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RESEARCH ARTICLE

USE OF WATERMELON WASTE MINIMALLY PROCESSED IN THE FEEDING OF TILAPIA

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ABSTRACT

The study proposed to assess ways for inclusion of watermelon waste in feed for tilapia. Thus, three tests were conducted: 1st – measuring the chemical composition of experimental feeds; 2nd – evaluating the digestibility of feed for fish and 3rd – determining the level of inclusion of waste in feed for tilapia. The following treatments were analyzed: T1 – reference diet; T2 – kiln-dry waste and introduced in 30% in the bran feed; T3 – kiln-dry waste and introduced in 30% in the pellet diet; T4 – sun-dried waste and introduced in 30% in the bran feed; T5 – sun-dried waste and introduced in 30% in the pellet feed. The variables analyzed were: chemical composition, coefficient of digestibility, metabolic energy, weight gain, feed intake and feed conversion. The T4 and T5 treatments showed no significant difference, with higher metabolic energy and digestibility coefficient, and are therefore chosen to perform the performance test. It was observed that the weight gain decreased quadratically ($p<0.01$) while increasing the level of inclusion of the waste in the diet. The feed intake and feed conversion were affected by the physical form of diet.

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INTRODUCTION

The fruit culture is a significant activity in Brazil. Intended to provide for the global demand for fresh fruits, and also provide for the market for processed products such as preserves, juices, jams and candies. For this, the number of installed agricultural industries has increased significantly, generating increases in production of agro-industrial waste not suitable for human consumption and which can be used in animal feed. Therefore, the concern about environmental problems is a consensus and has led to increasing interest about the destination of the waste generated by these activities. The use of these residues in animal nutrition, like in alternative feeds to maize, also contributes to minimizing environmental impact, also enables the animal production, since it constitutes a way of reducing the production cost of cattle, swine, fish, among others.

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The tilapia culture has been proving to be a great alternative to freshwater and estuarine aquaculture. The expansion of Nile tilapia farming (*Oreochromis niloticus*) is due to the excellent performance, high ruggedness, easy obtainment of fingerlings, adaptability to several farming systems and acceptance in leisure activity (fishing ponds) and food market (slaughterhouse), for its nutritional and organoleptic qualities of its fillet (Meurer, 2002). Thus, the purpose of this study was to evaluate the best technology in order to provide the waste generated during the minimal processing of watermelon for the feeding of Nile tilapia, as some producers, often have such waste as an environmental problem at the time of disposal.

MATERIALS AND METHODS

Test 1 - Chemical Composition

To obtain the wastes from minimal processing of watermelon, fruit and utensils were previously washed with aqueous solution of sodium hypochlorite at 100 ppm of free chlorine, the pulp was withdrawn to obtain minimally processed

watermelon and the remaining the composes the residue was taken part to sun drying and part to kiln drying at ± 65 ° C. Then they were analyzed to verify the chemical composition of them in relation to nutritional and anti-nutritional parameters. Analyses of chemical composition: crude protein (CP), humidity (H), crude fiber (CF), ash (A), ether extract (EE), phenols, nitrate and oxalic acid, were performed at the Laboratório de Produtos Vegetais (Laboratory of Plant Products) DCA / UFLA through the following methodologies: Van de Kamer & Van Ginkel (1952), Goldstein and Swein (1963), Cataldo *et al*. (1975) and AOAC (1990).

Test 2 – Digestibility

The test was conducted at the Laboratório de Digestibilidade da Estância da Lagoa (Laboratory of Digestibility at Lagoa Ranch) in the city of Perdões – MG – Brazil, to evaluate the apparent digestibility coefficient (ADC) of dry matter, crude protein and ether extract in the waste of minimal processing of watermelon fruits for further balancing a feed for Nile tilapia fingerlings. 800 fingerlings were used, distributed in 20 slant tanks with capacity for 40 liters of water. The determination of apparent digestibility and apparent metabolizable energy was performed by the indirect method, being used as an indicator of 1.0% chromium oxide (Cr_2O_3) incorporated into the feed, according to the methodology described by Cho (1987) and Cho *et al*. (1985).

