss	13.0	10.8	14.0	11.8	13.1	0.724	0.256	0.428	0.200
Boiling loss	8.6^b	11.7^a	11.9^a	10.2	11.2	0.543	0.028	0.388	0.692
Thiobarbituric acid reactive substances (TBARS; mg malondialdehyde/ kg fillet)									
Day 0	0.29	0.40	0.50	0.35	0.44	0.041	0.117	0.256	0.234
Day 1	0.82	1.07	1.08	0.873	1.11	0.093	0.415	0.207	0.961
Day 3	0.89	1.27	1.45	0.900^y	1.31^x	0.084	0.169	0.018	0.503
Day 6	1.55	1.55	1.68	1.40^y	1.78^x	0.084	0.747	0.026	0.934
Day 9	2.11	2.36	2.68	2.01^y	2.76^x	0.153	0.318	0.018	0.559

$^{a, b, c}$ Mean within the same row with different superscripts differ significantly (*P*<0.05) by age effect.^{x,y} Mean within the same row with different superscripts differ significantly (*P*<0.05) by muscle.[1] Interaction between age and muscle.

The meat firmness, measured as shear force, found in the present study, increased (*P*<0.001) with increasing slaughter weight in raw and cooked fillets (Table 2). The cooked fillets had a higher shear force than the raw fillets. The heat during cooking results in protein denaturation (Laakkonen, 1973). The dorsal fillet had a higher shear force than the ventral fillet (*P*<0.001). The energy needed for shearing was also increased with slaughter weight in raw fillet (*P*<0.05) and cooked fillet (*P*<0.001), respectively. The dorsal fillet needed more energy for shearing than the ventral fillet (*P*<0.001). Firmness depends on muscle fiber properties, but also to some extent on the fat concentration in the muscle (Dunajski, 1979).

Table 2
Shear force, collagen concentration and sensory grading of fillets of Nile tilapia as depending on slaughter weight and fillet section

Criteria	Slaughter weight (g)			Fillet		SEM	*P*-value		
	600	800	1200	Dorsal	Ventral		Weight	Muscle	Interaction[1]
Warner-Bratzler values									
Maximal force, N									
Raw fillets	5.14^{b}	5.58^{b}	7.46^{a}	8.36^{x}	3.76^{y}	0.271	<0.001	<0.001	0.039
Cooked fillets	7.51^{b}	8.06^{b}	10.98^{a}	10.23^{x}	7.47^{y}	0.329	<0.001	<0.001	0.339
Shear energy, J									
Raw fillets	0.65^{b}	0.77^{b}	1.06^{a}	1.16^{x}	0.497^{y}	0.051	0.005	<0.001	0.012
Cooked fillets	1.26^{b}	1.40^{b}	2.05^{a}	1.81^{x}	1.32^{y}	0.056	<0.001	<0.001	0.164
Collagen concentration (g/100 g fillet)									
Soluble collagen	1.47	1.44	1.48	1.30^{y}	1.62^{x}	0.048	0.516	<0.001	<0.001
Insoluble collagen	0.477^{c}	0.534^{b}	0.685^{a}	0.428^{y}	0.702^{x}	0.008	<0.001	<0.001	0.110
Total collagen	1.95^{b}	1.97^{b}	2.16^{a}	1.73^{y}	2.32^{x}	0.020	<0.001	<0.001	<0.001
Sensory grading[2]									
Firmness	6.40	6.19	6.28	6.32	6.26	0.070	0.468	0.648	0.759
Flavor	6.04^{b}	6.49^{a}	6.70^{a}	6.26^{y}	6.56^{x}	0.058	<0.001	0.013	0.878
Juiciness	5.53^{b}	6.46^{a}	6.68^{a}	5.98^{y}	6.46^{x}	0.072	<0.001	<0.001	0.442
Tenderness	5.81^{b}	6.60^{a}	6.70^{a}	6.14^{y}	6.60^{x}	0.068	<0.001	<0.001	0.153
Acceptability	6.22^{b}	6.70^{a}	6.98^{a}	6.46^{y}	6.80^{x}	0.059	<0.001	0.005	0.772

$^{a, b, c}$ Mean within the same row with different superscripts differ significantly (*P*<0.05) by age effect.
^{x,y} Mean within the same row with different superscripts differ significantly (*P*<0.05) by muscle.
[1] Interaction between age and muscle.
[2] 1=low intensity 5=moderate 9=high intensity.

Collagen concentration and its solubility also affect meat texture in a way that a high proportion of soluble collagen results in a lower firmness and a high concentration of insoluble collagen has the opposite effect (Jaturasitha et al., 2008). In the present study there was no significant difference in soluble collagen between groups (Table 2) (*P*>0.05), whereas the insoluble collagen of the 1200 g weighing Nile tilapia was the highest (*P*<0.05). The total collagen concentration was also highest in this group (*P*<0.05). Concentrations of soluble collagen, insoluble collagen and total collagen were higher in the ventral fillets than in the dorsal fillets (*P*<0.001). Total collagen was found to be 0.66% of fresh weight, with a relative distribution of 6% acid soluble, 93% pepsin-soluble and 1% insoluble collagen (Eckhoff et al., 1998). Fish species low in collagen concentration are sardine (*Sardinops melanostictus*), brook masusalmon (*Oncorhynclus masoumasou*), argentine (*Glossanodon semifasciatus*), rainbow trout (*Oncorhynchus mykiss*) and house mackerel (*Trachurus japonicas*) (Masniyom et al., 2005).

The sensory evaluation included firmness, flavor, juiciness, tenderness and acceptability as descriptors. The firmness was not significantly different between groups. The grading in flavor, juiciness, tenderness and acceptability was lowest with the 600 g weighing Nile tilapia (*P*<0.05). The ventral fillets were judged superior in flavor, juiciness, tenderness and acceptability than the dorsal fillets (*P*<0.05). Wu et al. (1996) described that protein and fat level in feed is important for flavor of the fillet. They found that the intensity of flavor of cooked fillets from tilapia increased when fed on pellets containing 16% of corn gluten meal or corn gluten feed. Additionally, the shelf life of the fish meat is important for the impression of color, flavor, odor, texture and acceptability.

4. Conclusion

Slaughter weight had clear effects on the tilapia fillets in terms of chemical composition, collagen concentration, shear force and on sensory grading. The tilapia with the highest slaughter weight yielded fillets which contained more fat, had more flavor and had a higher apparative firmness than those obtained from the 600 and 800 g weighing tilapia. Depending on the consumers' preference, the present results give indications which slaughter weight should be best chosen with Nile tilapia.

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