Revista Ciência Agronômica, v. 49, n. 3, p. 467-474, jul-set, 2018
Centro de Ciências Agrárias - Universidade Federal do Ceará, Fortaleza, CE
www.ccarevista.ufc.br

Scientific Article
ISSN 1806-6690

Valine in diets for Nile tilapia[1]

Valina em dietas para tilápia do Nilo

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ABSTRACT - This study verified the effect of valine on the zootechnical performance, percentage composition and growth of skeletal muscle fibre in fingerlings of Nile tilapia. A total of 270 fish (average initial weight 1.57 ± 0.05 g and total initial length 4.16 ± 0.46 cm) were used, distributed in 18 tanks (250 litres), in a completely randomised design with six treatments and three replications. Six diets (26.81% DP and 3200.00 kcal DE) were formulated with increasing levels of valine (0.82, 0.86, 0.98, 1.04, 1.10 and 1.26% of the diet). The zootechnical performance, percentage composition of the fish, and muscle-fibre distribution were evaluated. There was no effect from the different levels of valine (P>0.05) on zootechnical performance, percentage composition or the frequency distribution of muscle fibre. The addition of 0.82% valine (2.65% crude protein valine) is recommended in the diet of Nile tilapia fingerlings.

Key words: Essential amino acid. Aquaculture. Zootechnical performance. *Oreochromis niloticus*.

RESUMO - Neste estudo foi verificada a influência da valina no desempenho zootécnico, composição centesimal e crescimento das fibras musculares esqueléticas de alevinos de tilápia do Nilo. Foram utilizados 270 peixes (peso médio inicial de 1,57 ± 0,05 g e comprimento total inicial de 4,16 ± 0,46 cm), distribuídos em 18 caixas (250 litros), em delineamento inteiramente ao acaso com seis tratamentos e três repetições. Foram formuladas seis dietas (26,81% PD e 3200,00 kcal ED), com níveis crescentes de valina (0,82; 0,86; 0,98; 1,04; 1,10 e 1,26% da dieta). Foram avaliados o desempenho zootécnico, composição centesimal dos peixes e a distribuição das fibras musculares. Não houve efeito dos diferentes níveis de valina (P>0,05) para o desempenho zootécnico, composição centesimal e frequência de distribuição das fibras musculares. Recomenda-se a inclusão de 0,82% de valina na dieta (2,65% de valina da proteína bruta) para alevinos de tilápia do Nilo.

Palavras-chave: Aminoácido essencial. Aquicultura. Desempenho zootécnico. *Oreochromis niloticus*.

DOI: 10.5935/1806-6690.20180053
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Received for publication 06/06/2016; approved 18/09/2017
[1]Parte da Dissertação em Recursos Pesqueiros e Engenharia de Pesca do primeiro autor, apresentada na Universidade Estadual do Oeste do Paraná/UNIOESTE. Pesquisa apoiada pelo Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) e pela Comissão de Aperfeiçoamento de Pessoal do Nível Superior (CAPES).
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INTRODUCTION

Among the various fish species with a potential for aquaculture production in Brazil, the Nile tilapia (*Oreochromis niloticus*) is the most popular, due to such desirable characteristics as its resistance to handling, good adaptation to environmental variables, high breeding densities (FERREIRA *et al*., 2011), and omnivorous feeding habits, including making good use of food plants (TAKISHITA *et al*., 2009). In addition, it has good quality meat, which when filleted contains no Y-bones (SILVA *et al*., 2009).

The highest cost in intensive fish production is feeding; in a balanced diet, protein foods are usually the most costly and the most important for the growth of organisms (AHHED; KHAN, 2006). It is extremely important for diets used in fish farming to be balanced, so that wastage of excess nutrients can be avoided and nutrition can be more efficient, offering better zootechnical indices to producers.

