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Evaluation of cassava leaf meal in the *Clarias gariepinus* feeding

Evaluación de harina de hojas de yuca en la alimentación de *Clarias gariepinus*

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Different levels (0, 6, 9 and 12 %) of cassava leaf meal (variety CMC-40) were evaluated in the feeding of *Clarias gariepinus* small fish. A total of 180 animals with an average initial weight of 10.34 (0.08) g were randomly placed in twelve circular cement tanks with a capacity of 68 L. The experimental treatments consisted of four diets: the commercial catfish pre-fattening feed (control) and the remaining ones with 6, 9 and 12 % cassava leaf meal as a partial substitute for soybean and wheat. The experimental cassava leaf meal had 23.87 % crude protein and 16.60 % crude fiber. There were not differences between the amount of food (87.13, 85.57, 86.43 and 85.33 g) and protein supplied per animal (26.80, 26.57, 26.21 and 25.78 g). The growth rates (62.58, 61.31, 62.44 and 59.95 g of final average weight) and the feed conversion ratio (1.65, 1.68, 1.66 and 1.71) were not affected by either diet. Survival was 100 % for all treatments. Economic analysis showed that increasing the amount of cassava leaf meal reduced feeding and rations costs in all treatments. The greatest cost savings resulted from the inclusion of 9 % cassava leaf meal. It is concluded that the inclusion of up to 12 % cassava leaf meal does not compromise the productive performance of *Clarias gariepinus* small fish and has a positive economic impact.

Key words: *agricultural by-product, alternative food, catfish, nutrition*

Se evaluaron diferentes niveles (0, 6, 9 y 12 %) de harina de hojas de yuca (variedad CMC-40) en la alimentación de alevines de *Clarias gariepinus*. Un total de 180 animales de 10.34 (0.08) g de peso promedio inicial se ubicaron al azar en doce tanques circulares de cemento de 68 L de capacidad. Los tratamientos experimentales consistieron en cuatro dietas: el pienso comercial de preceba de bagres (control) y las restantes con 6, 9 y 12 % de harina de hojas de yuca como sustituto parcial de la soya y el trigo. La harina de hojas de yuca experimental tuvo 23.87 % de proteína bruta y 16.60 % de fibra bruta. No se encontró diferencia entre la cantidad de alimento (87.13, 85.57, 86.43 y 85.33 g) y proteína suministrada por animal (26.80, 26.57, 26.21 y 25.78 g). Los crecimientos (62.58, 61.31, 62.44 y 59.95 g de peso promedio final) y la conversión alimentaria (1.65, 1.68, 1.66 y 1.71) no se afectaron con una u otra dieta. La supervivencia fue 100 % para todos los tratamientos. El análisis económico mostró que el incremento de harina de hojas de yuca disminuye los costos de las raciones y de alimentación en todos los tratamientos. El mayor ahorro monetario resultó cuando se incluyó 9 % de harina de hojas de yuca. Se concluye que la inclusión hasta 12 % de harina de hojas de yuca no compromete el desempeño productivo de alevines de *Clarias gariepinus* y tiene una repercusión económica positiva.

Palabras clave: *alimento alternativo, bagre, nutrición, subproducto agrícola*

Introduction

The catfish *Clarias gariepinus* is the main species of intensive culture in Cuba. The commercial feeds formulations contain high levels of soybean and wheat, products that are not produced in Cuba, so it is necessary to resort to imports. Given the country's difficult economic situation and the upward trend in the prices of these raw matters, the alternative of the integral use of cassava (*Manihot esculenta,* Crantz) is presented, a shrubby plant that is mainly cultivated to take advantage of its tubers in human and animal feeding and for industrial use.

The use of cassava tubers involves the generation of large volumes of leaves that have protein, vitamin and mineral content (Díaz and López 2021). The protein levels of leaves vary from 17 to 30 % (Leguizamón *et al.* 2021) and although they are deficient in methionine and energy, in combination with other raw matters, cassava tubers constitute a product of good nutritional quality for animal feeding (Blanquiceth *et al.* 2025).

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The amount of cassava foliage varies with the age of the plant. However, at harvest time it is abundant, but due to the cyanide level it is toxic and is completely wasted. Valdivié (2022) reported that in chopped leaves, after a 24 h drying period, the cyanide content (HCN) decreases and they can be supplied to domestic animals. The objective of this study was to evaluate different inclusion levels (0, 6, 9 and 12 %) of cassava leaf meal (CLM) in the feeding of *C. gariepinus* small fish.