The diet was prepared by using a practical reference feed composed by 70% reference diet + 30% of the ingredient to be tested according to the table of requirements for fish (NRC, 1993).The tilapia fingerlings, were originated at the Laboratório de Reprodução da Estância da Lagoa (Laboratory of Reproduction at Lagoa Ranch), in the city of Perdões – MG - Brazil, average size of 5 cm and weight average of 3 g. The treatments were selected for the beginning of the pre-trial phase, with 40 fingerlings per tank, where there were four treatments with the different forms of watermelon waste inclusion and 1 treatment with reference feed summing to a total of five treatments with four replications. In the following layout T1 reference diet (bran), T2, reference feed + 30% kiln-dried watermelon waste (bran), T3, reference feed + 30% of the kiln-dried waste (pelleted), T4, reference feed + 30% sun-dried watermelon waste (bran) and T5 reference feed + 30% sun-dried watermelon waste (pelleted). The fingerlings received the experimental diets during the first three days, called pre-trial period. The experimental period lasted for seven days with collection of feces.

Feces collection was performed once each day at 7:30 am, through hose attached to the bottom of the tank which connects to the feces collector. The feeding of the fingerlings was held at 8:30 am, 10:30 am, 1:30 pm and 4:30 pm. 30 minutes after the last meal, all tanks were siphoned through a hose attached at the bottom of them, to eliminate the remaining of feed, feces and waste; 70% of the water was removed for cleaning them, getting the system ready for feces collection the next day.

After the collecting, the feces and water were sealed in glass, and then were centrifuged at 4200 rpm / 8 min at 20-22 ° C, and kiln-dried at 65 ° C. Approximately 28 hours after drying they were macerated and stored in glass jars with lids, for further analysis. At the end of the collection period, the samples were homogenized and subjected to bromatologic analysis performed at the Laboratório de Produtos Vegetais do Departamento de Ciência dos Alimentos da Universidade Federal de Lavras (Laboratory of Plant Products, Department of Food Science, UFLA) Lavras – MG, according to AOAC (1990).

Table 1. Reference feed used in the digestibility test

Ingredients	Quantity (kg)
Corn	61.00
Soy Bran	30.00
Dicalcium phosphate	2.60
Limestone	1.60
BHT	0.20
Binder (Alginate)	0.20
Salt	0.50
Kaolin	2.40
Mineral and Vitaminic Sulpement[1]	0.50
Chromium Oxide	1.00
Calculated values:	
Crude Protein (%)	30.00
Digestible Energy (kcal/kg)	3000
Total Calcium (%)	0.74
Total Phosphorus (%)	0.60
Available Phosphorus (%)	0.60
Ether Extract (%)	4.60
Crude Fiber (%)	3.76

[1] Mineral Vitaminic Supplement (Supremais) Vit. A, 1.200.000UI; Vit. D_3, 200.000UI; Vit. E. 12.000 mg; Vit. K_3, 2.400 mg; Vit. B_1, 4.800 mg; Vit. B_6, 4.000 mg; Vit. B_{12}, 4.800 mg; Folic acid, 1.200 mg; Pantothenic acid Ca, 12.000 mg; Vit. C, 48.000 mg; Biotin, 48 mg; Colin, 65.000 mg; Niacin, 24.000 mg; Fe, 10.000 mg; Cu, 6.000 mg; Mn, 4.000 mg; Zn,6.000 mg; I, 20mg; Co, 2 mg; Se, 20 mg.

The average maximum temperature during the experiment was 23 ° C and average minimum temperature was 17 ° C.The apparent digestibility coefficients of dry matter and nutrients, besides digestible energy were determined using the methodology described by Cho (1987) and Cho *et al*. (1985).The tests for determining the concentration of chromium, in the feces and test feed, were performed at the Laboratório de Pesquisa Animal do Departamento de Zootecnia da Universidade Federal de Lavras (Laboratory of Animal Research, Department of Animal Husbandry at UFLA) Lavras – MG, determined by atomic absorption spectrophotometry, as described by Kimura & Miller (1957), for subsequent calculations of the digestibility coefficient (Mukhopadhyay & Ray 1997, NRC, 1993).

Test 3 – Performance

The experiment was conducted in the structures of Fish Culture at Lagoa Ranch in the city of Perdões, MG – Brazil, over a period of 150 days. 24 hapas were used, made of mosquito screen 2 meters wide by 5 meters long, arranged in ponds of 400 m². 1200 fingerlings on Nile tilapia (*Oreochromis niloticus*) were used, measuring 5 cm on average. After screening, 50 fingerlings were housed in their respective hapas, which constituted the experimental units. The layout used was completely randomized, with a factorial of 2 (bran feed and pellet) x 4 (waste levels 0, 10, 20 and 30%) with three replications, totaling 24 hapas. The feed was given four times a day at 9:00 am, 11:30 am, 2:00 pm and 4:00 pm,

in the proportion of 10% of body weight. The pre-trial period lasted five days, when the animals not adapted were eliminated and the amount of fish that died was restored. After the pre-trial period, lasting 180 days. On the first day, the fingerlings were weighed to correct the amount of feed to be provided from the beginning of the experiment.

