Utilization of proteinic sugarcane meal in the feeding of juvenile red tilapia

A. Botello[1], M.V. Cisneros[1], María T. Viana[2], M. I.Valdivié[3], E. Pullés[4], E.Téllez[4], G.S. Silvera[1], Y. Valera[5], I.G. Angulo[1], A.B. Rodríguez[6], R.B. Rodríguez[5] and Kirenia P. Corría[1]

[1]*Instituto de Investigaciones Agropecuarias "Jorge Dimitrov", Carretera Bayamo-Manzanillo km 16 ½, Peralejo, Bayamo-Granma-Cuba. C.P. 85300*
Email: abotellol@dimitrov.cu
[2]*Instituto de Investigaciones Oceanológicas, Universidad Autónoma de Baja California, México*
[3]*Instituto de Ciencia Animal, Apartado Postal 24, San José de las Lajas, Mayabeque, Cuba*
[4]*Dirección Provincial de Acuicultura, Granma, Cuba*
[5]*Facultad de Medicina Veterinaria, Universidad de Granma, Carretera a Manzanillo, km 17, Apartado Postal 21, Bayamo, Granma 85100*
[6]*Instituto de Medicina Veterinaria, Holguín, Cuba*

In order to determine the biological response of juvenile red tilapia (*Oreochromis spp*.), fed different levels of inclusion of proteinic sugarcane meal (PSM), four isoprotein diets were formulated with different levels of PSM inclusion (T0:0 %; T6:6 %; T8:8 %, and T10:10 %). Six hundred young red tilapias with average initial weight of 4.16 ± 0.01 g were fed for 60 d. They were spread in a completely randomized design of five rectangular cages per treatment (0.256 m^3; 0.8 × 0.8 × 0.4 m), suspended on a circular concrete pond (8 m diameter and 2 m height), with 30 fishes per cage. They were determined final weight, daily weight increase, protein efficiency rate, feed conversion factor, and survival. There were not significant differences between the treatments as to growth indicators and feed utilization. Survival showed values of 99 %. It was concluded that the PSM can be included in the diets of juvenile red tilapia up to 10 %, not affecting the bio-productive indicators.

Key words: *proteinic sugarcane meal, red tilapia.*

Tilapia is the common name by which several species of the Oreochromis and Tilapia genera are known. They are fresh water fish, native of Africa and the Near East (Baltazar 2007). They can be grown in ponds or cages. They support high densities and stand adverse environmental conditions (Cantor 2007).

Their production can be limited by the current rise in costs associated with their feeding (González 2010). Thus, the efficient utilization of residuals from fisheries is of great importance, as well as those from aquatic organisms that, due to their color, smell, taste, shape, or size, are not apt to human consumption (Blanco *et al*. 2007). The fast deterioration and the heterogeneity in the raw material constitute a limitation to this goal. Besides, its storage and transport makes the product more expensive, hence, a method is needed to allow its immediate utilization at low cost.

The chemical fish silage is a variant of the efficient utilization of residuals. It has, as fundamental principle, the preservation through the addition of organic and inorganic acids, stored at room temperature, and it can be a component of animal rations (Álvarez 1972 and Borghesi *et al*. 2007).

The chemical fish silage, stored at room temperature, is kept up to two years without putrefaction (Tatterson and Windsor 1974). However, it has high humidity content (70-80 %), thus, it is convenient to mix it with raw materials facilitating the drying and providing nutrients. Fagbenro (1994) used several meals: soybean, poultry byproducts, and hydrolyzed products of feathers, meat and bones. Goddard and Perret (2005) used wheat bran. Although these feeds contribute to reduce the cost by transportation and to optimize the storage, they have high prices in the world's market.

In order to decrease the liquid content of the chemical fish silage, Cisneros *et al*. (1999) used sugarcane meal, cheap feed and with high availability in Cuba, having high hygroscopic capacity. Besides, when mixing it with the silage, the proteinic sugarcane meal (PSM) is created, with average crude protein value of 28.0 %. For the feeding of laying hens, broiler chickens, and ducks, it has been included up to 20 % in the feedstuffs and favorable results have been obtained in bio-productive and economic indicators.

The objective of this work was to determine the biological response of juvenile red tilapia (*Oreochromis spp*.) fed different inclusion levels of proteinic sugarcane meal.