Materials and Methods

The research was conducted at the Fish Nutrition and Feeding Laboratory of the Aquaculture Technology Development Enterprise (ATDE) in Havana, Cuba. The facility has circular cement tanks with a capacity of 68 L with constant water flow (100 % daily exchange).

Preparation of cassava leaf meal: The leaves were collected from a cassava plantation (variety CMC-40) of six months of planting. They were chopped in a homemade chopper and the resulting product was placed on a metal tray to airing in the open air and sun for three days. They were turned over each day to ensure even drying. After this time, the material was milled in a hammer mill to a size of 3 mm and then sieved through a 1 mm sieve. Its chemical composition is shown in table 1.

Table 1. Chemical composition of experimental cassava leaf meal

Indicators	%	SD
Dry matter	88.36	0.09
Crude protein	23.87	0.21
Ether extract	4.84	0.35
Crude fiber	16.60	0.25
Ashes	10.05	0.10

Diet preparation: All meals were milled in a Creole hammer mill, approximately to 250 µm. Wheat meal was mixed with 30 % hot water (100°C) to hydrate the starch and form a gel to improve mixing with the rest of the ingredients, mainly with cassava leaf meal. The ingredients were mixed in a mixer (HOBART MC-600®, Canada), where vegetable oil, dicalcium phosphate, vitamin and mineral premixture, and 20 % water were gradually added for its conditioning. Pelletizing was done in a meat grinder (JAVAR 32, Colombia) and dried in an oven (Selecta, Spain) at 60 °C for 24 h. The bromatological analyses were performed on the ingredients according to the methods described by AOAC (2016). Digestible energy (DE) was calculated using the caloric coefficients referred by Toledo *et al.* (2015).

Bioassay: C. gariepinus small fish were used, which spent a week in a 4.5 m^2 cement pool, where they received commercial catfish pre-fattening feed (30.84 % CP). After this time, a total 180 animals with an average weight of 10.34±0.08 g were selected and randomly placed in twelve tanks (15 fish per tank). The treatments consisted of four diets: a control that corresponded to the formulation of the commercial catfish pre-fattening feed and the experimental ones with 6, 9 and 12 % CLM as a partial substitute for soybean and wheat (table 2), each with three repetitions, where each tank was the experimental unit.

Experimental procedure: The diets were offered in two rations at 6 % of the biomass for 60 days. Feeding times were 09:00 am and 04:00 pm. Every day, temperature and dissolved oxygen values were recorded using a digital oximeter (*HANNA*, Romania) and pH was recorded using a digital pH meter (*HANNA*, Romania). Group sampling was carried out every 15 days to fit the rations. At the end of the bioassay, all fish were individually weighed using a digital scale (DIGI model DB, Japan) to calculate the following productive indicators:

- Food/fish (g) = total amount of food/final number of fish
- Protein supplied/fish (g) = total amount of protein/final number of fish
- Final average weight (g)
- Daily weight gain (g/day) = (final weight - initial weight)/ days of cultivation
- Feed conversion ratio = food added/weight gain
- Protein efficiency = weight gain/protein supplied
- Survival rate (%) = (final number of animals/initial number of animals) x 100

Statistical analysis: Analysis of variance was performed according to a one -way model. The theoretical assumptions of ANOVA were verified for all variables using the Shapiro and Wilk (1965) tests for normality of errors and the Levene (1960) test for homogeneity of variance. The variables fulfill the theoretical assumptions of ANOVA. The statistical package InfoStat version 2012 (Di Rienzo *et al.* 2012) was used and mean values were compared using Duncan (1955) test where necessary.

Economic analysis: It was carried out according to Toledo *et al.* (2015) procedure. The costs of the rations were calculated based on international commodity prices for June 2025 (www.indexmundi.com/marketprices) (table 3). The results were increased by 45 % of the total raw matters costs for additional expenses (transportation, industrial manufacturing and administrative) for Cuba. These values were multiplied by the feed conversion ratios obtained in this study to determine the feeding costs.