Afterwards, they were weighed and measured every 10 days, both to make the adjustment of the feed, and to evaluate the weight, height and length gain. The fish in each hapa were weighed in groups of 10 units for greater precision. To obtain the height and length, 10 fish in each hapa were measured with a millimeters ruler.

The experimental feed on Table 4 were formulated with increasing levels of watermelon waste in the proportion of 0, 10, 20 and 30% to replace corn in the feed, according to the requirements for the species, according to NRC (1993), which were isocaloric and isoproteic.

Table 2. Experimental feeds with increasing inclusion levels of watermelon waste

	Waste Percentage			
Ingredients(kg)	0%	10%	20%	30%
Corn	5.76	5.184	4.608	4.032
Soy Bran	57.6	57.45	57.5	57.45
Fish Bran	26.0	26.0	26.0	26.0
Soy Bean	9.1	9.14	9.14	9.14
Watermelon Waste	0.0	0.576	1.152	1.723
Inert	1.33	1.44	1.43	1.44
Supremais	0.2	0.2	0.2	0.2
BHT	0.01	0.01	0.01	0.01
Total	100.0	100.0	100.0	100.0
Calculated Values:				
Crude Protein (%)	42.0	42.0	42.0	42.0
Metabolizable Energy (kcal/kg)	2878	2878	2878	2878
Calcium (%)	0.135	0.143	0.147	0.156
Phosphorus (%)	0.098	0.098	0.097	0.097

1 Mineral and Vitaminic Supplement (Supremais): Vit. A, 1.200.000UI; Vit. D3, 200.000UI; Vit. E. 12.000 mg; Vit. K3, 2.400 mg; Vit. B1, 4.800 mg; Vit. B6, 4.000 mg; Vit. B12, 4.800 mg; Folic acid, 1.200 mg; Pantothenic acid Ca, 12.000 mg; Vit. C, 48.000 mg; Biotin, 48 mg; Colin, 65.000 mg; Niacin, 24.000 mg; Fe, 10.000 mg; Cu, 6.000 mg; Mn, 4.000 mg; Zn,6.000 mg; I, 20mg; Co, 2 mg; Se, 20 mg.

At the end of the experiment, individual measuring was conduced as weight (g) and total length (cm) of the fish in each experimental unit. The evaluated variables were: average daily weight gain (g), apparent feed conversion, survival and length increase. The data obtained at the end of each experiment were statistically analyzed separately.

The statistical model for the layout was:

$y_{ijkl} = \mu + F_i + N_j + (FN)_{ij} + e_{ijkl}$
where:

y_{ijkl} = observation l in the fish submitted to feed in the physical form i, with i = 1,2;

μ = general average;
T_i = effect of physical form of the feed i, with i = 1,2;
N_j = effect of level j, with j = 1,2,3,4;
$(FN)_{ij}$ = effect of interaction;
e_{ijkl} = error associated to each observation.

RESULTS AND DISCUSSION

Test 1 – Chemical composition

For a better understanding of the nutritional value of the alternative food mentioned, some chemical analyses were conduced, which are shown on Table 3. It is noteworthy that analyses of nutritional and anti-nutritional components were conduced, occasionally present in the evaluated waste. The protein is of great importance as fish food, especially for carnivorous fish that use protein as an energy source. The protein requirement depends on the feeding habits, fish size, source of protein, energy content of the diet, water temperature, feeding frequency, physiological function and species (Logato, 1999). The use of the waste in the feed did not alter negatively the protein content in Table 1, it is possible to see that the experimental feeds did not differ significantly from the reference feed according to the Tukey test at 5% probability. The T4 treatment had lower protein content when compared to the basal feed. One of the barriers to the use of waste in animal feed are the high amounts of fiber and the presence of anti-nutritional factors that may cause problems when given to animals, especially regarding weight gain. The fiber content found in the feed that the waste was included much higher than the reference feed (Table 1). This fact can be explained by the high fiber content which is presented on the watermelon waste (21.20% dry matter) contributing to this increase in the feed. This increase may affect the digestibility and thus influence the performance of the fish.

