BODY COMPOSITION OF NILE TILAPIAS (*Oreochromis niloticus*) IN DIFFERENT LENGTH CLASSES

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ABSTRACT

The objective of this research was to evaluate the body composition of Nile tilapias in different length classes of Thai and Commercial strains, being the latter derived from the GIFT program (Genetically Improved Farmed Tilapia) regrding the levels of moisture, crude protein, ether extract, ash and energy. The fish were cultivated in cages in a dam in Presidente Prudente, SP – Brazil. As the animals grew, fish sampled randomly from each strain were weighed and measured in length. The body composition showed differences between the strains in the levels of moisture, carbohydrates, ether extract and energy as the fish grew (P<0.05). The content of protein and ash was similar for both strains, but the percentage of ash increased with the fish growth. A decrease in the percentage of moisture and increase in the percentage of ether extract and in the energetic content were observed in the larger class length. Differences in rates of growth of tilapia strains influence the metabolic rates of mobilization, particularly of water and ether extract, changing the dynamics of deposition of these elements and the energy content.

KEYWORDS: chemical composition; GIFT; lipids; protein; Thai.

COMPOSIÇÃO CORPORAL DE LINHAGENS DE TILÁPIA DO NILO (*Oreochromis niloticus*) EM DIFERENTES CLASSES DE COMPRIMENTO

RESUMO

Objetivou-se avaliar a composição corporal de tilápias do Nilo em diferentes classes de comprimento da linhagem Tailandesa e de uma linhagem comercial, produzida a partir do programa GIFT (*Genetically Improved Farmed Tilapia*), quanto aos teores de umidade, proteína bruta, extrato etéreo, cinzas e energia. Os peixes foram cultivados em tanques-rede, em uma represa em Presidente Prudente, SP, Brasil. Com o crescimento, peixes coletados aleatoriamente de cada linhagem foram pesados e medidos em comprimento. A composição corporal mostrou diferenças entre as linhagens quanto à umidade, carboidratos e energia, com o crescimento dos peixes (P<0,05). O conteúdo de proteínas e cinzas foi semelhante nas linhagens, mas apenas o conteúdo de cinzas aumentou com o crescimento das tilápias. Observaram-se diminuição na porcentagem de umidade e aumento na porcentagem de extrato etéreo e no conteúdo energético nas maiores classes de comprimento. O crescimento diferenciado das linhagens de tilápias influencia as taxas metabólicas de mobilização, principalmente de água e extrato etéreo, alterando a dinâmica de deposição desses elementos e do conteúdo energético.

PALAVRAS-CHAVE: composição química; GIFT; lipídios; proteínas; Tailandesa.

INTRODUCTION

The quality of tilapia meat and its rapid growth are the main factors that have stimulated both consumers´ and producers´ interest in this species. The search for tilapia strains of superior performance by the producers along with the increasing demand for healthy food by the population of the world have required evaluations of this fish.

The tilapia strain Chitralada (Thai) and those from the GIFT program *(Genetically Improved Farmed Tilapia)* are being widely disseminated in Brazil, because they show faster growth than the common tilapia. This may affect carcass and meat quality regarding proteins and lipids concentration dynamics.

Thai Tilapia was developed in Japan and improved in Chitralada Royal Palace, in Thailand. This strain was introduced in Brazil in 1996, from fingerlings donated by the *Asian Institute of Technology* (AIT) (ZIMMERMANN, 2000).

Some strains introduced in the Brazilian market come from the largest tilapia breeding program, the *Genetically Improved Farmed Tilapia* (GIFT), which was carried out in the Philippines (ZIMMERMANN, 2003). The GIFT program consisted of four wild tilapia strains, captured in Egypt, Ghana, Kenya and Senegal, in 1988-1989, and four confined strains, from Israel, Singapore, Thailand and Taiwan, introduced in the Philippines from 1979 to 1984 (BENTSEN, 1998).

