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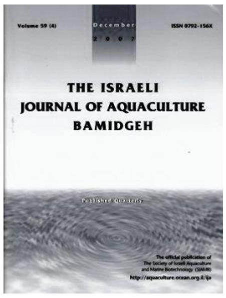


# Chemical Composition and Fatty Acid Profile of Trans-Andean Shovelnose Catfish *Sorubim cuspicaudus*

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Key words: lipids, proteins, ash, fatty acids, larva, mesocosms, pimelodids.

**Abstract**

Chemical composition and fatty acid profile were studied in larvae and adult Trans-Andean shovelnose catfish muscle. The chemical composition in dry matter of the larvae and the food they consumed were: moisture, 89.2%, 91.8%; protein, 79.8%, 70.6%; ethereal extract, 7.8% 7.2%; and ash, 12.7% and 14.5%, respectively. In adult muscle there were no significant differences between sexes in the percentages of moisture, protein, ethereal extract, and ash. Similarly, there was no statistical difference between sexes for monounsaturated fatty acids and polyunsaturated fatty acids. A significant difference between the sexes was found in the fatty acid profile which showed a predominance of saturated fatty acids. This study demonstrated that there is a great similarity in the chemical composition of the species. The percentage of protein and variation in ethereal extract and ash content was dependent upon the composition of its food. These results provide basic information for formulating adequate nutritional diets to meet the requirements of Neotropical fish.

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## Introduction

The Trans-Andean shovelnose catfish, *Sorubim cuspicaudus*, is a carnivorous migratory pimelodid (Villadiego et al., 2004) of commercial importance due to its adaptability to captivity, resistance to a variety of management regimes, excellent meat quality, and absence of intramuscular spines and scales, making it ideal for fish farming in continental waters. However, despite the progress achieved in its artificial reproduction, its large-scale cultivation is limited due to the absence of basic biological information, in particular, nutritional requirements.

Developing fish require a diet which provides essential nutrients for normal growth, taking into account the eating habits and nutritional requirements of each developmental phase, the age of the individuals, and the type and composition of ingested food, as well as the fact that chemical composition varies in relation to their eating habits (FAO, 1995). The larvae are considered zooplankton-eating (Tesser et al., 2005). The beginning of the piscivorous life of Trans-Andean shovelnose catfish usually coincides with the decline of zooplankton and other natural food sources in ponds, or when the amount of food does not meet the demands and food preferences of growing fingerlings.

There is no specific formulated diet that meets the nutritional needs of the different stages (larvae, fingerlings, adults) of the Trans-Andean shovelnose catfish, and this is a significant constraint to aquaculture management. Diets formulated for other fish with similar feeding habits are therefore used but the quality of the muscle of the fish is influenced by many factors such as the time of capture, environment, species, age, sex, reproductive cycle and gonadal development (FAO, 1995; Izquierdo et al., 2001). These factors have motivated research into, and standardization of, techniques for nutritional management of larvae, fingerlings and adults of this species. It is fundamental to understand the body structure through proximal analysis describing percentages of protein, lipid and carbohydrate (Adrián and Esteban, 2000), as well as minerals, moisture, and fatty acids, since all these are essential for physiological function, formation, and tissue regeneration (Berg et al., 2011).

The aim of the present study was to determine the chemical composition and fatty acid profile of Trans-Andean shovelnose catfish at different stages of biological development as a preliminary step aimed at preparing adequate feed for this species.

## Material and Methods

Eight adult Trans-Andean shovelnose catfish specimens, four females and four males, average size 29.7 cm and 53.8 cm, respectively, which had been kept in captivity for 12 months in ponds at the CINPIC (Center of Fish Farming Research at the University of Córdoba, Colombia) were selected for fish fillets. An incision was made from the base of the caudal fin to the base of the dorsal fin, cutting below it and discarding the section next to the abdominal cavity. A total of 8 fillets wrapped in transparent non-sticky plastic paper were prepared, labeled according to the sex of the specimens. The fillet weight for males was between 46.9-118 g, and for females between 63.1-127.8 g; they were immediately frozen at -12°C for future analysis.