In addition to the fibers, other chemicals components may have harmful effect on the protein utilization. The polyphenols, for example, may reduce the digestibility and availability of amino acids (Sgarbieri, 1987, 1996). The results found for the studied feed were between 0.33% and 1%. According to Pinto *et al*. (2000) greater levels or levels equal to 0.63% tannins have highly significant harmful effect on the digestibility of nutrients by Nile tilapia. As the technique used in this experiment does not detect only tannins, nothing can be said about it. A high intake of nitrate, which under certain conditions can be reduced to nitrite, represents a risk, for being the starting point for a chain of reactions that converts it into toxic substances. The analyzed feed did not present a high content of nitrate (Table 1).

Test 2 – Digestibility

The species of animals utilize the food differently, this variation being quantified by determining the digestibility coefficients (Andrigueto *et al*., 1982). Table 4 represents the apparent digestibility coefficients of dry matter, ether extract, ash, protein and fiber as well as apparent metabolizable energy of the diets studied. It is observed that the digestibility coefficients, although not presenting significant differences between the types of feed preparation, were high and satisfactory values when compared with those obtained by Pezzato *et al*. (2002) for plant foods commonly used in feed, with this same species.If compared with other alternative ingredients it is possible to notice the high value of apparent digestibility coefficients found for the feeds with the watermelon residue.

Table 3. Average contents of some constituents of the feeds obtained with the inclusion of watermelon waste, integral matter

	Treatments				
Analysis	T1	T2	T3	T4	T5
Humidity(%)	12.19a (± 0.06)	12.42[a] (±0.22)	7.52b (±0.06)	12.39a (±0.17)	7.62b (±0.15)
Ether Extract(%)	2.74a (±0.47)	2.65[a] (±0.15)	2.77a (±0.25)	2.56a (±0.32)	1.96a (±0.38)
Protein(%)	18.53ab (±0.72)	19.10ab (±0.10)	18.84ab (±0.43)	15.26b (±0.22)	20.17a (±0.40)
Crude Fiber(%)	4.65c (±0.55)	11.91b (±0.50)	10.91b (±0.45)	16.47a (±0.38)	17.46a (±0.41)
Ash(%)	2.67d (±0.65)	5.40b (±0.18)	5.79a (±0.21)	4.26c (±0.18)	5.67ab (±0.15)
Nitrogen free Extract*	59.21a (±2.69)	48.52c (±1.00)	54.16b (±2.02)	49.06c (±2.43)	47.11c (±2.13)
Phenolic Compounds(%)	0.267c (±0.02)	0.661b (±0.01)	1.015a (±0.00)	0.338c (±0.02)	0.593b (±0.01)
Nitrate(%)	0.079bc (±0.02)	0.360b (±0.01)	0.458a (±0.01)	0.128c (±0.01)	0.028c (±0.01)
Oxalic Acid(%)	-	-	-	-	-

Averages followed by same letter in row did not differ among themselves, at 5% probability, by Tukey test.
* Determined by difference: 100 - (Humidity + Ethereal Extract + Protein + Fiber + Ash)

Table 4. Apparent digestibility coefficient and metabolizable energy of the products obtained by the inclusion of minimally processed watermelon waste for the Nile tilapia

	Treatments				
Variables	T1	T2	T3	T4	T5
DCDM (%)*	93.52 (±1.35)	92.93 (±1.52)	93.66 (±1.32)	96.94 (±0.86)	96.93 (±0.59)
ADCEE (%)*	97.74 (±0.54)	96.03 (±0.28)	96.89 (±0.42)	97.85 (±0.40)	96.93 (±0.55)
ADCA (%)*	88.20 (±0.18)	95.60 (±0.24)	95.10 (±0.22)	95.00 (±0.36)	93.80 (±0.17)
ADCCP (%)*	96.90 (±0.09)	95.20 (±0.12)	96.90 (±0.19)	97.00 (±0.05)	96.22 (±0.10)
ADCCF (%)*	91.00 (±0.14)	89.40 (±0.20)	86.40 (±0.08)	90.20 (±0.15)	89.60 (±0.22)
AME kcal/kg**	3372a (±0.70)	2250b (±0.64)	2493b(±0.73)	3003ab(±0.68)	3439a (±0.54)

* There was no significant difference between the averages on the same line by the Tukey test at 5% probability.
** There was significant difference between averages on the same line by the Tukey test at 5% probability.