Materials and Methods

Elaboration and characterization of the proteinic sugarcane meal. For the elaboration of the PSM, sugarcane (*Saccharum officinarum*), variety Jaronú 60-5, was used complete and without leaves. It came from the areas of the sugarcane mill "Bartolomé Masó" of the Granma province.

The fish silage came from the industrial fishery "Andrés Luján Vázquez", located in Manzanillo, Granma. It was made using Atlantic thread herring (*Opisthonema oglinum*) complete and fresh (byproduct of the fauna surrounding shrimps, species not apt to human intake). It is later added sulfuric acid, according to the methodology of Miranda (1999).

The PSM was elaborated according to Cisneros *et al*. (1999). Three samples were collected to conduct the chemical analysis (table 1).

Table 1. Chemcial composition of the proteinic sugarcane meal (% dry basis)

Nutrients	(%)
Dry matter (DM)	90.5±0.6
Crude protein (CP)	29.8±0.3
Crude fat	03.5±0.4
Crude fiber (CF)	13.3±0.6
Ash	12.1±0.3
Nitrogen free extract (NFE)	41.2±0.8
pH	03.9±0.3

Means ± Standard deviation (SD)

Preparation of the diets. Four diets were formulated with different levels of PSM (T0 0 %; T6 6 %; T8 8 %; and T10 10 %) (table 2). The ingredients were ground in a hammer mill and mixed for five minutes until obtaining a homogeneous product. The formation of the pellets was performed in a meat mill, with 1.0 mm diameter. Later, they were put in the oven at 60 ºC for eight hours. In order to conduct the chemical analysis, three samples of 1000 g were collected from each diet.

Chemical analysis. It was performed by triplicate (AOAC 1995): dry matter (DM), crude protein (CP), crude fat, ashes, crude fiber (CF), and nitrogen free extract (NFE). The digestible energy (DE) was calculated according to New (1987), considering 3.0 KJ g^{-1} for carbohydrates (no legume), 2.0 (legume), 4.3 animal protein, 3.8 plant protein, and 8.0 for lipids.

Bio-assay. It was conducted in the ACUIPASO fishery, at the mill "Bartolomé Masó", located in Granma, Cuba. Six hundred juvenile male red tilapia (*Oreochromis spp*.) were used. The tilapias were adapted to the system for seven days. In this period, they consumed commercial feed of tilapia. Organisms of 4.16 ± 0.01 g were distributed randomly in rectangular cages (0.256 m^3; 0.8 × 0.8 × 0.4 m), suspended (five for each treatment) within a circular pond of concrete (8 m diameter and 2 m height), located in a roofed pen. The water flow was of 0.47 L s^{-1}. Thirty animals were put in each cage for 60 d. The mesh bird feeders (0.5 mm of mesh and 0.4 × 0.4 m) were used to measure the feed intake. The feeding frequency was of four daily rations (7:30 am, 10:00 am, 12:30 pm, and 3:30 pm) and the rate of 7 % in respect to the body eight per day (Toledo 2007).

Biological evaluation. The organisms were weighed individually (0, 15, 30, 45, and 60 d) to obtain the following parameters, according to Tacon (1989): initial weight (IW), final weight (FW), daily weight increase (DEI) (DWI = FW-IW/ culture time), protein efficiency rate (PER), and weight gain throughout the assay/ total of protein consumed. The feed conversion factor (FCF) was calculated out of the total of the feed consumed/weight gain throughout the assay. The survival was determined according to the number of final animals/number of initial animals x 100.

Physico-chemical variables in water. Temperature, concentration of dissolved oxygen (Oxyguard MK III), and pH were recorded daily before each feeding, whereas the nitrites, nitrates, and ammonium every 10 d through YSI 2030 spectrophotometer, according to APHA (1981).

Design of the assays. The bio-assay was performed in completely randomized design, with four treatments, according to the PSM inclusion level (0, 6, 8, and 10 %), and five repetitions (30 fishes per repetition). The data were performed one-way analysis of variance, with previous test of the normal distribution of the data by means of the test of Kolmogorov Smirnov (Massey 1951). The test of Bartlett (1937) was applied for homogeneity of variance. In the instances the normality and the homogeneity of variance were not fulfilled, analysis of variance was applied by ranges of Kruskal-Wallis. In all the analysis, the software STATISTICA®, version 6,0 for Windows 2000 was used.