The growth is characterized by a harmonious development of major tissues, namely bones, muscle and adipose tissue. The differential growth of these tissues causes changes in chemical composition. These changes result from turnover stimulation or alteration and chemical components retention: proteins, lipids, carbohydrates and minerals, with normal or abnormal development of the specific tissues. Moreover, changes in composition of those components - classes of lipids, fatty acid composition, nature and functionality of proteins - also occur with the tissue growth and differentiation (FAUCONNEAU et al. 1995).

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

The main categories of body components of the fish are the same as those of other animals: water (with great predominance), lipids, protein and small amounts of carbohydrates and minerals (often called ash), which remain after the body is burned during calorimetry (WEATHERLEY & GILL, 1987).

FAUCONNEAU et al. (1995) reported that the percentage of lipid and protein and the energy content augmented while the water content reduced as the body weight increased.

The lipid content (% body weight) in fish tends to increase with age (and size), decline during the winter, migration and spawning and reach its maximum value at the end of the primary feeding period of the year. As an energy stock, it tends to be in the form of neutral fats - triglycerides. Phospholipids, free fatty acids, sterols etc. comprise only a small fraction of lipids (WEATHERLEY & GILL, 1987). Genetic origin is another factor that affects lipid content (FAUCONNEAU et al., 1991).

SHUL'MAN (1974) *apud* WEATHERLEY & GILL (1987) observed that, in contrast to the lipid dynamics in fish, protein content dynamics is essentially indistinguishable. While protein growth in immature fish occurs in the body as a whole, it is highly associated with gonadal development in mature fish. LUPATSCH et al. (2001) studied gilt-head bream *(Spaurus aurata),* and reported that the protein level remained basically constant, ranging from 15.7% to 19%, but major changes occurred in lipid content, from 5.5% to 21.0%, with the growth of the fish.

According to WEATHERLEY & GILL (1987), the growth of fish is also determined by the increase in mass of scales and bone tissue, which are composed of highly amounts of inorganic (mineral) matter. However, researchers have neglected the inorganic elemental composition of fish. SHEARER (1984) studied the inorganic elemental composition during growth of rainbow trout, and found that the concentration of some elements remains constant while others increase or decrease linearly with the increase in size of the fish.

Carbohydrates have generally been ignored, as they appear in a small percentage of body weight (approximately 0.5%), in the form of glycogen (WEATHERLEY & GILL, 1987).

This study was conducted in order to determine body composition in different length classes of Nile tilapia *(Oreochromis niloticus)* from Chitralada lineage (Thai) and a commercial strain from the GIFT program, regarding crude protein (CP), ether extract (EE), moisture (% M), ash and energy in these different lineages.

MATERIAL AND METHODS

The experiment was carried out in a dam at *Parque Ecológico Cidade da Criança*, in the city of Presidente Prudente, State of São Paulo, Brazil, from March to September 2006.

We used 500 fingerlings of the Thai strain (Chitralada) and 500 of a commercial strain. The commercial strain used in this work is derived from the GIFT program, run in the Philippines, and was named "Commercial". The fingerlings came from a male monosex population (treated with 17α--methyltestosterone), weighing approximately 10g. The fish were grown in four 2.7 m^3 netcages, with 250 fish from each strain in each tank.

The fish were fed a commercial ration, twice a day, containing 32% crude protein and a minimum of 7% ether extract. The daily amount was provided according to the biomass of the tank and the water temperature, ranging from 7% to 4% in the first and last weeks, respectively.

We collected limnological data (oxygen, pH, alkalinity and transparency) of the breeding environment weekly, using a technical commercial kit for water analysis carried out in the early morning (8 a.m.) and in the afternoon (2 p.m.).

During the cultivation, three samples were made with 40 fish of each strain, which were submitted to a fasting period of 48 hours, anesthetized and euthanized by heat shock (anoxia). Fish were weighed and measured for length, from the anterior end of the head to the caudal peduncle, disregarding the caudal fin.

At the time of sampling, 18 samples were collected, consisting of fish ranging in length classes of 5-10cm, 10-15cm and 15-20cm. Each length group was composed of six samples of about 150g of fish for each strain.