Proteins and amino acids are indispensable in animal nutrition, since they play an important structural and metabolic role (NRC, 2011), being physiological constituents at all stages of development, besides being responsible for the formation of enzymes and hormones (PEZZATO *et al*., 2004). Fish do not have a specific nutritional need for protein, but rather for an adequate balance of amino acids (BICUDO; CYRINO, 2009).

Valine is an essential amino acid, characterised as hydrophobic, and belongs to the group of branched-chain amino acids together with leucine and isoleucine (NRC, 2011). This group of amino acids is responsible for the development of skeletal tissue (KHAN; ABIDI, 2007); the synthesis of neurotransmitters and energy production (FERNSTROM, 2005); muscle synthesis (SHIMOMURA; YAMAMOTO; BAJOTTO, 2006); the maintenance of immunological parameters in the animals, since they aid in the responsive capacity of lymphocytes and in other cellular functions related to homeostasis (CALDER, 2006); and for the synthesis of non-essential amino acids, especially glutamine and alanine (WU, 2009).

The formulation of diets with an adequate amino acid profile and ideal protein content is indispensable for the best use of these nutrients for growth and the reduction of nitrogen excretion in the growth environment (PERES; OLIVA-TELES, 2009), bearing in mind that nitrogen residue, together with phosphorus, are among the main eutrophic compounds of such environments. However, there are still few studies which aim to determine the ideal concentration of valine in fish diets and its effect in the organism on zootechnical performance and the physiological responses of the animals.

This study was carried out to evaluate valine concentrations in diets for fingerlings of Nile tilapia, analysing responses of zootechnical performance, percentage composition of the animals and the frequency distribution of muscle fibre.

MATERIAL AND METHODS

The experiment was carried out at the Laboratório de Aquicultura do Grupo de Estudos de Manejo na Aquicultura (GEMAq), da Universidade Estadual do Oeste do Paraná, Brazil. The study was approved by the Ethics Committee of the Universidade Estadual do Oeste do Paraná, under protocol 11/2015 of July 2015.

A total of 270 Nile tilapia were used (average initial weight 1.57 ± 0.05 g and total initial length 4.16 ± 0.46 cm). The animals were distributed in 18 fibreglass tanks with a capacity of 250 litres, for a total of 15 fish per experimental unit. A recirculation system was used for the water, with an individual water inlet and outlet for each tank, a central biological filter, constant aeration by means of a central blower, and temperature control by thermostat.

The breeding tanks were cleaned daily by syphoning off the fish excreta and the remains of the feed. Before cleaning the tanks, water was collected from each of the experimental units and from the outlet of the biological filter, to monitor the physical and chemical parameters of the water, such as temperature (28.5 ± 0.03 °C), dissolved oxygen (5.28 ± 0.10 $mg.L^{-1}$), pH (6.95 ± 0.15) and electrical conductivity (115.55 ± 1.75 $\mu S.cm^{-1}$), with the aid of the YSI Professional Plus Multiparameter Water Quality Meter (YSI, Pro Plus, Yellow Springs, OH, USA).

The experimental diets (Table 1) were formulated to be isoproteic (26.81% digestible protein) and isoenergetic (3200.00 Kcal digestible energy), meeting the nutritional requirements for Nile tilapia recommended by Furuya (2010), containing increasing concentrations of valine (0.82, 0.86, 0.98, 1.04, 1.10 and 1.26% of the diet), as per the amino acid compositional analysis of the experimental diets (Table 2). The ingredients were ground in a hammer mill (Vieira, MCS 280, Tatuí, São Paulo, Brazil) with a 0.3 mm diameter sieve, and the feed processed by extrusion (Extec®, Ex-Micro, Ribeirão Preto, São Paulo, Brazil). The fish were fed to apparent satiety four times a day (08:00, 11:00, 14:00 and 17:00) for 79 days.

At the end of the experimental period, the fish were fasted for 24 hours to empty the gastrointestinal tract, and then rendered insensible in 80.0 mg L^{-1} eugenol

(DERIGGI; INOUE; MORAES, 2006) for individual measurement of weight (g) and total length (cm). Three fish from each tank were euthanised in 300 mg.L^{-1} eugenol and then packed in ice for removal of the visceral fat and liver. Three fish from each experimental unit were placed in a freezer to carry out a percentage analysis of the complete fish.