Results and Discussion

In this study, when mixing sugarcane with the fish silages it was obtained 30 % of CP (table 1), good value of protein, and 3.5 % of crude fat. Nevertheless, high values of CF (13. 3%) were attained limiting the utilization in animal feeding. The results of the chemical PSM composition were similar to those of Cisneros *et al*. (1999) and Rodríguez (2007). The chemical analysis (table 2) of the diets confirmed that they are isoprotein, with average values of CP (35 %). The requeriments of crude protein for juvenile and fingerlings of tilapia were of 35 % (Winfree and Stickney 1981, Santiago *et al*. 1982, and Teshima *et al*. 1985).

Elangovan and Shim (1997) noted that protein is the most abundant chemical group of the organism after water. It is also the essential nutrient that promotes the growth and has the capacity of being used as energy source. The levels of protein required by fishes varied in the different species, according to the physiological status, culture and environment conditions.

In this study, CF was of 1.5 % in the control diet and the values were of 2.2 to 2.6 % in the feedstuffs including the PSM (table 2). These results were lower than the 4 % recommended by Shiau *et al*. (1989) for the nutrition of tilapias.

The average calculated value of the DE (11.7 KJ g^{-1} of feed) (table 2) was superior to9.2 KJ g^{-1} of feed, reported by Toledo *et al*. (2007). These authors used

Table 2. Percent and chemical composition of the diets (% dry basis)

Ingredients	Inclusion levels			
	T 0%	T 6%	T 8%	T 10%
Fishc meal	30.00	25.30	24.38	23.44
Proteinic sugarcane meal	-	6.00	8.00	10.00
Soybean meal	33.80	34.20	34.60	35.00
Wheat meal	20.00	20.00	20.00	20.00
Corn meal	6.55	4.85	3.37	1.91
Soybean oil	3.00	3.00	3.00	3.00
Sodium chloride	0.15	0.15	0.15	0.15
Premixture of minerals[a]	1.00	1.00	1.00	1.00
Premixture of vitamins[b]	1.00	1.00	1.00	1.00
Bentonite	2.50	2.50	2.50	2.50
Monocalcium phosphate	2.00	2.00	2.00	2.00
Total (%)	100.00	100.0	100.0	100.00
Chemical composition (%)				
Dry matter (DM)	92.70	92.50	92.50	92.40
Crude protein (CP)	35.10	35.00	34.90	35.00
Crude fat	6.80	6.80	6.70	6.70
Crude fiber (CF)	1.50	2.20	2.40	2.60
Ashes	13.20	13.70	13.70	13.80
Nitrogen free extract (NFE)	43.50	42.40	42.20	42.00
Calculated values				
DE (KJ g^{-1} of feed)	11.82	11.76	11.71	11.70
CP DE^{-1} (mg CP KJ^{-1})	27.77	27.75	27.72	27.72
CP animal origin CP $Total^{-1}$ (%)	50.30	50.20	50.30	50.30

[ab] Recommended by Llanes (2010)

40 % of chemical fish silages in the diets to feed the African catfish (*Claria gariepinus*), but with levels of CP of 21.40 %.

El-Dahhar and Lovell (1995) reported, for tilapias of 4.0 to 8.0 g, a CP DE^{-1} ratio (mg CP KJ-1) from 26.8 to 28.20. Similar results were obtained in this research (27.7) (table 3).

The average final weight and the daily weight increase of the four treatments did not have significant differences (table 3), which could be related to the similar chemical composition of the feedstuffs (table 3).

Oliveira *et al*. (2007) elaborated chemical silage of shrimp head and acetic acid (15.0 %) to substitute the fish meal in 0, 33.3, 66.6, and 100 %. They formulated four diets, with values of CP of 36.0 % for the nutrition of juvenile tilapia (*Oreochromis niloticus*) during 60 d of culture, and they did not observed significant differences as to the final weight.

Deyab *et al*. (2003) substituted the fish meal in 0, 25, 50, 75, and 100 % by a mixture of plant meals (soybean, cotton, sunflower and linseed) and 0.5 % of methionine and lysine. They also formulated, five isoportein (33.6 % CP) and isocaloric diets (19.7 KJ g^{-1} of feed gross energy), with similar amino acid composition for

Table 3. Biological indices of juvenile red tilapia fed PSM

Indicators	Treatments				
	T 0 %	T6 %	T8 %	T10 %	SE ±
Initial weight (g)	4.15	4.17	4.16	4.15	0.01
Final weight (g)	28.28	28.33	28.31	28.23	0.08
Daily weight increment (g day^{-1})	0.40	0.40	0.40	0.40	0.001
Protein efficiency rate	1.71	1.72	1.72	1.71	0.006
Feed conversión factor	1.81	1.79	1.80	1.81	0.007
Survival (%)	99.00	99.00	99.00	99.00	-

SE = standard error. No significant differences were observed within the rows ($P < 0.05$)

the nutrition of juvenile tilapias (*Oreochromis niloticus*). After 16 weeks, no significant differences between the treatments were observed as to the final weight.