From the onset of feeding (two days post-hatching) the Trans-Andean shovelnose catfish larvae were fed cultivated zooplankton in mesocosm systems (blend of copepods *Diaptomus* sp, cladocerans *Moina* sp, *Moinodaphnia* and *Diaphanosoma*, and microalgae *Scendesmus* sp and *Ankistrodesmus* sp) for six days. Samples of 50 g of wet biomass of larvae, average weight 15 mg per larvae, and samples of 60 g biomass of mesocosms were deposited in plastic vials, labeled and stored at -12°C for future analysis.

Each sample of six replicates was analyzed using standard methods (AOAC, 2006): the percentage of crude protein was measured by the Kjeldahl method; ether extraction by the Soxhlet method using petroleum ether extraction as the solvent; ash by calcination in a muffle furnace at 450°C for 12 hours; and dry matter by drying the samples at 110°C for 24 hours until the weight of the sample remained constant. The determination of fatty acids included the extraction of lipids of the muscle samples which were trans-methylated based on the methodology described by Folch et al. (1957*).* A gas chromatograph (Shimadzu GC-14, Shimadzu Inc. Kanda-Nishikicho, Tokyo, Japan) fitted with a flame ionization detector (FID) was used, with an Omega

Wax TM 320 capillary column (Supelco Park, Bellefonse, PA, USA). Transporter helium gas was used at a linear speed of 32 cm/sec (0.75 pressure Kg/cm$^2$; the hydrogen pressure and the FID air was at 0.5 Kg/cm$^2$). The oven temperature was maintained between 80-220°C, the injector temperature 250°C and the detector 260°C. 2 μL of standard methyl esters of fatty acids (Supelco TM 37 Component FAME Mix, Supelco Inc., Bellefonte, PA, USA) were injected. Samples were injected using the split mode: 2 μL in a ratio 1:50 μL of MethPrep II. The extraction solvent used was chloroform:methanol (1:1). Peaks of fatty acids were integrated through Varian Star software (Varian Inc., Palo Alto, CA, USA). Identification and quantification of fatty acids was performed by comparing the retention times of the patterns of methyl esters with all samples.

*Statistical Analysis:* The values were analyzed using descriptive statistics and the results were expressed as average ± standard deviation (See table 2). To establish significant difference between the averages of proximal composition and fatty acid profile between the sexes, data were subjected to a one-way analysis of variance (ANOVA), followed by Duncan's multiple range test for the comparison of means ($p < 0.05$).

## Results

*Chemical composition.* The average percentages of nutrients present in the larvae and the food that was offered (zooplankton produced in mesocosm systems) are presented in Table 1.

Table 1. Chemical composition, on a wet basis (WB) and dry basis (DB), of Trans-Andean shovelnose catfish larvae and their food (zooplankton cultivated mesocosm).

| | *Proteins* % | | *Ethereal* % | | *Ash* % | | *Moisture* % |
|---|---|---|---|---|---|---|---|
| | WB | DB | WB | DB | WB | DB | |
| *Larvae* | 8.6 | 79.6 | 0.8 | 7.8 | 1.4 | 12.7 | 89.2 |
| *Zooplankton* | 5.8 | 70.6 | 0.6 | 7.2 | 1.6 | 14.5 | 91.8 |

The moisture content for larvae was 89.2%, giving the proportion of dry matter as 10.8%. The largest component of dry matter was protein (79.6%), confirming the importance of this product as a nutrient. The second largest component was ash (12.7%), followed by ethereal extract (7.8%). Similar values were found in the consumed zooplankton, which showed a fairly high moisture content of 91.8%, a protein percentage of 70.6%, an ash percentage of 14.5% (reflecting the abundance of mineral salts) and a lipid percentage of 7.2%. The variation in the chemical composition of muscle from adult Trans-Andean sholvelnose catfish males and females are presented in Table 2.

