DOES LARGEMOUTH BASS (*Micropterus salmoides*) HAVE A SEASON TO BE CONSUMED? A STUDY ON PÓVOA E MEADAS RESERVOIR, ALENTEJO, PORTUGAL

Data de aceite: 02/05/2023

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ABSTRACT: Introduced in the second half of the 20th century in Portugal, the largemouth bass (*Micropterus salmoides*) can currently be found in most of the lakes and reservoirs of Southern Europe, being an invasive species in Portugal and other Mediterranean regions. Increasingly in Portugal, the largemouth bass is one of the most sought-after species for recreational fishing activities and a species with the potential to boost the interior regions of the Alentejo. Currently, this species is already described as a regional gastronomic cultural landmark. In this way, the interest of sport fishmen for the species plus the nutritional profile of the edible muscle of largemouth bass could promote the interest of sport fishermen in capturing exotic species, which could contribute to a correct management of reservoirs, aiming at a better balance between native and exotic species. As the complexity of the lipid profile of fish species is highly influenced by 3 major parameters such as genetics (species, stage of development in the life cycle); environment (type of environment, water temperature, salinity) and diet and food availability, the study characterized the nutritional profile of the edible part of the largemouth bass in two seasons: winter and summer, when major differences occur at the environmental level and in the food availability. Forty animals were captured, divided between winter and summer, from Póvoas e Meadas reservoir. It was found that the season significantly influenced the lipid and protein profile of largemouth bass edible muscle. The results obtained revealed that the edible part presents nutritional quality in terms of these profiles. However, its nutritional composition in the summer may prove to be a less healthy practice, as its profile revealed alterations in terms of the main groups of lipids analyzed.
KEYWORDS: largemouth bass; nutritional profile; reservoirs; Portugal.

EXISTE UMA ÉPOCA DO ANO PARA CONSUMIR ACHIGÃ (*Micropterus salmoides*)? UM ESTUDO NO RESERVATÓRIO DE PÓVOA E MEADAS, ALENTEJO, PORTUGAL

RESUMO: Introduzido na segunda metade do século XX em Portugal, o achigã (*Micropterus salmoides*) pode ser atualmente encontrado na maior parte das albufeiras e reservatórios da Europa Meridional, sendo uma espécie invasora em Portugal e restantes regiões mediterrânicas. Cada vez mais em Portugal, o achigã é uma das espécies mais procuradas em pesca desportiva e, como tal, uma espécie com potencial dinamizador de regiões interiores alentejanas. Uma gestão correta das albufeiras, objetivando um melhor equilíbrio entre espécies autóctones e exóticas passa pela promoção do interesse dos pescadores desportivos na captura de espécies exóticas. Desta forma, surgiu a ideia de aliar-se o interesse que a espécie desperta aos pescadores desportivos com o potencial nutricional do achigã. Atualmente, esta espécie já é muito procurada em Portugal no âmbito da gastronomia, sendo que em alguns locais é descrito como marco cultural regional. Como a complexidade do perfil lipídico das espécies piscícolas é altamente influenciada por 3 grandes parâmetros tais como a genética (espécie, fase de desenvolvimento no ciclo de vida); o ambiente (tipo de meio, temperatura da água, salinidade) e a dieta/disponibilidade de alimento, o estudo caracterizou o perfil nutricional da parte edível do achigã em duas épocas: inverno e verão, quando ocorrem diferenças a nível ambiental e na disponibilidade de alimento. Foram capturados 41 animais divididos entre inverno e verão, provenientes da Albufeira de Póvoas e Meadas. Verificou-se que a época do ano influenciou significativamente o perfil lipídico e proteico da carne de achigã. Os resultados obtidos revelaram que a parte edível apresenta

qualidade nutricional ao nível destes perfis. Contudo, a sua composição nutricional no verão pode revelar-se uma prática menos saudável, já que o seu perfil apresenta alteração ao nível dos principais grupos de lípidos analisados.

PALAVRAS-CHAVE: achigã; perfil nutricional; reservatórios, Portugal

1 I INTRODUCTION

Largemouth bass (*Micropterus salmoides,* Lacépède, 1802), belongs to Centrarchidae family and is native to North America from the Great Lakes region (Sanches and Rodrigues, 2011), and is one of the most widely distributed species worldwide due to its great popularity for sport fishing (Brown *et al.*, 2009). Largemouth bass was introduced to the European continent at the end of 19^{th} century, namely in countries such as France, Germany, Spain, Italy, and Russia (Sanches and Rodrigues, 2011). Specifically in Portugal, its introduction dates to 1952 (Godinho and Ferreira*,* 1996).

In Portugal, and especially in Alentejo region, this non-indigenous species continues to be widely consumed by fishermen, and in some regions, it is even described as an important gastronomic and cultural product. The edible part of fish has a chemical composition that varies from species to species, but also between individuals of the same species, depending on age, gender, environment, and time of capture (Huss, 1995). Beyond of the mentioned factors, food intake is also related to the proximal composition of fish muscle (Huss, 1995) and be influenced by periods of animal´s stress such as the reproduction or scarcity of food. So, wild largemouth bass information on its nutritional profile is still scarce (Jorge *et al.*, 2021).