In this research, the ocntributions of CP of animal origin were considered in respect to the total CP of the diet (50 %) to contribute to equal the amounts of essential amino acids (table 2) and attain a similar response of the biological variables (table 3).

Yue and Zhow (2008), when substituting soybean meal by cotton meal, in 0, 8, 4, 16,9, 25,3, 33.8 and 56.3 %, elaborated six isoprotein diets, with 31.0 % of CP for the nutrition of juvenile red tilapia (*Oreochromis niloticus* x *Oreochromis aureus*) and obtained PER of 2.4. Fagbenro *et al*. (1994) used fish silages to feed juvenile *Oreochromis niloticus* and reported values of 2.0. They were slightly superior to those in this research.

The FCF did not have differences between the treatments (table 3), which is related to the similar chemical composition of the feedstuffs. Fagbenro and Jauncey (1994) fed juvenile *Clarias gariepinus* with fish silages and formulated four semi-humid diets. These authors obtained higher values in this indicator (2.5). Llanes (2010) used semi-humid diets, formed by 40 % of fish silage, and reported superior values of 3.6 for the FCF in the feeding of juvenile red tilapia (*Oreochroomis spp*.). The FCF was lower (1.8) in this study, which permitted better economic and biological outcome.

The survival of the juvenile fish in all the treatments had satisfactory performance (99 %). This evidenced the adequate role of the juvenile fish throughout the assay (table 3).

The average temperature of the water during the culture was of 27.8 ºC. The average values of concentration of dissolved oxygen were of 4.5 mg/L. Nitrites, nitrates, and ammonium were kept throughout the culture, with optimum levels for the normal growth of this fish (Cantor 2007).

It was concluded that the proteinic sugarcane meal can be part of complete diets in the feeding of juvenile red tilapia (*Oreochromis spp*.) up to 10 %, not affecting the growth indicators, feed utilization and survival. This is an alternative in order to use fishery residuals.

References

Álvarez, R.J. 1972. A comparative study of the nutritional value of the protein from ensiled fish. Cuban J. Agric. Sci. 6:219

AOAC 1995. Official Methods of Analysis. Off. Agric. Chem. 16th Ed. Washington. D.C. USA

APHA 1981. Standard methods for the examination of water 15th Ed. American Public Health Association. New York. 769 pp.

Baltazar, P.M. 2007. La tilapia en el Perú: acuicultura, mercado, y perspectivas. Rev. Perú. Biol. 13:267

Bartlett, M. 1937. Properties of sufficiency and statistical tests. Proc. Royal Soc. Lond. 160:268

Blanco, M., Sotelo, C.G., Chapela, M.J. & Pérez-Martín, R.I. 2007. Towards sustainable and efficient use of fishery resources: present and future trends. Food Sci. Tech. 18:29

Borghesi, R., Portz, L., Oetterer, M. & Cyrino, J. E. 2007. Apparent Digestibility coefficient of protein and amino acids of acid, biological and enzymatic silage for Nile tilapia *Oreochromis niloticus*. Aquaculture Nutr. 3:1

Cantor, F. A. 2007. Manual de producción de tilapia. Available: <http://www.sdr.gob.mx/Contenido/Cadenas%20Productivas/DOCUMENTOS%20CADENAS%20AGROPECUARIAS/acuicolas/tilapia/MANUAL%20TILAPIA.pdf> [Consulted: August 24, 2009]

Cisneros, M., Otero, M., Castillo, E., Miranda, O., Rodríguez, R., González, J. L., Betancourt, M. & Fonseca, J. 1999. . Harina de caña enriquecida con proteínas HCP para la ceba de pollos y peces. Technical report. Centro de Estudio de Producción Animal. Universidad de Granma, Cuba. 26 pp.