Table 2. Variation in the chemical composition of muscle from adult Trans-Andean shovelnose catfish males and females on a wet basis (WB) and dry basis (DB).

| *Sex* | *Proteins %* | | *Ethereal extract %* | | *Ash %* | | *Moisture* |
|---|---|---|---|---|---|---|---|
| | WB | DB | WB | DB | WB | DB | |
| *Male* | 22.1 ±1.2$^a$ | 72.3±6.9$^a$ | 9.3±3.0$^a$ | 29.2±8.6$^a$ | 1.2±0.1$^a$ | 3.8±0.4$^a$ | 69.2±1.7$^a$ |
| *Female* | 21.3±0.8$^a$ | 78.8±5.3$^a$ | 5.7±1.6$^a$ | 20.90±5.5$^a$ | 1.1±0.0$^a$ | 4.0±0.5$^a$ | 72.9±1.8$^a$ |

Means with the same letter are not significantly different.

The percentages of nutrients in the chemical composition of Trans-Andean shovelnose larvae and adults, showed no significant differences between the two stages (Table 3).

Table 3. Chemical composition, on a wet (WB) and dry basis (DB), of Trans-Andean shovelnose catfish larvae and adults.

| | *Proteins* % | | *Ethereal extract* % | | *Ash* % | | *Moisture* % |
|---|---|---|---|---|---|---|---|
| | WB | DB | WB | DB | WB | DB | |
| *Larvae* | 8.6 | 79.6 | 0.8 | 7.8 | 1 | 12.7 | 89.2 |
| *Adults* | 21.7 | 75.5 | 7.5 | 25 | 1.11 | 3.9 | 71 |

*Fatty acid profile.* The fatty acid composition of male and female muscle samples is expressed as average percentage of methyl esters (Table 4).

Table 4. Saturated (SAFA), monounsaturated (MUFA) and polyunsaturated fatty acid (PUFA) composition in fillets of Trans-Andean shovelnose catfish (males and females), as a percentage of the total fatty acids present (means ± standard deviation, n = 8). Docosahexaenoic acid (DHA), Eicosapentaenoic acid (EPA).

| *Fatty acids* | *% FA* Males | Females |
|---|---|---|
| C14:0 | 2.34±0.20 [b] | 3.32±0.30 [a] |
| C15:0 | 1.05±0.16 [a] | 1.28±0.12 [a] |
| C16:0 | 38.17±1.30 [a] | 41.53±1.56 [a] |
| C18:0 | 13.40±1.11 [a] | 12.61±1.97 [a] |
| **Total SAFAs** | **54.97±0.62 [a]** | **58.74±0.87 [b]** |
| C14:1 | 0.33±0.12 [b] | 0.95±0.28 [a] |
| C16:1 | 4.45±1.19 [a] | 6.10±1.00 [a] |
| C18:1n-9 c/t | 17.78±1.98 [a] | 18.02±1.46 [a] |
| C20:1n-9 | 1.99±0.45 [a] | 2.47±0.28 [a] |
| **Total MUFAs** | **24.57±3.80 [a]** | **27.54±2.55 [a]** |
| C18:2n-6 c/t | 4.89±0.96 [a] | 3.63±0.14 [a] |
| C18:3n-6 | 0.15±0.05 [a] | 0.68±0.46 [a] |
| C18:3n-3 | 1.39±0.20 [a] | 1.47±0.11 [a] |
| C20:3n-6 | 0.87±0.19 [a] | 0.87±0.16 [a] |
| C20:3n-3 | 3.52±1.68 [a] | 1.16±0.47 [a] |
| C20:5n-3 | 0.92±0.21 [a] | 0.86±0.25 [a] |
| C22:5n-3 | 1.88±0.26 [a] | 1.82±0.31 [a] |
| C22:6 n-3 | 6.83±2.45 [a] | 3.22±0.65 [a] |
| **Total PUFAs** | **20.45±3.83 [a]** | **13.72±2.43 [a]** |
| n – 3 | 14.54±3.70 [a] | 8.54±1.33 [a] |
| n – 6 | 5.91±1.13 [a] | 5.18±1.21 [a] |
| n – 3 / n – 6 | 2.46 ±0.87 [a] | 1.64 ±0.17 [a] |
| n - 6 / n – 3 | 0.40 ±0.13 [a] | 0.60 ±0.73 [a] |
| **EPA/DHA** | **0.13 ±0.15 [a]** | **0.25 ±0.04 [a]** |
| **DHA/EPA** | **7.42 ±2.36 [a]** | **3.74 ±0.72 [b]** |