The samples were frozen, ground and homogenized for determination of moisture (M), ether extract (EE), crude protein (CP) and ash, according to the Association of Official Analytical Chemists, AOAC (1995). Carbohydrates determination was performed by calculation by difference, according to SILVA & QUEIROZ (2002):

%CHO = 100 - %M - %EE - %CP - %ashes

The amount of energy was calculated based on carbohydrates, fat and protein metabolizable energy. We considered the sum of the product of protein content by four, the lipid content by nine and the carbohydrate content by four (SILVA & QUEIROZ, 2002).

The experimental design was completely randomized with treatments in a 2 x 3 factorial arrangement (train x class size) with six replications. Data were analyzed using the following statistical model:

$$Y_{ijk} = \mu + L_i + T_j + LT_{ij} + e_{ijk}$$

wherein

μ: general mean;

Yijk: observation k of strain i in class size j;

Li: effect of strain i, where i = 1, 2;

Tj: effect of class size j, where j = 1, 2, 3;

LTij: effect of interaction between strain i and length class j;

eijk: error associated with each observation, which by assumption is NID $(0,\sigma^2)$.

We compared data between strains by using F test at 5% significance, and applied the Tukey test at 5% for the effect of length class, using the GLM procedure, of SAS for Windows version 8.1.

RESULTS AND DISCUSSION

Analysis of variance showed a significant effect (P <0.05) of the interaction between strain and class size for moisture, ether extract, carbohydrates and energy. The percentage of ash showed significant effect of fish size, regardless of the strain. On the other hand, the percentage of proteins revealed no significant effect (P> .10), with an average of 10.12%.

All the unfolding of the interactions showed significant effect of the size of the fish on each tilapia strain and of the strain on class sizes of 5-10cm and 10-15cm. We observed no difference between strains regarding chemical composition in the class of 15-20cm. The average values of the chemical components are shown in Table 1.

Fish in the shortest length class (5-10cm) showed higher percentage of moisture and lower percentage of lipids and energy (kcal / g), when compared with fish from the other classes (Table 1), and this behavior was similar for both tilapia strains.

We observed no difference in the chemical components of Thai strain in the classes of 10-15 and 15-20cm, which we did not observe in the Commercial strain, because 15-20cm-fish had lower moisture content and higher percentage of carbohydrates and energy than 10-15cm-fish. This indicates a greater dynamism of the chemical components in the Commercial strain, compared with the Thai strain.

Table 1.Means and standard errors (SE) of the variables of body chemical composition of tilapia strains, depending on the size of fish

Variable	Strain	Size (cm) 5-10		10-15		15-20		SE
Moisture (%)	Thai	76.74	aB	73.55	bB	73.34	bA	0.618
	Commercial	80.53	aA	75.58	bA	72.35	cB	
EE (%)	Thai	4.76	bA	9.34	aA	8.77	aA	0.412
	Commercial	3.09	bB	7.81	aB	8.77	aA	
CP (%)	Thai	10.15	aA	9.71	aA	9.90	aA	0.338
	Commercial	10.19	aA	10.40	aA	10.37	aA	
Ash (%)	Thai	2.99	aA	3.02	aA	3.72	bA	0.163
	Commercial	2.99	aA	3.43	aA	3.52	aA	
Carbohydrate (%)	Thai	5.36	aA	4.38	aA	4.28	aA	0.316
	Commercial	3.21	bB	2.79	bB	4.98	aA	
Energy (kcal / g)	Thai	104.87	bA	140.38	aA	135.62	aA	3.924
	Commercial	81.35	cB	123.02	bB	140.34	aA	

Means followed by different capital letters in the column are different by F test at 5%. Means followed by different small letters in the line are different by Tukey test at 5%.

The Commercial strain presented higher percentage of moisture in length classes of 5-10cm and 10-15cm and lower in the class of 15-20cm compared to the Thai strain. This indicates a greater reduction in the percentage of moisture in the Commercial strain as the fish grow. Thai and the Commercial strains showed a decrease of, respectively, 4.4% and 10.2% in the moisture percentage of fish in the length class of 5-10cm compared with fish in the 15-20cm class (Figure 1).