The data for zootechnical performance under evaluation were weight gain (g) (final body weight - initial body weight); daily weight gain (g) (weight gain/days of the experiment); apparent feed conversion (diet consumed/weight gain); visceral fat (%) (weight of visceral fat (g)/final weight (g)*100); hepatosomatic index (%) (weight of liver (g)/final weight (g)*100); condition

Table 1 - Ingredients (g/kg) and calculated proximate composition (%) of the experimental diets for fingerlings of Nile tilapia with increasing levels of valine

Food	Valine level (%)					
	0.82	0.86	0.98	1.04	1.10	1.26
Wheat, bran	320.00	320.00	320.00	320.00	320.00	320.00
Maize, grain	244.10	243.70	243.30	242.90	242.50	242.10
Maize, gluten 60	100.00	100.00	100.00	100.00	100.00	100.00
Meat and bones, meal	30.00	30.00	30.00	30.00	30.00	30.00
Fish, meal	25.00	25.00	25.00	25.00	25.00	25.00
Poultry viscera, meal	25.00	25.00	25.00	25.00	25.00	25.0
Soybean oil	40.70	40.40	40.10	39.80	39.40	39.10
Glutamic acid	65.70	66.60	67.40	68.30	69.10	70.00
L-alanine	55.00	53.80	52.60	51.40	50.30	49.10
L-lysine	11.60	11.60	11.60	11.60	11.60	11.60
L-threonine	9.50	9.50	9.50	9.50	9.50	9.50
Isoleucine	6.00	6.00	6.00	6.00	6.00	6.00
L-arginine	5.60	5.60	5.60	5.60	5.60	5.60
DL-methionine	3.70	3.70	3.70	3.70	3.70	3.70
L-tryptophan	3.50	3.50	3.50	3.50	3.50	3.50
Histidine	1.90	1.90	1.90	1.90	1.90	1.90
Valine	0.00	1.00	2.10	3.10	4.10	5.20
Mineral and vitamin supplement[1]	10.00	10.00	10.00	10.00	10.00	10.00
Dicalcium phosphate	13.40	13.40	13.40	13.40	13.40	13.40
Limestone	24.00	24.00	24.00	24.00	24.00	24.00
Salt	3.00	3.00	3.00	3.00	3.00	3.00
Antifungal	2.00	2.00	2.00	2.00	2.00	2.00
BHT	0.20	0.20	0.20	0.20	0.20	0.20
	Proximate composition (%)					
Digestible energy (Kcal)	3200.00	3200.00	3200.00	3200.00	3200.00	3200.00
Crude protein	30.88	30.88	30.88	30.88	30.88	30.88
Digestible protein	26.81	26.81	26.81	26.81	26.81	26.81
Calcium	2.00	2.00	2.00	2.00	2.00	2.00
Crude fibre	3.54	3.54	3.54	3.54	3.54	3.54
Total phosphorus	1.00	1.00	1.00	1.00	1.00	1.00
Available phosphorus	0.72	0.72	0.72	0.72	0.72	0.72
Fat	7.16	7.13	7.10	7.06	7.03	7.00

[1]Guaranteed levels per kg of product - Premix (DSM-Roche®): Vit. A, 24,000 IU; Vit. D3, 6,000 IU; Vit. E, 300 mg; Vit. K3, 30 mg; Vit. B1, 40 mg; Vit. B2, 40 mg; Vit. B6, 35 mg; Vit. B12, 80 mg; Folic acid, 12 mg; Ca pantothenate, 100 mg; Vit. C, 600 mg; Biotin, 2 mg; Choline, 1000 mg; Niacin; Iron, 200 mg; Copper, 35 mg; Manganese, 100 mg; Zinc, 240 mg; Iodine, 1.6 mg; Cobalt, 0.8 mg

