AGRO PRODUCTIVIDAD

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Somatic indices and nutritional composition of the roe of the native fish *Dormitator latifrons*

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ABSTRACT

Objective: To evaluate some reproductive aspects of *Dormitator latifrons* and the nutritional quality of its eggs.
Design/methods/approach: Eighty-two fish were randomly collected (August 2021), and their sex, length, weight, somatic indices, Fulton condition index (K), proximate composition, and amino acid and lipid composition (fatty acids) of the gonads were determined.
Results: Of the total specimens collected, 62% were females; length and weight values were higher in males, but their gonadosomatic index (GSI) was lower than in females. Somatic indices did not show differences between different weight ranges. In the roe of *D. latifrons*, the average proximate composition was 24.3% protein and 8.5% lipids. The most abundant essential amino acids were leucine and lysine. Linoleic acid (C18:2n6) was the fatty acid with the highest concentration.
Limitations/implications: It is necessary to complement the analysis of the amino acid and fatty acid profile of the roe in wild organisms to relate the changes caused by balanced feed.
Findings/conclusions: This study shows that the *D. latifrons* roe is a good source of amino acids and PUFA.

Keywords: proximate composition, fatty acids, essential amino acids.

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INTRODUCTION

Fish by-products have become increasingly important worldwide due to their nutritional, economic, and environmental benefits (Chakraborty *et al.*, 2020). Mexico is home to species with great economic potential that have not yet been exploited, including the species *Dormitator latifrons*, which is only consumed in some locations in the southeast of the country, despite its delicious flavor and excellent nutritional properties. (López-Huerta *et al.*, 2018). Food products with high nutritional value and acceptability could be produced from this species (Montoya-Martínez *et al.*, 2022). Moreover, the characteristics of this fish make it ideal for farming, even though there is still little information on this species (Vega-Villasante *et al.*, 2021).

Although roe is considered a high-quality food, due to its nutritional value and importance in the international market, little information is available on its chemical composition, quality, and safety (Vasconi *et al.*, 2020), especially for freshwater species.

The present study aimed to determine the somatic indices, proximate composition, and amino acids and fatty acids profile of the roe of *D. latifrons* to expand our knowledge about the reproductive performance of the species and the nutritional quality of its roe.

METHODS

Sample preparation

Adult *D. latifrons* fish were collected in August 2021 from the ponds of a shrimp farm (*D. latifrons* is considered a pest in shrimp farming) in the municipality of San Blas, in the state of Nayarit. The collected fish were killed by immersion in ice water and then frozen at −20 °C. The fish were transported in coolers to the Laboratorio de Calidad de Agua y Acuicultura Experimental of the Universidad de Guadalajara in Puerto Vallarta, Jalisco, where they were kept at −20 °C for further processing.

The specimens were thawed in a refrigerator at 5 °C for 17 h. Once thawed, the length and weight of each specimen were determined, and the Fulton condition index (K)=(total weight/length3)×100 (Ricker, 1975) was calculated. The fish were then dissected and eviscerated. The liver and gonads were separated and weighed to determine the gonadosomatic index (GSI)=(gonad weight/total weight)×100, the hepatosomatic index (HSI)=(liver weight/total weight)×100 and the viscerosomatic index (VSI)=(viscera weight/total weight)×100. The 82 collected specimens were grouped into three weight ranges (200-299, 300-399, 400-499).

The female gonads (roe) were cleaned of foreign material such as scales, blood, etc. Their surface was manually washed with tap water and rinsed with drinking water, and they were then frozen at −20 °C for later lyophilization.

Proximate analysis

The roes of 6 fish were used for the proximate analysis. The roe was first lyophilized; once dry, it was ground, mixed, and divided into two groups of 3 gonads each. Moisture was determined from weight loss during lyophilization. All analyzes were performed using the AOAC (1995) method. Crude protein was determined by the micro Kjeldahl method, using a protein conversion factor of 6.25. Lipids were determined by the Soxhlet method, using hexane as solvent. The ashes were determined by the calcination method at 550 °C for 4 h until reaching constant weight. All analyzes were performed in triplicate.