Lipids content, as an indicator of fat content, increased significantly in 10-15cm-fish, when compared with 5-10cm-fish, and was not different from 15-20cm-fish. This increase was similar in both strains, although it was more pronounced in the Commercial strain than in Thai (153% and 96%, respectively). However, the Thai strain showed higher percentage of lipids in fish of 5-10cm and 10-15cm classes than the Commercial strain. We observed no difference between strains in the 15-20cm class (Figure 2).

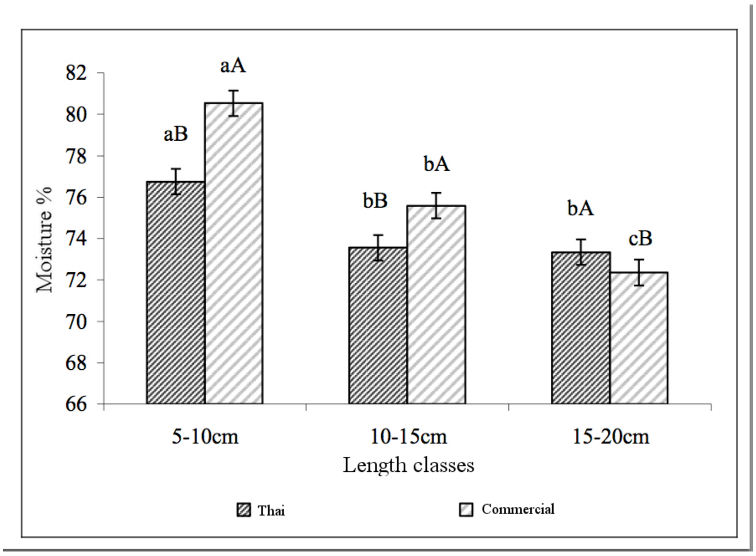

Figure 1. Moisture behavior (%) with the growth of tilapia strains (Thai and Commercial), differentiating the length classes with lowercase and the strains with uppercase letters.

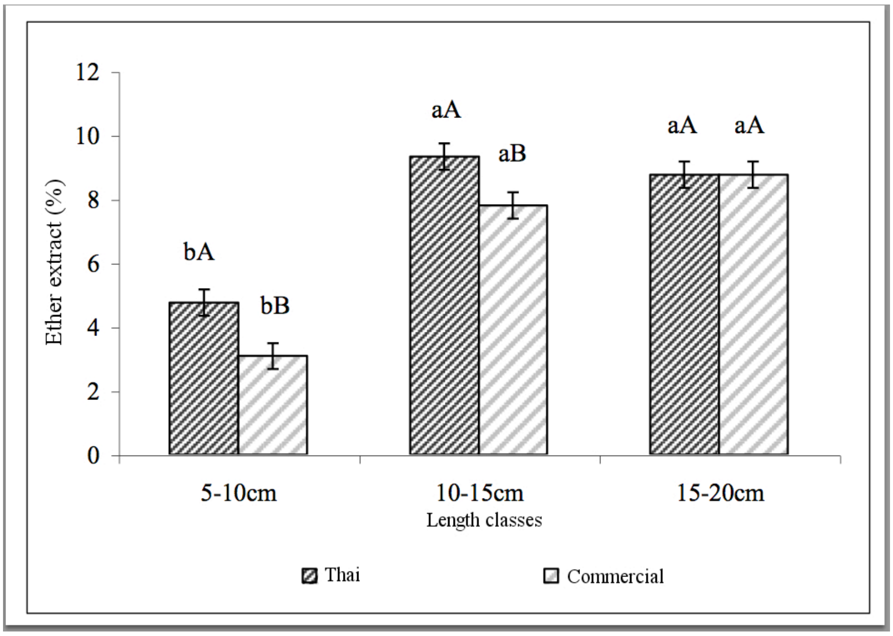

Figure 2. Ether extract behavior (%) with the growth of tilapia strains (Thai and Commercial), differentiating the length classes with lowercase and the strains with uppercase letters.