Table 2. Percentage and chemical composition of experimental diets for feeding *Clarias gariepinus* small fish, %

Ingredients	Control	% CLM 6	% CLM 9	% CLM 12
Fish meal	10	10	10	10
Soybean meal	45	42.5	40	38.5
Milled soft wheat	39.5	36	35.5	34
Cassava leaf meal	0	6	9	12
Vegetable oil	3	3	3	3
Dicalcium phosphate	1	1	1	1
* Vit-mineral mixture	1	1	1	1
Carboxymethyl cellulose	0.5	0.5	0.5	0.5
Total	100	100	100	100
Calculated analysis				
Crude protein	30.84	30.77	30.32	30.21
Ether extract	4.93	5.15	5.28	5.4
Crude fiber	4.36	4.68	4.79	4.95
Ashes	6.72	7.10	7.24	7.42
Available phosphorous	0.6	0.6	0.6	0.6
Digestible energy (MJ/kg)	11.34	11.25	11.20	11.18

*Vitamin-mineral mixture (Composition per kg of diet): Vitamin A, 5500IU; Vitamin D3,1000 IU; Vitamin E, 50 mg; Vitamin K3, 10 mg; Vitamin B1, 20 mg; Vitamin B2, 20 mg; Vitamin B3 (pantothenic acid), 25 mg; Vitamin B6,10 mg; Vitamin B12, 0.05 mg; Vitamin C, 150 mg; Niacin, 120 mg; Folic acid, 5 mg; Biotin, 0.3 mg; Choline, 600 mg, Inositol, 100 mg, Calcium pantothenatic, 50 mg; Selenium, 0,1mg; Ferrous sulfate , 50 mg; Manganese sulfate , 15 mg; Magnesium, 6,75 mg; Zinc sulfate , 30 mg; Copper sulfate, 5 mg; Sodium chloride , 0.2 mg; Iodine, 0.5 mg; Cobalt sulfate, 0.1 mg; Butylated hydroxytoluene (BHT), 1 mg.

Table 3. Prices of raw matters used in experimental diets (US$/t)

Raw matters	Value
Fish meal	1 660.60
Soybean meal	435.64
Soft wheat	253.75
Cassava leaf meal	56.23
Vegetable oil	1 145.17
Dicalcium phosphate	322.50
Vit-mineral mixture	1 380.00

Results and Discussion

The water temperature in the ponds ranged from 25.7 to 26.9 °C and the dissolved oxygen between 5.1 and 6.0 mg/L. The pH varied from 7.1 to 7.3. These recorded values of water quality are considered of welfare for the good productive performance of the species (Kasihmuddin *et.al* 2021).

The chemical composition of the experimental CLM showed that the level of crude protein was similar to the 24.6 % reported by Amare *et al.* (2024) when drying cassava leaves (CL) in air. These authors evaluated other processing methods and reported that fermentations with rumen fluid, yeast with molasses, and rumen fluid with molasses increased the CP levels of CLM, due to the growth of bacteria and yeast during the fermentation process.

Blanquiceth *et al.* (2025) reported levels of 25.3 % CP for leaf meal from a Venezuelan sweet cassava variety (MCol 2215) and 19.1 % for the bitter cassava variety Corpoica Tai (MTAI 8). The protein content of CLM is among the values referenced by Leguizamón *et al.* (2021), who alluded that these levels depend on agroclimatic factors, the crop management system, the type of yield for which the varieties are used and their genetics, as well as the processing methods in the preparation of meal. These authors reported that CLM have a high concentration of lysine, proline, and leucine.

The crude fiber (CF) level of the experimental CLM was high relative to the requirements for fish, which limits its inclusion level. The value found was similar (15 and 19 %) to the CLM referred by Blanquiceth *et al.* (2025). These same authors also made meal from the petioles and reported values of 48 % (MCol 2215) and 32 % (MTAI 8), while with the stems they were 64 % (MCol 2215) and 37 % (MTAI 8).

The previous suggests that for fish feeding it is important to use only the leaves. The remaining aerial parts of the cassava plant are limited by their high CF content, which makes these meals a priority supplement for ruminants, because they have a functional microbial flora in the rumen and a pyloric caecum that allows them to assimilate fibrous foods and, therefore, have better feed conversion (Suárez *et al.* 2022), not so the fish.

It was observed that the pellets from the diets with CLM had good physical integration when they were poured into the water, although their capture by the animals was very rapid, which is a characteristic of predatory animals in confinement at high densities. This can be attributed to the hydration of wheat starch with hot water, whose gel contributed to the final binding of the ration.