Different letters indicate significant differences ($p < 0.05$).

Of the total lipids present in males and females, saturated fatty acids dominated, with percentages of 54.97% and 58.74%, respectively. Among the saturated fatty acids, palmitic acid (C16:0) was prominent, with average values between 38.17% and 41.53%, as well as stearic acid (C18:0), with average values between 13.40% and 12.61%, for males and females, respectively. The second most important group was the monounsaturated fatty acids (24.57 to 27.54%), in particular, oleic acid (C18:1n-9). Finally, the percentages of polyunsaturated fatty acids were 20.45% and 13.72% in males and females, respectively. This group contained docosahexaenoic acid (DHA, C22:6n - 3), 6.83% and 3.22% for males and females, respectively, in addition to linoleic (C18:2n – 6; 4.89% and 3.63% for males and females, respectively) and eicosatrienoic (C20:3n - 3) acids. There were no significant differences ($p < 0.05$) in fatty acids in both sexes for the majority of the 16 fatty acids identified, with the exception of the acids 14:0 and 14:1.

There were greater concentrations of fatty acids from the n-3 series than from the n-6 series. Trans-Andean shovelnose catfish exhibited n-3/n-6 and n-6/n-3 ratios of 2.46 and 0.40, respectively, for males, and 1.64 and 0.60, respectively, for females. The relationships between the highly unsaturated fatty acids, Eicosapentanoic acid (EPA) and docosahexaenoic acid (DHA) - EPA/DHA and DHA/EPA, were 0.13 and 7.42, respectively, for males, and 0.25 and 3.74, respectively, for females. Overall, there were no significant differences between the males and females, except for the DHA/EPA ratio.

## Discussion

*Chemical composition*. The results of nutrients (proteins and lipids) and minerals (ash) between larvae and the feed offered (zooplankton cultivated in mesocosm systems), show that these organisms have similar chemical composition suggesting that the composition of their food had a significant effect on the chemical composition of the larvae. (Bell et al., 2010; FAO, 1995; Sargent et al., 2002; Schulz et al., 2006). The high content of protein in the larvae due to the protein profile in zooplankton was consistent with the results of other studies (Izquierdo et al., 2001; Sargent et al., 2002; Prieto et al., 2006; Bell et al., 2010). This type of food met the essential nutrient requirements of larvae, in this case, proteins and lipids which are essential for growth. The high levels of protein in this phase directly influence rapid growth rate. This growth also occurs from diets with high energy density (Hillestad, 2001). Higher protein than lipid content does not indicate a deficiency in the latter, but rather suggests the possibility of protein being a source of energy for the larvae. The findings of this study are consistent with other results obtained showing that protein content is inversely related to lipid content (Otchoumou et al., 2011, Molnar et al., 2006; Schulz et al., 2007).

Compared with other species of catfish, the Trans-Andean shovelnose catfish muscle has a high percentage of proteins and minerals, and generally higher levels of other nutrients as well.