Determination of amino acids and fatty acids

For the analysis of amino acids and fatty acids, the lyophilized samples were sent to the Laboratorio de Nutrición Acuícola of the Universidad Autónoma de Baja California. The content of amino acids was determined on 100 mg of material taken from previously defatted and dried samples. The samples were hydrolyzed with a mixture of 6 N HCl and phenol (0.06%) and refrigerated at −30 °C until further processing. Derivatization was performed on an Agilent HPLC (1200 infinity series). The calibration curve was generated using a standard amino acid solution (P.N. 061-3330). The area under the curve was estimated using the “OpenLAB” program (Agilent Technologies 2000) to determine the proportion of amino acids to the protein content in the samples.

The content of fatty acids (FA) was determined using the technique of Folch *et al.* (1957) with modifications. Butylhydroxytoluene 0.01% ($C_{15}H_{24}O$) was added as the antioxidant solution, using the lowest possible temperature for lipid extraction. The FA were separated, identified, and quantified on an AGILENT GC 7820A gas chromatograph, equipped with a Split/Splitless injector, a flame ionization detector, and an AGILENT 122-2361 capillary column (DB-23, 60 m × 0.25 mm with an internal diameter of 15 mm). Nitrogen (N_2) was used as carrier gas. Fatty acids were identified by comparison with the retention times of the following standards: 37 Component FAME Mix (Supelco/Sigma-Aldrich®), GLC 87, GLC 96 (Nu-Chek Prep®), RM-2, RM-6, and GLC 90 (Supelco/Sigma-Aldrich®). In addition, polyunsaturated fatty acids (PUFAs) from marine oils (PUFA1 and 3, Supelco/Sigma-Aldrich®) were used as an identification pattern. Nonadecanoic acid (C19:0) was used as an internal standard. The composition of each FA was estimated based on the corresponding area in the respective chromatogram. The calculations were made using the GC Chemstation Data Analysis software and expressed as the weight percentage of the total lipids in the roe of *D. latifrons*. All analyzes were performed in duplicate.

The protein quality of the gonads was evaluated using the chemical score method (CS) (Block & Mitchell, 1946) by dividing the EAA content of the evaluated protein by the amino acid content of a reference protein (mg/g protein) defined according to the amino acid requirements for children (2-3 years) established by the U.S. Food and Nutrition Council (FNB/USA, 2002 in Hernández-Triana, 2004).

Statistical analysis

The Shapiro-Wilk normality test and Bartlett’s homogeneity of variance test ($\alpha=0.05$) were applied to the results of weight, length, and somatic index. Compared were made with the one-way analysis of variance (ANOVA) (weight, length, and k index in sexes) or the Kruskal-Wallis (somatic indexes, weight, and length in different weight intervals). Statistically significant differences ($P<0.05$) between treatments were determined using Tukey’s test. All statistical analyzes were performed using SigmaPlot 11.

RESULTS AND DISCUSSION

The sex distribution of the 82 collected specimens was 62% (51) females and 38% (31) males. The males were significantly larger in both length and weight, but their GSI was lower than that of females ($P<0.05$) (Table 1). In fish, the Fulton condition index (K) is used as an indirect estimate of the state of robustness (Urquidez *et al.*, 2016) or physiological and reproductive condition (Arellano-Martínez *et al.*, 2001). For this species, Chang & Navas (1984) report K variations during the year, finding the maximum peaks (approx. 1.8) during the rainy season. The average K value (Table 2) was 2.3 ± 0.3, which means that