It is important to highlight that CLM is part of the foliage and has little weight when dry. Therefore, 12 % represented a volume almost identical to the rest of the mixture. This is against the agglutination of the diet, as there is no other raw matter with a high concentration of starch. In this study, the fourth treatment (% CLM 12) had 34 % wheat, which provides approximately 19 % starch, which together with 0.5 % carboxymethylcellulose could contribute to the good agglomeration of the pellets.

The good acceptability of these diets may indicate that chopping and drying the leaves reduced antinutritional factors (ANFs) and helped to maintain the rations intake. Suárez *et al.* (2022) reported that in sweet cassava varieties, the HCN contents are low in roots but can be high in leaves. These authors reported values of 333 mg/kg DM in fresh leaves and 61.2 mg/kg DM in dried leaves.

There were not differences (P>0.05) in the amounts of food and protein supplied per animal (table 4). This is because food intake was not affected by increased CLM levels, and no mortalities occurred that could increase food availability.

Growth and feed efficiency indicators did not differ (P>0.05) up to 12 % inclusion of CLM in catfish rations (table 4), which indicates that up to this level, nutritional imbalance is not promoted for the species, in terms of the composition of essential amino acids (mainly methionine) and energy, nutrients that affect the performance of animals when CLM is used (Valdivié 2022 and Blanquiceth *et al.* 2025). This suggests that CLM should be mixed with other protein ingredients to supplement methionine levels and a starch-rich energy source or vegetable oil to supply the necessary energy and complement the nutritional value of the ration.

Amare *et al.* (2024) reported that air-dried cassava leaf had apparent digestibility values of 54.8 % of dry matter and 79.8 % of protein in Nile tilapia small fish *Oreochromis niloticus*; a species that also has omnivorous feeding habits. Previously, researchers on the digestibility of CLM protein in mice revealed values close to 80 % in young leaves and 67 % in older leaves. Hence the importance of determining the most convenient cut times for a nutritional composition more appropriate with the requirements of the species. It was also found that protein use was low. It reached 32 % in young leaves and 39 % in older leaves, but improved to 61 % when methionine was added (Lancaster and Brooks 1983).

Toledo *et al*. (2015) reported that the condensed tannins present in cassava leaves may be partially responsible for the low absorption of protein when intake, due to the formation of indigestible tannin-protein complexes or the effect of tannins on enzyme activity. Additionally, when stems are included in the production of CLM, the fiber level increases and the protein level decreases.

The literature consulted does not mention the use of CLM in catfish. However, there are studies that report on the evaluation of various foliage meals in the feeding of this species. Tiamiyu *et al.* (2015) evaluated the leaves meal of

Table 4. Productive performance in the fattening of *Clarias gariepinus* with experimental diets

Indicators	**Control**	**% CLM 6**	**% CLM 9**	**% CLM 12**	**± SE**	***P***
Food supplied/fish, g	87.13	85.57	86.43	85.33	0.48	0.593
Protein supplied/fish, g	26.80	26.57	26.21	25.78	0.18	0.175
Final weights, g	62.58	61.31	62.44	59.95	1.29	0.683
Weight gain, g/day	0.88	0.85	0.87	0.84	0.02	0.743
Feed conversion	1.65	1.68	1.66	1.71	0.01	0.484
Protein efficiency	1.96	1.93	2.00	1.94	0.02	0.494
Survival, %	100	100	100	100	-	-

leucaena, *Leucaena leucocephala* (23.54 % CP and 19.2 % crude fiber, CF) as a partial substitute for soybean and corn and concluded that it has considerable potential to contribute to the species feeding. According to reports, up to 20 % can be included without negative effects on growth. Llanes *et al.* (2016) studied the effect of 12.5 and 25 % of *Moringa oleifera* Lam, var Supergenius foliage meal (25.6 % CP and 23.1 % CF) as a partial substitute for fishmeal and corn, and found a decrease in food intake, growth, and feed efficiency. Ayoola and Ogundele (2018) evaluated 2.72, 5.45, 8.17 and 10.9 % of water lettuce meal *Pistia stratiotes* (16.76 % CP and 10.97 % CF) and did not obtained differences in growth, but the best feed conversion was with 8.17 %. Irabor *et al*. (2023) with sweet potato leaf meal *Ipomoea batatas* (24.44 % CP and 17.23 % CF) managed to replace up to 20 % of soybean meal, which represented an inclusion of 6.40 %, without affecting the performance of animals.