Table 5. Chemical composition, on a wet basis (WB) of different species of catfish.

| *Authors (Data)* | *Species* | *Proteins %* | *Ethereal extract %* | *Ash %* | *Moisture %* |
|---|---|---|---|---|---|
| This research | Trans-Andean shovelnose catfish | 21.7 | 7.5 | 1.11 | 71.0 |
| Poulter and Nicolaides, 1985 | *Pseudoplatystoma tigrinum* | 15.8 | 8.9 | - | ** |
| | *Ageneiosus sp* | 14.8 | * | - | ** |
| Perea et al., 2008 | *Pseudoplatystoma magdaleniatum* | 21.2 | * | 1.0 | ** |
| Molina et al., 2001 | *Pseudoplatystoma corruscans* | 12.7 | - | - | - |

* *These percentages were lower than our results.*
** *These percentages were higher than our results.*

In this study, the percentage of protein in the muscle for both sexes was within the reported range for freshwater species (16.4 to 22.1%) such as *Oncorhynchus mykiss*, *Oreochromis* sp, *Piaractus brachypomus*, *Prochilodus magdalenae* and *Pseudoplatystoma magdaleniatum* (Perea et al., 2008).

Moisture percentages for both sexes were within the normal range (66 to 81%) as reported by FAO (1995). The mean values of moisture and the ethereal extract in males and females, respectively, showed an inverse relationship as seen in other studies (Izquierdo et al, 2000; Molina et al, 2001). The proportion of lipids in both sexes was high compared with those reported in other catfish studies (0.8 to 7.4%) (Vargas and Bessonart, 2007). This may have been due to the fact that adult Trans-andean shovelnose catfish were at their initial stage of vitellogenesis and their lipids had not been transferred to the gonads from the muscle. Fish store lipids which are essential during the reproductive period, hence, the lipid level is high in the muscles during onset of vitellogenesis (Molina et al., 2001; Arveláiz and Bello, 2005). Although protein levels during vitellogenesis normally decrease as a result of reproductive migration, in our study they remained high, possibly because confinement in the ponds reduced energy consumption (Arvelaiz and Bello, 2005).

The content of ash in males and females reflected an abundance of mineral salts such as phosphorus, calcium, iron, magnesium and manganese The mineral percentages recorded in this study are in the range (0.9 - 2.1% wet basis) for tropical fish (Izquierdo et al., 2000).

Protein content in both larvae and adults were very similar, but differed from figures quoted by NRC (1993), which indicated that as fish size increases, the demand for protein decreases due to increased activity of proteolytic enzymes which lowers concentrations of protein in the muscle. The content of ash in larvae was 69.1%, higher than that observed in adults. This could be due to the composition of samples in each case; the larvae samples used for analysis consisted of the entire body and thus included traces of bone structure, while the fillet samples of adults used muscle with no bones for analysis. High levels of ash found in Trans-Andean shovelnose catfish larvae were not consistent with the growth phase characterized by a faster increase in muscle mass than in bone mass, thus reducing the concentrations of calcium and phosphorus, the mineral components from the ash (Shearer, 1994). Normal ranges for protein and ash concentrations are between 16-21% and 1.2-1.5%, respectively (FAO, 1995).

*Fatty acid profile.* Lipid content was higher in adults than in larvae, possibly because larvae use lipids to increase in size before storing them, thereby resulting in low lipid and high humidity levels (Bórquez et al., 2011).

Fatty acids in this study of Trans-Andean shovelnose catfish were lower than in species with higher levels of SAFAs, whose concentrations were very similar to those of Trans-Andean shovelnose catfish in other studies. The *Prochilodus magdalenae* has the largest proportion of MUFAs and PUFAs compared to the findings in our species. Marine fish have a greater proportion of PUFAs than freshwater fish however Trans-Andean shovelnose catfish have PUFA levels similar to those of the aforementioned marine species (Table 6).