Table 2 - Amino acid compositional analysis of the experimental diets for fingerlings of Nile tilapia with increasing levels of valine

Total amino acids (%)[1]	Valine level (%)					
	0.82	0.86	0.98	1.04	1.10	1.26
Lysine	1.58	1.59	1.57	1.59	1.54	1.50
Threonine	1.48	1.51	1.50	1.48	1.53	1.51
Methionine	0.68	0.72	0.68	0.70	0.69	0.63
Cystine	0.24	0.24	0.24	0.24	0.25	0.25
Methionine+Cystine	0.92	0.97	0.93	0.94	0.94	0.88
Alanine	6.62	7.01	6.94	6.50	6.30	6.04
Arginine	1.46	1.40	1.42	1.39	1.37	1.38
Aspartic Acid	1.28	1.26	1.25	1.23	1.22	1.18
Glutamic Acid	10.09	10.50	10.55	10.30	10.02	9.81
Glycine	1.01	1.03	1.02	1.01	1.05	1.00
Histidine	0.56	0.64	0.59	0.60	0.57	0.52
Isoleucine	1.21	1.20	1.25	1.21	1.27	1.25
Leucine	1.93	1.87	1.90	1.84	1.89	1.85
Phenylalanine	0.89	0.87	0.93	0.88	0.89	0.90
Serine	0.80	0.82	0.79	0.82	0.85	0.84
Tyrosine	0.70	0.67	0.67	0.65	0.70	0.66
Valine	0.82	0.86	0.98	1.04	1.10	1.26
Tryptophan	0.47	0.48	0.48	0.47	0.47	0.47

[1]Analysis carried out by Ajinomoto Animal Nutrition

factor (%) ((final weight/final total length³)*100); specific growth rate (% day^{-1}) (((ln (final weight) - ln (initial weight))/days of the experiment)*100); protein efficiency ratio (weight gain (g)/dry matter crude protein intake (g)); protein retention efficiency (%) ((final carcass protein content*final biomass) - (initial carcass protein content*initial biomass))/protein intake); survival rate (%) (final number of fish/ initial number of fish)*100) and batch uniformity (%) (Number of fish of average body weight + or - standard deviation/(total number of fish*100).

Fish body composition was evaluated following a methodology proposed by AOAC (1995) for the analysis of moisture (pre-drying at 55 ºC for 72 hours followed by drying at 105 ºC for eight hours), proteins (Kjeldhal method: Marconi model MA-36, Piracicaba, São Paulo, Brazil), ether extract (Soxhlet extractor with ether as solvent: Tecnal model TE-044, Piracicaba, São Paulo, Brazil) and mineral matter (calcination of the samples at 550 ºC for 6 hours, model 2000B, Belo Horizonte, Minas Gerais, Brazil).

For histological analysis of the muscle, deep anaesthesia until the total loss of reaction was induced in three fish from each experimental unit, and a sample taken with the aid of a blade from the white dorsal muscle above the lateral line. These samples were placed in 10% buffered formaldehyde for 24 hours, and later preserved in 70% alcohol for analysis. The samples were passed through a process of paraffin embedment, and the paraffin blocks then cut using a microtome (MICROM International GmbH, Walldorf, Germany). The cross sections (5 µm) were submitted to haematoxylin-eosin staining. An image analysis system (Image-Pro Plus 4.5.0.29) was used for the morphometric analysis, and the smallest diameter in 200 muscle fibres was determined per animal, which were grouped into diameter class (<20 µm, 20-50 µm and >50 µm) to evaluate the contribution of hyperplasia and hypertrophy to muscle growth (ALMEIDA *et al*., 2008).

The experimental design was completely randomised with six treatments and three replications. The data were submitted to the Shapiro-Wilk test for normality and Levene's test for homogeneity. After meeting the statistical assumptions, the data were submitted to analysis of variance (ANOVA) at a level of 5%. All analyses were carried out using the Statistica 7.1 software.