Previous studies show that the use of foliage meals is limited and their level of use by fish is conditioned by the harvest age, the processing method and antinutritional factors. A characteristic common to most of these inputs is their high FC, which affects diet digestibility because it cannot be digested by fish. The CF also causes problems in the absorption of proteins and minerals, among other things (Toledo *et al.* 2015).

The survival values obtained in this study (table 4) show that CLM does not compromise the health of *C. gariepinus* small fish. According to Valdivié (2022), the cutting of cassava foliage can be manual or mechanized, but it is important to grind and air-dry the foliage outdoors for at least 24 hours to eliminate cyanogenic glycosides and hydrocyanic acid before making the meal. According to Mukhtar *et al.* (2023), this substance is a potent inhibitor of cellular respiration. Its affinity for metal ions, such as iron from hemoglobin and copper from cytochrome oxidase, causes nerve suppression in regulatory centers, which can lead to respiratory problems and, depending on the severity, the death of the animal.

The economic analysis showed that the increase of CLM decreases the cost of rations and feeding in all treatments (table 5). The greatest monetary savings resulted when 9 % CLM was included in the diet of *C. gariepinus*. These results are consistent with other studies that use foliage meals in fish feeding (Ayoola and Ogundele 2018, Irabor *et al*. 2023 and Amare *et al.* 2024).

Cassava (*M. esculenta*) as an energy source in alternative diets for feeding fish meets expectations in terms of nutrition and food intake, which is manifested in weight gain, feed conversion and yield showed in this species (Llanes 2025). However, this process generates large volumes of foliage, which can result in minimal profit margins per unit of product for the farmer. The productive sector that benefits most from this type of feeding is that of small and medium-sized farmers, since they manage small populations of fish, which makes it easier to take advantage of cassava produced on their land.

With regard to large-scale production, which must manage much larger volumes, they can guarantee agricultural competitiveness and sustainability by allowing small and medium-sized farmers to compete with respect to the demand from the final consumer and the delivery of a safe product with high nutritional value, thus guaranteeing efficiency in production at lower costs. It is necessary to emphasize the processing, which consists of chopping the leaf and dehydration, either by exposure to the sun or by means of a drying shed. This manage does not generate additional costs, reduces its toxicity and facilitates its storage, which could become a key ingredient for fish feeding.

Conclusions

The inclusion of up to 12 % cassava leaf meal does not compromise the productive performance of *Clarias gariepinus* small fish and has a positive economic effect.

References

Amare, T.A., Storebakken, T., Mørkøre, T., Nurfeta, A. & Ahlstrøm, O. 2024. Potency of cassava leaf as protein source for Nile tilapia (*Oreochromis niloticus*). *Aquaculture International*, 32: 10197-10214, ISSN: 1573-143X. https://doi.org/10.1007/s10499-024-01657-3.

AOAC 2016. Official methods of analysis of AOAC International. 20th ed., Rockville, MD: AOAC International, ISBN: 978-0-935584-87-5, Available at: http://www.directtextbook.com/isbn/9780935584875, [Consulted: September 22, 2016].

Ayoola, S.O. & Ogundele, D.C. 2018. Growth Performance of *Clarias gariepinus* Fed with Seaweed (*Pistia stratiotes*) Leaf Meal at Varying Inclusion Level. *African Journal of Resources Management Fisheries and Aquatic*, 3: 1-8, ISSN: 2672-4200. www.Theajfarm.com.

Table 5. Economic analysis of the fattening of *Clarias gariepinus* with experimental diets

Indicators	Control	CLM 6, %	CLM 9, %	CLM 12, %
Diet cost	744.88	721.10	705.92	693.37
Feeding cost	1 229.05	1 211.45	1 171.82	1 185.66
Savings	0.00	17.60	57.23	25.79

Blanquiceth, Y., Pérez, K., Tavera, M.J. & Salcedo, J.G. 2025. Caracterización de harinas derivadas de la parte aérea de dos variedades de yuca y su potencial aprovechamiento en alimentación animal. *Ciencia y Tecnología Agropecuaria*, 26(1): e3608, ISSN: 2500-5308. https://doi.org/10.21930/rcta.vol26_num1_art:3608.

Di Rienzo J A, Casanoves F, Balzarini M G, González L, Tablada M & Robledo C W 2012. Infostat versión 2012. Grupo Infostat. Universidad Nacional de Córdoba, Argentina. Available at: http://www.infostat.com.ar. [Consulted: October 09, 2019].