Deyab, M.S., El-Saidy, D., Magdy, M. & Gaber, A. 2003. Replacement of fish meal with a mixture of different plant protein sources in juvenile Nile tilapia, *Oreochromis niloticus* L. diets. Aquaculture Res. 34:1119

Elangovan, A. & Shim, K. F. 1997. Growth response of juvenile *Barbodes altus* fed isocaloric diets with variable protein levels. Aquaculture 158:321

El-Dahhar, A. A. & Lovell, R. T. 1995. Effect of protein to energy ratio in purified diets on growth performance, diet utilization and body composition of Mozambique tilapia, *Oreochromis mossambicus* Peters. Aquaculture Res. 26:451

Fagbenro, O. 1994. Dried fermented fish silage in diets for *Oreochromis niloticus*. The Israeli J. Aquaculture Bamidgeh 46:140.

Fagbenro, O. & Jauncey, K. 1994. Growth and protein utilization by juvenile catfish *Clarias gariepinus* fed moist diets containing autolysed protein from stored Lactic-acid-fermented fish-silage. Bioresource Tech. 48:43

Fagbenro, O., Jauncey K. & Haylor, G. 1994. Nutritive value of diets containing dried lactic acid fermented fish silage and soybean meal for juvenile *Oreochromis niloticus* and *Clarias gariepinus*. Aquaculture Living Res. 7:79

Goddard, J. S. & Perret J. S. 2005. Co-drying fish silage for use in aquafeeds. Anim. Feed Sci. Tech. 118:337

González, S.R. 2010. Cultivo de la *Lemna perpusilla* en el Valle del Cauto y su empleo en la alimentación de alevines y juveniles de tilapia roja (*Oreochromis mossambicus* x *Oreochromis niloticus*). PhD Thesis. Vet. Instituto de Ciencia Animal. Cuba

Llanes, J.E. 2010. Caracterización y evaluación del ensilaje de residuos pesqueros como sustituto de la harina de pescado en dietas semi-húmedas para tilapias rojas (*Oreochromis mossambicus* x *Oreochromis niloticus*). PhD Thesis. Instituto de Ciencia Animal. Cuba

Massey, F. J. 1951. The Kolmogorov-Smirnov test for goodness of fit. J. Am. Stat. Assoc. 46:68

Miranda, O. 1999. Caracterización físico-química del ensilaje de pescado conservado con acido sulfúrico comercial. Master's Thesis in Animal Nutrition. Centro de Estudios de Producción Animal. Universidad de Granma, Cuba

New, M.B. 1987. Feed and feeding of fish and shrimp. A manual on the preparation of compound feeds for shrimp and fish in aquaculture. FAO. Rome. Italy. 275 pp.

Oliveira, J.M., Oliveira, E.S. & Singh, P.B. 2007. Utilization of shrimp industry waste in the formulation of tilapia *Oreochromis niloticus* Linnaeus feed. Bioresource Tech. 98:602

Rodríguez, R.B. 2007. Valor nutritivo de la harina de caña proteica y su inclusión en la alimentación de gallinas ponedoras White Leghorn L33. PhD Thesis. Instituto de Ciencia Animal. Cuba

Santiago, C.B., Banes-Aldaba, M. & Laron, M. A. 1982. Dietary crude protein requirement of tilapia nilotica fry. Philipp. J. Biol. 11:255

Shiau, S.Y., Kwok, C. C., Chen, C. J., Hong, H. T. & Hsteh, H. B. 1989. Effects of dietary fiber on the intestinal absorption of dextrin, blood sugar level and growth of tilapia, *Oreochromis mossambicus* x *Oreochromis aureus*. J. Fish Biol. 34:929

STATISTICA for Windows. 6.0. 2000. Available: <http:// http://www.statsoft.com>

Tacon, A.G. 1989. Nutrición y alimentación de peces y camarones cultivados manual de capacitación. Proyecto Aquila II. Documento de campo no 4. FAO-Italia

Tatterson, I. & Windsor, M. 1974. Fish silage. J. Sci. Food Agric. 25:369

Toledo, J. P. 2007. Procedimientos operacionales de trabajo para los aspectos nutricionales del cultivo de la tilapia. Ministerio de la Industria Pesquera. Cuba. 9 pp.

Winfree, R. A. & Stickney, R. R. 1981. Effects of dietary protein and energy on growth feed conversion efficiency and body composition of *Tilapia aureus*. J. Nutr. 111:1001

Yue, Y.R. & Zhow, Q.C. 2008. Effect of replacing soybean meal with cottonseed meal on growth, feed utilization, and hematological indexes for juvenile hybrid tilapia, *Oreochromis niloticus* x *O. aureus*. Aquaculture 284:185

Received: June 6, 2011