RESULTS AND DISCUSSION

The fish fed on diets containing increasing levels of valine presented similar results (*P*>0.05) for weight gain, apparent feed conversion, daily weight gain, protein efficiency, condition factor, survival rate, protein retention efficiency, visceral fat, hepatosomatic index, batch uniformity and specific growth rate (Table 3). This indicated that valine supplementation was not necessary in this study, since a valine concentration of 0.82% in the diet supplied the nutritional needs of the Nile tilapia fingerlings for zootechnical performance, with that valine concentration being obtained from the amino acid content of the diet without supplementation.

A study by Santiago and Lovell (1988) working with larvae of Nile tilapia and purified feed, determined the nutritional requirements for valine to be 0.78%, slightly lower than found in the present study (0.82%). The differences seen between the studies may be related to the composition of the diets, since according to Griffin, Brown and Grant (1992), purified feed has a recognised lower acceptability in fish, as it is less palatable compared to practical feed, resulting in less weight gain and feed efficiency.

Wilson, Poe and Robinson (1980) working with *Ictalurus punctatus*, found that the species requires 0.71% valine in the diet, which is also lower than the value reported in the present study. However, values higher than this concentration are found in the literature, such as that of Ahmed and Khan (2006), who defined a requirement of 1.52% for *Cirrhinus mrigala*; Rahimnejad and Lee (2013), who proposed a requirement of 0.90% valine for *Pagrus major*; and Dong *et al*. (2012), who suggested a requirement of 1.37% valine for *Cyprinus carpio* var. Jian.

The differences found in the literature regarding nutritional requirements for valine can be explained, as several factors besides the species under evaluation can influence the results, such as the physiological state of the animals, the environmental conditions, and the size and age of the animals (WILSON, 2002); the differences in methodology, including growth conditions and nature of the protein source (BENAKAPPA; VARGHESE, 2003); and the statistical model applied. Another important factor that may affect fish demand for valine is the composition of the test diet in relation to the presence, absence and the quantity of other branched-chain amino acids (AHMED; KHAN, 2006), taking into consideration the antagonism or synergism between this group of amino acids.

Therefore, the nutritional balance of the branched-chain amino acids may have influenced the zootechnical performance of the animals of each treatment so that they were similar, as Wu (2009) emphasises that the addition of the three branched-chain amino acids is necessary to heighten the action of leucine in muscle growth. Thus, it can be inferred that there was no imbalance of the branched-chain amino acids in any of the treatment diets, since animal growth and protein retention was similar.

Table 3 - Mean values and standard deviation for the variables of zootechnical performance in fingerlings of Nile tilapia fed with increasing levels of valine in the diet

Variable	Valine level %						P value*
	0.82	0.86	0.98	1.04	1.10	1.26	
IW	1.56 ± 0.01	1.58 ± 0.06	1.60 ± 0.08	1.57 ± 0.10	1.60 ± 0.06	1.55 ± 0.03	0.89
WG	20.25 ± 0.90	21.00 ± 1.39	22.59 ± 2.73	23.67 ± 1.35	21.68 ± 1.87	21.47 ± 2.54	0.20
AFC	1.54 ± 0.08	1.80 ± 0.21	1.60 ± 0.06	1.55 ± 0.04	1.59 ± 0.22	1.80 ± 0.32	0.34
DWG	0.26 ± 0.01	0.26 ± 0.02	0.29 ± 0.03	0.30 ± 0.02	0.27 ± 0.02	0.27 ± 0.03	0.20
RPE	1.56 ± 0.07	1.33 ± 0.14	1.45 ± 0.05	1.53 ± 0.04	1.51 ± 0.20	1.36 ± 0.23	0.30
CF	1.85 ± 0.08	2.05 ± 0.10	1.94 ± 0.18	1.99 ± 0.06	2.04 ± 0.01	2.17 ± 0.18	0.09
SUR	97.67 ± 4.04	86.67 ± 6.51	89.00 ± 3.46	84.67 ± 4.04	95.67 ± 7.51	84.33 ± 7.51	0.06
PRE	25.65 ± 0.71	20.27 ± 3.03	24.80 ± 0.81	25.51 ± 2.08	24.18 ± 2.97	21.78 ± 3.78	0.11
VF	1.46 ± 0.45	1.93 ± 1.45	1.93 ± 0.68	1.21 ± 0.41	1.90 ± 1.11	2.20 ± 0.92	0.78
HSI	1.96 ± 0.36	2.44 ± 0.68	1.48 ± 0.97	2.05 ± 0.88	2.57 ± 1.07	2.10 ± 1.27	0.75
UNI	72.86 ± 5.96	66.54 ± 4.95	62.82 ± 11.10	76.28 ± 1.11	62.74 ± 10.05	59.92 ± 10.80	0.17
SGR	3.29 ± 0.09	3.37 ± 0.10	3.39 ± 0.10	3.54 ± 0.02	3.39 ±0.09	3.41 ± 0.12	0.11