Table 5. Average values of performance parameters of tilapia fingerlings fed on diets with different physical forms

	Physical Form of the Feed		
Variables	Bran	Pelleted	CV(%)
Weight Gain (g)	547.45	549.08	0.346
Feed Intake (g)*	840.99	797.05	0.360
Feed Conversion*	1.53	1.45	0.041

*The averages in the line differ statistically by the F test(P<0,01).

Table 6. Average values of performance parameters of tilapia fingerlings fed on diets containing different levels of watermelon waste

	Waste Level				
Variables	0	10	20	30	CV(%)
Weight Gain(g)*	550.65	550.15	548.57	543.70	0.346
Feed Intake(g)	822.38	821.87	819.18	812.65	0.360
Feed Conversion	1.4948	1.4939	1.4935	1.4934	0.041

*Quadratic regression (P<0,01)

Santos *et al*. (2007) determined the digestibility of feeds with the inclusion of 30% guava waste bran and coconut bran. The digestibility values of the guava waste bran were 43.36% for dry matter and 61.49% for crude protein and the coconut bran were 60.36% for dry matter and 75.62% for crude protein. Pezzato *et al*. (2004) obtained for coconut bran dry matter and protein digestibility coefficient values of 60.53% and 86.78% respectively. Oliveira *et al*. (1994) determined the apparent digestibility of dry matter and protein of palm kernel cake (70.3% and 91.5%) and cocoa seed coat (64.5% and 62.9%) in experiment with Nile tilapia fingerlings. Furuya *et al*. (2001) also worked with Nile tilapia and obtained a value for apparent digestibility of crude protein of 86.92% for canola bran (*Brassica nabus*). The digestibility of fiber in the feed showed no significant difference compared to the reference feed, indicating possibility for using of the proportions studied on the project. It is possible to observe, through Table 2, that there were significant differences in apparent metabolizable energy between the products obtained by the inclusion of watermelon waste. Feeds containing sun-dried watermelon waste and introduced into pellets and bran, T4 and T5, showed no significant difference between them, and are therefore chosen to perform the performance test.

Test 3 – Performance

Tables 5 and 6 show the results obtained for the performance test. The physical form did not affect weight gain (P> 0.05), but influenced the feed intake and feed conversion (P <0.01), with the pelleted feed was more effective. It can be noticed from the results that there were significant differences in weight gain, as the weight gain decreased quadratically (P <0.01) by increasing the level of inclusion of the waste in the diet. Santos *et al*. (2007) evaluated the productive performance of Nile tilapia fed different levels of coconut bran in feeds. According to these authors, there were no significant

differences observed (P> 0.05) for weight gain and average feed intake, but there was an linear increasing effect on feed conversion with increasing levels of coconut bran, worsening significantly (P <0.05). According to Santos *et al*. (2007) this negative effect was due to the removal of protein sources, these being replaced by coconut bran, rich in fiber. According to Pezzato *et al*. (2004) the inclusion of up to 30% coconut bran in the diets of Nile tilapia provided better results in weight gain. Guimarães *et al*. (2004) working with cassava flour (*Manihot esculenta*) as an energetic ingredient in feed for Nile tilapia, replacing corn at levels of 0, 50, 75 and 100%, concluded that cassava flour can replace corn in up to 50 % without affecting weight gain, feed conversion and fillet yield. In this study the increase of the waste level in the feed may negatively affect the performance of the animals probably due to the high fiber content which is present in watermelon waste (21.20% dry matter), interfering with the proper use of the protein. It is noteworthy that in all treatments suitable slaughter weight for tilapia was obtained, and therefore the option for using this alternative ingredient can be based on the economic advantage of this practice.

Conclusion

It is feasible to replace the feed by the studied waste, because the experimental diet showed good results in terms of nutritional composition; the levels of anti-nutritional found, on average, were low; the analyzed diets showed apparent digestibility coefficients and relatively high and the performance results proved that the use of minimally processed watermelon waste as feed for Tilapia (*Oreochromis niloticus*) is possible, because in all the treatments slaughter weight suitable for tilapia was obtained, even with the inclusion of 30% waste, in which the gain weight was lower. The physical shape influenced the feed intake and feed conversion, and the pelleted diet was more effective.

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