In this study, we verified an inverse relationship between the percentage of water and fat. This has been observed in several studies conducted on fish and, apparently, various species living under different feeding, growth and reproductive development conditions present similarities (JOBLING et al., 2002).

The differences in growth rates between Thai and Commercial strains suggest different metabolic rates in mobilizing nutrients that alter the chemical composition, particularly the water and lipid contents found in this experiment. It is noteworthy that the two strains were reared on the same diet, containing the protein and lipid levels recommended for these fish, and in the same water quality.

Protein content (%) showed no change with the growth of the fish and was similar between strains (Figure 3). SHEARER (1994) stated that the protein content of salmonid in the growing phase is determined only by the size of the fish and it is not affected by growth rate, diet or environmental factors. The protein content of many species of fish increases slowly or remains more or less stable with the increase in body weight (RAMSEYER, 2002).

HEINSBROEK et al. (2007) found a decrease in protein content with the increase the size of eel *Anguilla anguilla.* This information explains the lack of significance of the effect of the length on the protein content found in this experiment.

The fish in the 15-20cm class also had higher percentage of ashes than fish in the 5-10cm class, but similar to the fish in the 10-15cm class. The increase in the percentage of ash was 21% and it did not differ between Thai and Commercial strains (Figure 4).

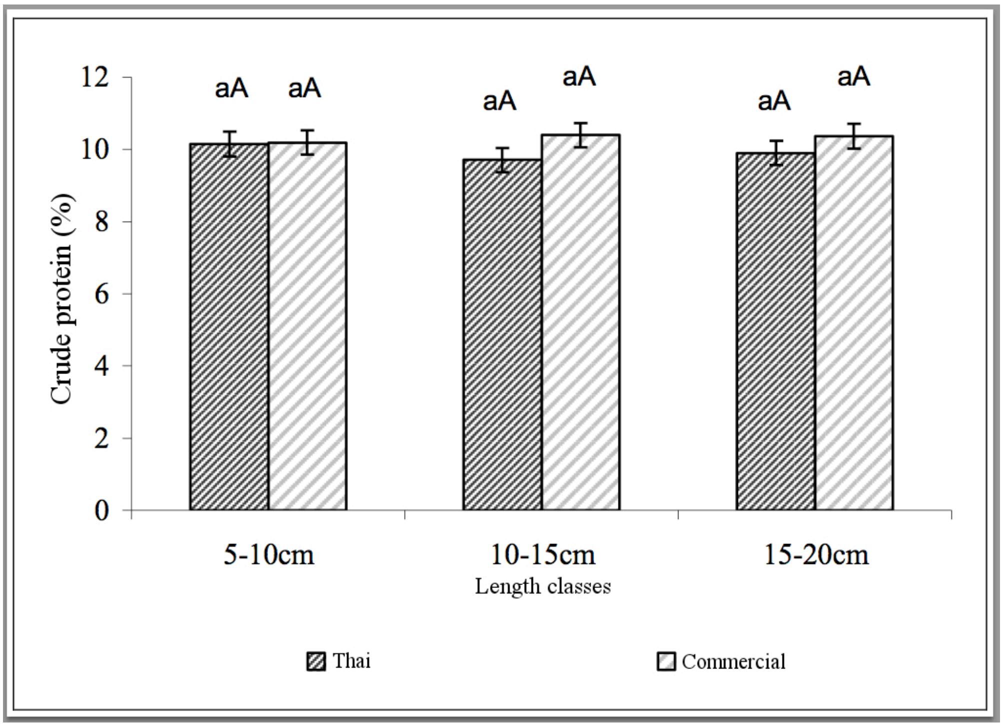

Figure 3. Crude protein behavior (%) with the growth of tilapia strains (Thai and Commercial), differentiating the length classes with lowercase and the strains with uppercase letters.