IW = Initial weight (g); WG= Weight gain (g); AFC = Apparent feed conversion; DWG = Daily weight gain (g day^{-1}); RPE = Rate of protein efficiency; CF = Condition factor (%); SUR = Survival rate (%); PRE = Protein retention efficiency (%); VF = Visceral fat (%); HSI = Hepatosomatic index (%); UNI = Uniformity (%); SGR= Specific growth rate (% day^{-1}); *Not significant (*P*>0.05)

According to Luo *et al*. (2014), unbalanced valine diets (deficiency or excess) can lead to problems in the intestinal mucosa of the animals, with a reduction in lysozyme synthesis and acid phosphatase activity, thereby impairing the growth of the immune cells. However, Dong *et al*. (2012) found that an increase of valine in the diet increases the activity of the digestive enzymes, which helps the animal digest food more efficiently and the body make better use of nutrients. The effects discussed above were not found in the present study: the diets used showed no valine deficiency, since the treatment with the lowest concentration of the amino acid (0.82%) was sufficient for animal growth.

There was no effect (P>0.05) from the valine in the diet of the Nile tilapia fingerlings on the variables of moisture, crude protein, ether extract or mineral matter (Table 4).

The result obtained for carcass percentage composition in the present study agrees with those obtained by Han *et al*. (2014) in a study with *Paralichthys olivaceus*. However, Ahmed and Khan (2006) found differences in the percentage composition of *Cirrhinus mrigala* fed different concentrations of valine in the diet, where moisture and mineral matter decreased, while protein and body fat increased with an increase in the valine content. Dong *et al*. (2012) found differences in the body composition of *Cyprinus carpio* var. Jian, where body protein increased and fat and mineral matter decreased with increases in the levels of valine in the diet. Rahimnejad and Lee (2013) corroborated the effect of including valine in the diet of *Pagrus major* on body composition.

The results obtained in the present study can be explained by the diets having been developed to remain isoproteic and isoenergetic, thereby avoiding changes in the percentage composition of the animals. Although valine participates in protein synthesis (SHIMOMURA; YAMAMOTO; BAJOTTO, 2006) and energy production (FERNSTROM, 2005) through catabolism that generates products for the citric acid cycle (ROGERO; TIRAPEGUI, 2008), valine concentrations in the diets offered to the fish in each treatment were not sufficient to alter the protein content of the animal carcass, protein retention or the protein efficiency ratio, nor were they able to alter fat retention, considering that the ether extract carcass composition and the visceral fat of the animals were similar.