D. latifrons has high K values since this index, although it varies according to the species, is close to 1.0 in marine fish (Urquidez *et al*., 2016). Cifuentes *et al*. (2012) reported the condition indices of 12 species of native fish from Chile during two annual cycles, with values ranging from 0.1 to 1.3. They found the most significant variability (from 0.1 to 2.6) in *Percilia gillissi*, probably associated with the reproductive seasons. In most fish, the highest condition index values coincide with the time of sexual maturity, and the lowest values with weight loss after spawning. This difference is the reason for the high value of K found in the present study in *D. latifrons* since most of the organisms analyzed were between stage V (gravid) and VI (spawning) of the sexual maturity scale based on empirical data on gonadal development (Vega-Villasante *et al*., 2021). This result coincides with the reports from Mexico that the reproductive phase of this species lasts between June and November (Rojas-Herrera *et al*., 2009).

The somatic indices did not show significant statistical differences ($P>0.05$) between different weight intervals (Table 2). Chang & Navas (1984) report for *D. latifrons* the maximum GSI values between March and April (approx. 17.5%) during the rainy season in Ecuador because fish present gonadal development in this period. Despite the variability observed in the K index, the highest values were found in the maturation period, which shows a certain tendency to coincide with the GSI. Rojas-Herrera *et al*. (2009) reported a seasonal variation in the GSI of *D. latifrons*, with a maximum value in June (approx. 8.2%) and 4.8% in August. The GSI values obtained in the present study were higher than 9% in August. These high GSI values correspond to the state of maturity in which the fish gonads were found since it has been reported that this index tends to increase with increasing gonad size as the gametogenesis process progresses, which is why this index is considered an indicator of sexual maturity in fish (Re-Vega *et al*., 2020). The HSI is considered a good indicator of the physiological condition since it is associated with the energy storage in the

Table 1. Total length, body weight, and gonadosomatic index (GSI) and Fulton condition index (K) of females and males of *D. latifrons* were used in this research.

Organisms	Number of fish	Length (cm)	Weight (g)	GSI	K
Total	82	24.6±1.6	346.2±68.0	10.61±4.9	2.3±0.3
Females	51	24.1±1.4[a]	331.1±58.8[a]	13.59±3.5a	2.3±0.3
Males	31	25.4±1.6[b]	371.1±75.6[b]	5.72±2.3b	2.3±0.4

Table 2. Weight, length, and somatic index values of *D. latifrons* according to weight range.

Variables	Weight range (g) 200-299 (n=27)	300-399 (n=34)	400-499 (n=21)
Weight (g)	272.7±24.0 [a]	349.5±32.2 [b]	435.4±25.0 [c]
Length (cm)	23.1±0.9 [a]	25.0±1.3 [b]	26.0±1.0 [c]
Gonadosomatic index	12.3±4.9	10.3±4.7	9.0±5.1
Hepatosomatic index	4.2±1.5	4.4±1.1	4.1±1.1
Viscerosomatic index	22.5±6.2	21.5±4.2	19.5±5.2

liver, which decreases during vitellogenesis and spawning (Arellano *et al*., 2001); however, these values may vary with the species. The HIS values found in the present study for *D. latifrons* are probably low, but no published data was used as a reference. Higher GSI values were found in the present study than those reported in other species. This GSI value is probably associated with the morphology of this fish, which has a wide abdominal cavity since the females produce a large amount of roe (they are very fertile). This roe has excellent commercial potential and an enjoyable flavor and texture.

Table 3 shows the proximate composition of the roe of *D. latifrons*, with an average protein content of 24.3% and an average lipid content of 8.5%, higher values than what has been reported for this fish meat (Montoya-Martínez *et al*., 2022). Balaswamy *et al*. (2009) evaluated the proximate composition of four freshwater species (*Catla catla* (catla), *Cyprinus carpi* (carp), *Labeo rohita* (rohu), and *Channa striatus* (murrel). They found that the roe protein content of these species ranged from 16.6 to 28.2%, while the lipid content ranged from 3.2 to 9.5%. Iwasaki & Harada (1985) analyzed the proximate content of the gonads of 14 species of marine fish, finding that the protein content ranged from 11.5 to 28.7% and the lipid content ranged from 3.0 to 19.8%.