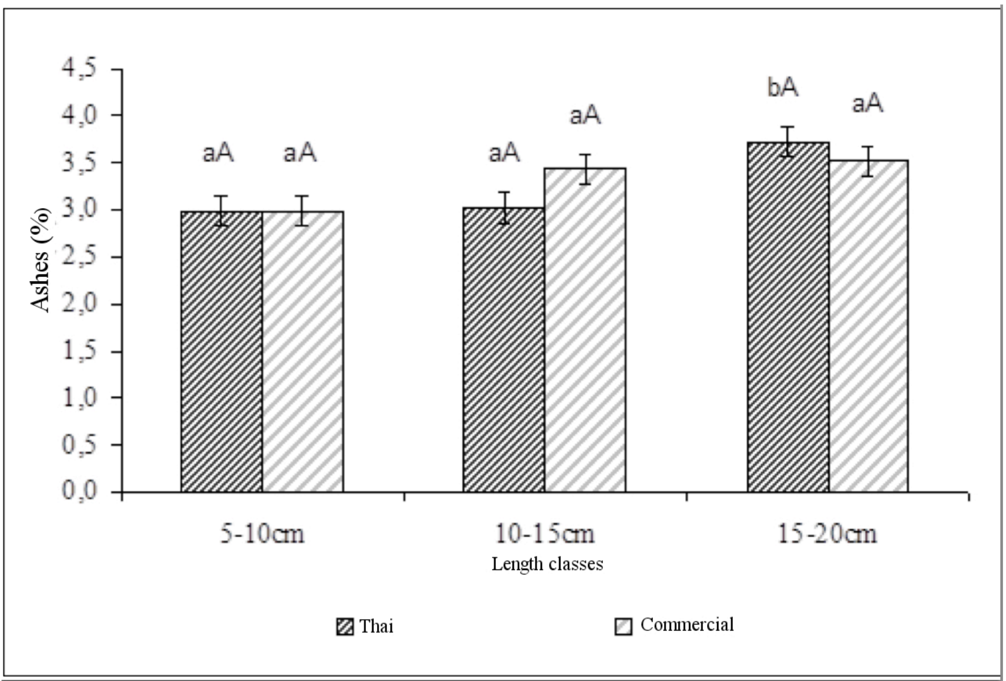

Figure 4. Ashes behavior (%) with the growth of tilapia strains (Thai and Commercial), differentiating the length classes with lowercase and the strains with uppercase letters.

Regarding the percentage of carbohydrates, we observed no alteration among the different length classes for the Thai strain, whereas in the Commercial strain fish of the 15-20cm class showed an increase of 55% compared to the 5-10 and 10-15cm classes (Figure 5). This increase with the growth of the fish in the Commercial strain and the differences found in Thai strain may be associated with differences in allometric growth of muscle tissue, since the carbohydrate found basically correspond to muscle glycogen. SANTOS et al. (2006) verified significant differences in allometric growth of fillet in Thai and Supreme strains, and the Supreme strain had a positive allometric coefficient (b> 1), i.e. the development of fillet is proportionally higher than the body development. As for the Thai, growth fillet was isogonic (b = 1), i.e. proportional to the development of the body.

The biomass gain (in body weight) in animals is the result of the deposition of water, protein, fat, minerals and a small amount of other components (glycogen, etc.). The amount of components deposited per unit of body weight gain is not constant, it changes with the weight of the animal, the kind of feed used, the physiological status, among other factors (BUREAU et al., 2006). The protein content of fish remains relatively constant among the stages of life and is little affected by dietary factors. The lipid content of fish varies depending on the input of energy and growth (SHEARER, 1994).

The amount of energy (kcal/g) increased 32% and 72% for the Thai and the Commercial strains with the growth of the fish. The Thai strain presented higher amounts of energy in 5-10cm and 10-15cm classes compared to the Commercial strain, but there was no difference between them in the 15-20cm class. This difference was about 22% and 12% in the fish of the 5-10cm and 10-15cm classes, respectively (Figure 6).

Carbohydrates, crude protein and lipids contain 17.2; 23.6 and 39.5 kJ/g of gross energy, respectively. Since the carbohydrate content is relatively small in fish (SHEARER, 1994), its contribution to the gross energy content of the whole body is insignificant. The energy content of fish is therefore dependent on crude protein and lipids (GUNTHER et al., 2005). However, in this experiment, the carbohydrate content was approximately 5% and could not be disregarded.