Muscle growth can be influenced by a number of factors, including nutrition (KOUMANS; AKSTER, 1995). The branched-chain amino acids are essentially anabolic, aiding in regulating the translation and initiation of protein synthesis in various tissues, and are thus essential for protein synthesis and muscle growth (SHIMOMURA; YAMAMOTO; BAJOTTO, 2006). There was no effect from the different levels of valine in the diet on the frequency distribution of muscle fibres for the diameter classes under evaluation (less than 20 μm, between 20 and 50 μm and greater than 50 μm) (Table 5), demonstrating that the different valine concentrations in the experimental diets provided a similar contribution to muscle-fibre development.

According to Suryawan *et al*. (2011), valine has important physiological functions in the growth of muscle tissue and protein synthesis in the body. Chung and Baker (1992) describe that valine deficiency reduces the use of other limiting amino acids for protein deposition, and is thus essential. On the other hand, its presence in the amount required by the animal results in normal protein synthesis. It is suggested that the valine concentrations in the experimental diets were sufficient for normal muscle growth, consequently the fish of each treatment showed the joint effects of hyperplasia and hypertrophy, with no treatment being more prominent.

There was however a greater presence of fibres of small and intermediate diameter, which is characteristic of the fingerling stage, since in this phase of animal development, there is a greater presence of the effect of hyperplasia. However, there is a need for further research into the relationship between nutrition and muscle growth, especially when linked to amino acids, since they contribute

Table 4 - Mean values and standard deviation for the variables of percentage composition in fingerlings of Nile tilapia fed with increasing levels of valine in the diet

Variable	Valine level %						P Value*
	0.82	0.86	0.98	1.04	1.10	1.26	
MO (%)	71.29 ± 0.35	71.20 ± 0.60	70.90 ± 0.67	71.38 ± 1.18	71.61 ± 0.95	70.13 ± 1.07	0.39
CP (%)	16.13 ± 0.25	14.96 ± 0.77	16.74 ± 0.90	16.36 ± 0.99	15.75 ± 0.19	15.78 ± 0.18	0.07
EE (%)	9.61 ± 0.83	10.59 ± 0.52	9.75 ± 0.41	9.87 ± 0.96	9.71 ± 1.08	10.58 ± 1.54	0.67
MM (%)	4.15 ± 0.18	4.30 ± 0.28	4.04 ± 0.23	4.14 ± 0.07	4.36 ± 0.17	4.68 ± 0.41	0.08

MO = Moisture (%); CP = Crude Protein (%); EE = Ether Extract (%); MM = Mineral Matter (%); *Not significant (P>0.05)

Table 5 - Mean values and standard deviation for the distribution frequency of muscle fibres in the three diameter classes (<20 μm, 20-50 μm and 0 μm) in fingerlings of Nile tilapia fed with increasing levels of valine in the diet

Variable	Valine level %						P Valor*
	0.82	0.86	0.98	1.04	1.10	1.26	
<20	29 ± 13.05	22.22 ± 13.15	23.55 ± 9.43	18.33 ± 6.79	24 ± 8.58	18.66 ± 9.33	0.27
20-50	70 ± 11.93	72.05 ± 10.29	72.44 ± 6.73	77.33 ± 6.62	71.72 ± 8.10	76.83 ± 9.42	0.44
>50	1 ± 2.09	5.72 ± 6.74	4 ± 3.96	4.33 ± 4.34	4.27 ± 3.17	4.5 ± 2.13	0.25

*Not significant ($P>0.05$)

in a unique way to the development of myofibrilla, and play a key role in muscle deposition in fish.

The results seen in the present study show that the dietary levels of valine under evaluation were appropriate for Nile tilapia fingerlings; there was neither a deficiency nor an excess of the amino acid, as animal growth was normal with all diets and the animals appeared to be in good condition and healthy, with no signs of disease or problems of development.

CONCLUSION

The use of diets containing 0.82% valine (2.65% crude protein valine) is recommended for fingerlings of Nile tilapia.

ACKNOWELEDGEMENTS

The authors would like to thank the Araucária Foundation and CAPES for the financial assistance made available via edict 12/2013. Thanks also go to Ajinomoto Animal Nutrition for the amino acid analysis and to CNPq via process no 457.186/2014-3.

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