Table 3 shows the amino acid composition of the roe of *D. latifrons*. The most abundant non-essential amino acid was GLU, followed by ASP and the essential amino acids LYS and LEU. The least abundant amino acid was the essential amino acid MET. The ratio between essential and non-essential amino acids (E/NE) in the roe protein was 0.9. These results coincided with what Iwasaki and Harada (1985) reported for gonads of 14 marine species. They found that GLU was the most abundant amino acid, followed by LEU or ASP, while the least abundant amino acids were MET and HIS, with an average E/NE that ranged from 0.71 to 0.75. As these authors indicated, a favorable and balanced E/NE ratio suggests that the roe of *D. latifrons* can be considered a food source of high-quality protein.

The fatty acid analysis of the roe of *D. latifrons* (Table 3) showed that 34.2% of the total fatty acids (FA) were polyunsaturated (PUFA), and 34.0% were saturated (SFA), and 30.7% were monounsaturated (MUFA). Linoleic acid (LA, C18:2n6) was the fatty acid with the highest concentration (23.6%), while eicosatetraenoic acid (ETA, C20:4n3) was the least abundant (0.6%), and the n-3/n-6 ratio was 0.4. This coincided with what López-Huerta *et al*. (2018) reported for the muscle of farmed *D. latifrons*, where LA was the most abundant fatty acid (20.5%), but the n3/n6 ratio was 0.85. These authors found differences between the concentrations of FA in wild and farmed fish, which may be related to the type of oil used in the formulation of the balanced feed since increasing the content of vegetable oils in the feed decreases the content of long-chain n-3 fatty acids in the cultivated fish, thereby reducing the nutritional quality of the fish meat.

In the roe of *D. latifrons* (Table 3), the most abundant SFA was palmitic acid (C16:0, 18.0%). In contrast, the most abundant MUFAs was oleic acid (OA, C18:1n9, 21.1%), similar to what has been reported for the roe of other freshwater species such as *Coregonus albula*, *Rutilus frisii kutum*, and *Silurus glanis* (Kaitaranta, 1980; Ghomi & Nikoo, 2010; Saliu *et al*., 2017), and in some marine species (Rincón-Cervera *et al*., 2009; Garaffo *et al*., 2011). The PUFA/SFA ratio was higher in the roe of *D. latifrons* than the minimum value (>0.45)

Table 3. Proximate composition and amino acid and fatty acid profile of *D. latifrons*.

Proximate analysis (%)		**Fatty acids (%)**	
Moisture	61.9±2.5	C13:0	8.4±0.7
Proteins	24.3±1.1	C14:0	1.4±0.2
Lipids	8.5±0.3	C16:0	18.0±0.9
Ash	3.5±0.4	C18:0	5.8±0.1
Amino acids (g/100g protein)		C24:0	0.8±0.2
Essential amino acids		**∑SFA**	**34.0±0.8**
HIS	2.2±0.1	C16:1n7	5.1±0.2
ILE	3.7±0.1	C18:1n9	21.1±1.2
LEU	5.8±0.1	C18:1n7	3.2±0.4
LYS	5.8±0.3	C22:1n9	1.5±0.4
MET	1.4±0.7	**∑MUFAS**	**30.7±1.3**
THR	3.5±0.1	C18:2n6	23.6±0.4
VAL	4.3±0.1	C18:3n3	1.7±0.0
PHE	3.0±0.1	C20:2	0.7±0.1
Non-essential amino acids		C20:4n3	0.6±0.0
ALA	4.4±0.2	C20:5n3	1.0±0.0
ARG	4.8±0.1	C22:5n3	2.4±0.2
ASP	5.8±0.1	C22:6n3	4.2±0.5
GLU	8.9±0.1	**∑PUFAS**	**34.2±1.2**
GLY	2.5±0.1		
SER	4.4±0.1	**n3/n6**	0.4±0.0
TYR	3.0±0.1	**DHA/EPA**	4.1±0.4
E/NE	0.9	**PUFA/SFA**	1.0±0.0