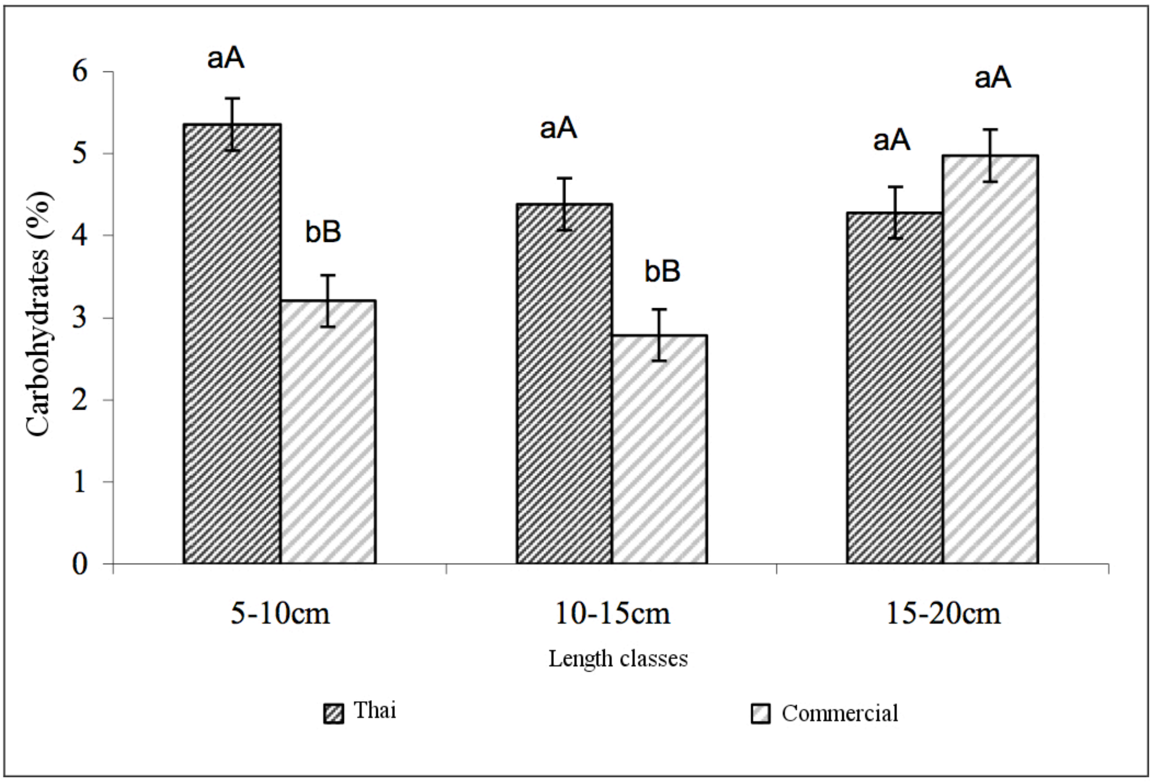

Figure 5. Carbohydrates behavior (%) with the growth of tilapia strains (Thai and Commercial), differentiating the length classes with lowercase and the strains with uppercase letters.