Table 6. Saturated (SAFA), monounsaturated (MUFA) and polyunsaturated (PUFA) fatty acid composition in fillets of different species of catfish as a percentage of the total fatty acids present.

| *Authors (Data)* | *Species* | *SAFAs %* | *MUFAs %* | *PUFAs %* |
|---|---|---|---|---|
| This research | Trans-Andean shovelnose catfish | 56.85* | 26.05* | 17.08* |
| Izquierdo et al. (2000) | Trouts | 29.3 | - | - |
| | Groupers | 40.0 | - | 16.5 |
| | Snappers | 37.1 | - | - |
| | European seabass | 49.0 | - | - |
| | Mullets | 50.2 | - | 14.07 |
| | Hakes | 51.7 | - | 18.06 |
| | *Prochilodus magdalenae* | - | 70.4 | 29.6 |

* *These values are the mean of the male and female fatty acids values.*

The high percentage of SAFAs in Trans-Andean shovelnose catfish are not a source of n-3 fatty acids, but of proteins, as seen in other species such as *Prochilodus magdalenae*, *Oreochromis sp* and *Piaractus brachypomus* (Perea et al., 2008), which have similar bioecological features, apart from their feeding habits. In addition, the oxidation of the highly unsaturated fatty acids (ω3-HUFAs), eicosapentaenoic acid (EPA), and docosahexaenoic acid (DHA), causes variations in the proportions of the different types of fatty acids, reducing the number and increasing the levels of SAFAs and MUFAs (Sargent et al*.,* 2002). Within the SAFAs, palmitic acid (C16:0) predominates, and together with the MUFA oleic acid (C18:1n - 9), constitutes an important source of energy (Tocher, 2003).

Palmitic acid occurs in the largest concentration, followed by stearic acid C18:0 in species such as cachama, *Rhamdia quelen* and Trans-Andean shovelnose catfish (FAO, 1995), similarly, Oleic acid (C18:1n – 9, MUFA) in cachama, catfish, and Trans-Andean shovelnose catfish. Furthermore, EPA has been reported to have values above that found in Trans-Andean shovelnose catfish (FAO, 1995). The content of DHA is similar to the other species.

The DHA/EPA ratio in Trans-Andean shovelnose catfish is higher than that reported for *Rhamdia quelen*; but the n-3/n-6 ratio is similar (Vargas and Bessonart, 2007) and it is similar to the ratio in freshwater fish ranging from 0.5 to 3.8 (Steffens, 1997). In the present study, this relationship was 2, typical of freshwater species and especially similar to fish from the same family. The PUFAs most abundant in the tissues of fish and crustaceans, both freshwater and marine species, belong to the n-3 series, while the n-6 series are usually present in lower concentrations. Higher levels of n-3 PUFAs were recorded for Trans-Andean shovelnose catfish.

The results of the present study show that the chemical composition of Trans-Andean shovelnose catfish larvae and adults in captivity are similar, retaining a high level of protein. In addition, the percentage of lipids and moisture are within the ranges established as normal, while the ash content is greater in larvae than in adults. Larvae and their food (Mesocosm) exhibit a similar chemical composition to Trans-Andean shovelnose catfish adults, saturated fatty acids (SAFAs) predominate, followed by monounsaturated (MUFAs) and to a lesser extent, polyunsaturated (PUFAs) fatty acids, with palmitic and stearic (SAFAs), oleic (MUFAs), DHA, linoleic and linolenic (PUFAs) acids being abundant. The n-3/n-6 ratio in Trans-Andean shovelnose catfish adults is typical of freshwater species, especially in fish of the same family.

These results provide basic and fundamental information for formulating adequate diets to meet the nutritional requirements of this neotropical catfish. The supply of cultivated zooplankton in mesocosm system is suitable for larvae. In breeding adults it is necessary to assess commercial diets for carnivores which supply a high percentage of protein and lipid content appropriate to accompany the fatty acid profile and the proportion of DHA / EPA found in this study. This outcome facilitates the formulation of diets with different nutritional standards of protein and energy closer to the optimum, obtaining greater retention and energy efficiency, in order to produce the highest biomass and to improve feed conversion. In this way parameters with optimum strategy for maximizing use of food without affecting growth or meat quality may be established for the cultivating this species under commercial conditions.

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