recommended for human consumption (Saliu *et al.*, 2017). The content of FA n-3 in the roe of *D. latifrons* was lower than the content of n-6 because LA (C18:2n6) was the most abundant FA (23.6 %) in the roe of *D. latifrons* (Table 3). This is like what was reported for *Gadus morhua* (Rincón-Cervera *et al.*, 2009), in which LA was the most abundant PUFA. However, these results differ from most of the results reported for other species, in which FA n-3 was the most abundant. The content of docosahexaenoic acid (DHA, C22:6n3) in the roe of *D. latifrons* was higher than that of the content of eicosapentaenoic acid (EPA, C20:5n3). The content values of these fatty acids were lower than those reported for other species (Kaitaranta, 1980; Rincón-Cervera *et al.*, 2009; Ghomi & Nikoo, 2010; Garaffo *et al.*, 2011; Saliu *et al.*, 2017). Lipid levels and FA composition vary according to species, sex, age, the season of the year, food availability, salinity, and water temperature (Vlieg & Body, 1988). The content values of the amino acid MET and FA in the roe of *D. latifrons* are mainly the result of the feed used in the shrimp farms where the fish were found since the content of oils of vegetable origin in the feed used for cultivation can lead to an increase in FA n-6, mainly of LA (Vasconi *et al.*, 2020).

Bastos-Rosales *et al.* (2020) and López-Huerta *et al.* (2018) reported the content of amino acids and fatty acids in the meat of *D. latifrons* in the wild and farmed specimens fed with a commercial feed for tilapia. They found that the only limiting amino acid was lysine, but only in wild fish. When comparing the FA content, they found a higher concentration of OA and LA and a lower proportion of EPA and DHA in farmed fish compared to wild fish, so they recommended paying attention to the quality of the oil used in the feed of farmed fish.

The consumption of fish products and by-products, of all kinds without exception, is widely recommended because they contain less SFA and cholesterol than other meat products (Acuña-Reyes, 2013). Furthermore, fish products are rich sources of amino acids and essential fatty acids that are beneficial for human health (Garaffo *et al.*, 2011), such as PUFAs of the n-3 family. Even when farmed lean and semi-lean fish, as well as their by-products, do not have sufficient amounts of n-3, they have a high content of OA and LA considered of high nutritional value (Garaffo *et al.*, 2011).

Even though MET is the limiting amino acid in the roe of *D. latifrons*, the roe was not deficient in the other analyzed amino acids (Table 4). The amino acid content of the roe of *D. latifrons* meets the essential amino acid requirements for children, according to the FNB/USA (2002).

Table 4. Chemical score (CS) of *D. latifrons* roe.

Essential amino acids	Children 1-3 years old	CS
Histidine	18	1.22
Isoleucine	25	1.48
Leucine	51	1.14
Lysine	55	1.05
Methionine/Cysteine	**25**	**0.56***
Phenylalanine/Tyrosine	47	1.28
Threonine	27	1.30
Valine	32	1.34

Data from the US Food and Nutrition Board (FNB/USA, 2002).
*Limiting amino acids.

CONCLUSIONS

Mexico has a long tradition of eating fish roe, especially in coastal and riverside areas, where roe is considered a delicacy, as is the case of the fish roe of the same species, *D. maculatus*, which is widely consumed in the states of Veracruz and Tabasco, reaching a price of $140 per kilo of fresh roe. This study presents the first report on the composition of *D. latifrons* roe, showing that they are a good source of amino acids and PUFAs so that they could be used as food supplements. Having ample sources of cheap, fresh *D. latifrons* roe, which can be processed and used as raw material in the production of various food products to improve its protein value and help combat malnutrition, should be considered an important objective. Moreover, using the roe would improve the commercial potential of the native fish *D. latifrons*.

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