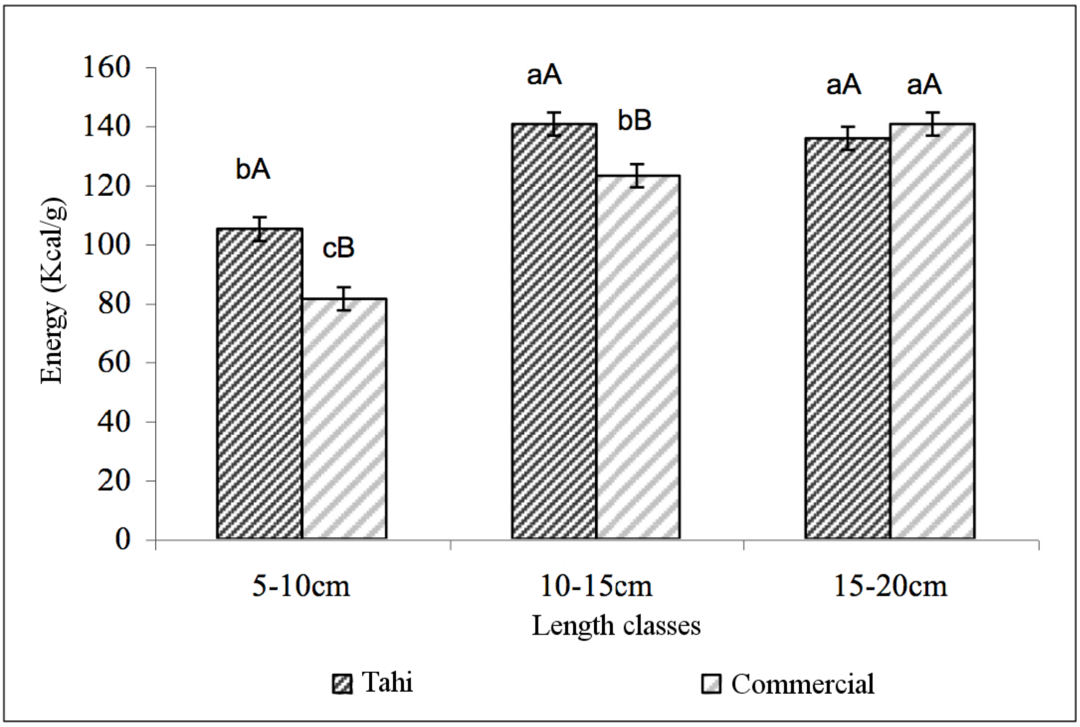

Figure 6. Energy behavior (%) with the growth of tilapia strains (Thai and Commercial), differentiating the length classes with lowercase and the strains with uppercase letters.

According to WEATHERLEY & GILL (1983), caloric content values obtained from direct calorimetry were higher than those obtained indirectly from protein and lipid values in trouts. However, disregarding the energy from carbohydrates, these authors reported that the differences were small between these ways of obtaining energy content.

In this study, protein content remained constant with the increase in length of the fish and was similar for both tilapia strains. Although the lipid content presented significant interaction between strain and size only at 10% of significance, they probably were responsible for the differences found in the energy content behavior between the strains in different size classes.

LUGO et al. (2003) compared the body composition of two genetic groups of tilapia. They were both similar, with differences only in the composition of the fillet. COOK et al. (2000) compared the growth and body composition of genetically modified and non-genetically modified Atlantic salmon *(Salmo salar)*, and reported significant differences. The transgenic genotype showed 2.62 to 2.85 times greater growth than the non-transgenic genotype, but the body composition of the transgenic genotype presented lower matter, protein, ash and lipids content. The difference in lipid content was outstanding, 2.84% and 5.57% in genetically modified and non-genetically modified genotype, respectively. The reduction in the content of proteins and lipids in transgenic genotype was due to their higher metabolic rate.

The fact that the Thai strain had higher lipid content in the first length classes could suggest greater development of its fat tissue; however, the Commercial strain showed greater hyperplasia and hypertrophy of this tissue. In fact, the relation of body mass corresponding to adipose tissue or the lipid content in carcass have not been studied, but visibly, the Thai strain had higher amounts of visceral adipose tissue.

SIMÕES et al. (2007) assessed the physical and chemical composition of tilapia fillet in Thai strain and found moderate lipid and high protein contents, and characterized tilapia as fish with intermediate fat and high protein contents. SIGNOR et al. (2010) studied the addition of an enzyme complex to the diet of tilapia and found better performance and feed conversion, but no effects on carcass composition. LUGO et al. (2003) stated that other body components and characteristics should be studied to determine elements that could assist in the profitable exploitation of tilapia. However, several tests must be performed, especially considering differences among genetic groups.

CONCLUSION

The differential growth rate of tilapia strains (Thai and Commercial) influences mobilization metabolic rates, especially water and lipids, altering the dynamics of deposition of these elements and of the energy content.

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