Díaz, P. & López, C. 2021. Yuca: Pan y Carne, Una Alternativa Potencial para Hacer Frente al Hambre Oculta. *Acta Biológica Colombiana*, 26(2): 235-246, ISSN: 1900-1649. https://doi.org/10.15446/abc.v26n2.84569.

Duncan, D.B. 1955. Multiple Range and Multiple F Tests. *Biometrics*, 11(1): 1-42, ISSN: 1541-0420. https://doi.org/10.2307/3001478.

Irabor, A.E., Obakanurhe, O., Pierre, J.H., Adeleke, H.L. & Chukwurah, I.A. 2023. Sweet potato (*Ipomoea batatas*) leaf meal as partial replacement for soyabean meal in catfish (*Clarias gariepinus*) juvenile diet. *Livestock Research for Rural Development*, 35(4): 31, ISSN: 0121-3784. http://www.Irrd.org/Irrd35/4/3531arno.html.

Kasihmuddin, S.M., Ghaffar, M.A. & Das, S.K. 2021. Rising temperature effects on growth and gastric empting time of freshwater African Catfish (Clarias gariepinus) fingerlings. *Animals*, 11(12): 3497, ISSN: 2076-2615. https://doi.org/10.3390/ani11123497.

Lancaster, P. A. & Brooks, J. E. 1983. Cassava leaves as human food. The New York Botanical Garden. Economic Botany. p. 341 -348.

Leguizamón, A.J., Rompato, K.M., Hoyos, R.E. & Audisio, M.C. 2021. Nutritional evaluation of three varieties of cassava leaves (*Manihot esculenta* Crantz) grown in formosa, Argentina. *Journal of Food Composition and Analysis*, 101(3): 103986, ISSN: 1096-0481. http://dx.doi.org/10.1016/j.jfca.2021.103986.

Levene, H. 1960. Robust tests for the equality of variance In: Olkin, I., Contributions to Probability and Statistics: Essays in Honor of Harold Hotelling, Stanford University Press, pp. 278-292, ISBN: 978-0-8047-0596-7.

Llanes, J. 2025. Evaluación de harina de yuca como sustituto del trigo en la alimentación de *Clarias gariepinus. Tropical Aquaculture*, 3(1): e5746, ISSN: 3061-7642. https://doi.org/10.19136/taa3n1.5746.

Llanes, J., Toledo, J. & Sarduy, L. 2016. Evaluación de la harina de moringa *(Moringa oleífera* Lam). *Revista Cubana de Investigaciones Pesqueras*, 33(1): 53 -58, ISSN: 0138-8452. http://hdl.handle.net/1834/10361.

Mukhtar, A., Latif, S., Barati, Z. & Müller, J. 2023. Valorization of Cassava By-Products: Cyanide Content and Quality Characteristics of Leaves and Peel. *Applied Sciences*, 13: 6340, ISSN: 2076-3417. https://doi.org/10.3390/app13106340.

Shapiro, S. & Wilk. M. 1965. An Analysis of Variance Test for Normality (Complete Samples). *Biometrika,* 52(3/4): 591-611, ISSN: 0006-3444. https://doi.org/10.2307/2333709.

Suárez, E.A., Mestra, L.I., Paternina, Y., Salcedo Carrascal, E.K., Luna C, L.L. & Vásquez, H.A. 2022. Yuca para la alimentación animal en la región Caribe: manejo, conservación y uso eficiente. Corporación Colombiana de Investigación Agropecuaria - AGROSAVIA. https://doi.org/10.21930/agrosavia.manual.740565.

Toledo, J., Llanes, J & Romero, C. 2015. Nutrición y alimentación de peces de aguas cálidas. *Revista AcuaCUBA,* 17(1): 5-22, ISSN: 1608-0467.

Tiamiyu, L.O., Okomoda, V.T. & Agbo, A.O. 2015. Nutritional Suitability of Leucaena Leaf Meal in the Diet of *Clarias gariepinus. Journal FisheriesSciences.com*, 9(1): 351-355, ISSN: 1307-234X. https://doi.org/10.3153/jfscom.201443.

Valdivié M 2022. Alternativas de alimentación para la producción animal en Cuba. Taller Producción de monogástricos. Memorias Convención Producción Animal y Agrodesarrollo. Del 10 al 14 de octubre 2022. Centro de Convenciones Plaza América. Varadero, Matanzas, Cuba. ISBN: 978-959-7171-86-7.