The main objective of this study was to determine the nutritional profile of wild largemouth bass edible muscle captured in Póvoa e Meadas reservoir, Alentejo and comparing this proximate composition between the winter and summer seasons, to provide information to consumers on the best time to eat this species.

2 I METHODOLOGY

Wild largemouth bass (#40) used for this experiment were captured in Póvoa e Meadas reservoir (PM: 7°33'9.62"W; 39°28'36.49"N; Datum WGS84), belonging to the Tagus River watershed (Almeida *et al.*, 2017) in winter season (winter: November/December) and summer season (June/July). Póvoa e Meadas it is characterized by a total area of 225.8 ha, 25.9 km away from the source and 261 km from the mouth. It has 7 tributaries, and the average temperature is around 16.1 °C. From the application of the IAAPR (Reservoir Suitability Index for Fishing

Recreative), Póvoa e Meadas obtained the classification of "Very Good" in terms of suitability of the body of water and the surrounding environment for fishing recreational (Almeida *et al.*, 2017; Jorge et al., 2021).

In each sampling season, #20 wild largemouth bass adults were captured using electrofishing (Hans Grassl EL62, 600V-DC). The euthanasia method used was authorized by DL113/2013 with the support of the favourable opinion issued by the Organism Responsible for Animal Welfare of the University of Évora (ORBEA-UÉ) Process Nº: GD/13426/2019/P1. After collection of biometric data, fish were eviscerated for determination of total eviscerated body mass (*EW*, nearest g), all specimens were filleted and the skin, liver, and gonads removed. The skinless fillets (i.e. all individual muscle in the proximity of the mid-dorsal line, in the left flank of the fish, close to the dorsal fin) were collected, washed with physiologic saline, and homogenized individually for subsequent analysis.

All determinations were made in duplicate. Moisture content was determined according to IPQ (1991); crude protein content was determined by combustion according to AOAC (1990) and total lipids and fatty acid profile were determined by Accelerated Solvent Extraction (Jorge *et al*., 2021). FAME was analyzed on a GC/MS system (Bruker GC 456 with a Bruker mass selective detector Scion TQ, equipped with an automatic sampler injector and a CTC analytics autosampler 197 CombiPal). For further details, see Jorge et al. (2021) and Almeida (2018).

Several indexes (PUFA/SFA: polyunsaturated/saturated fatty acid ratio; h/H: hypocholesterolemic/hypercholesterolemic ratio (Santos-Silva et al., 2002); TI: thrombotic index (Ulbricht and Southgate, 1991); AI: atherogenic index (Ulbricht and Southgate, 1991) and ω6/ω3 ratio (Simopoulos, 2002) were used to estimate the lipid quality of edible muscle of largemouth bass. For more details see Almeida (2018) and Jorge et al., (2021).

MANOVA was used to see the main and interaction effects of categorical variable (gender and season) on multiple interval variables. This method allowed the analysis of variance for dependent variables using two fixed factors (time and gender) and a covariate (fish total length). The significance level adopted for the statistical tests performed was 5%.

3 I RESULTS AND DISCUSSION

Our results showed that gender had no significant effect on total body mass and total length and only the season (*p=0.001*) had a significant effect on the nutritional composition of the edible part of the largemouth bass. It was found that the season factor had a significant effect (*p=0.001*) on moisture (*p=0.007*, eta=18.3%), total crude protein (*p=0.001*, eta=75.5%) and total lipids (*p=0.007*, eta=18.7%). The factor gender (*p=0.406*) and the season*gender interaction (*p=0.799*) had no significant effects for analysed variables (Figure 1). Moisture values for both seasons ranged between 77.30% and 81.20%, with an average value of 79.3% for winter samples and 78.54% for the summer ones. The values are within the range referenced for most fish (Afonso, 2009) and Huss (1995).

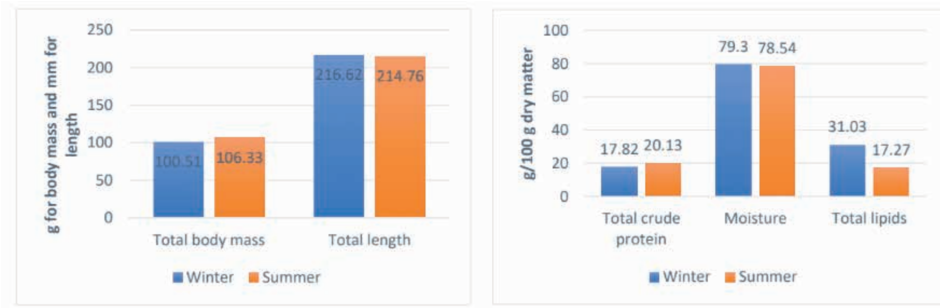

Figure 1 – Total body mass and total length of individuals captured in Póvoa e Meadas Reservoir and proximate composition (expressed in g/100 g of dry matter) in winter and summer seasons.

About total lipids, significant differences were found between winter and summer edible muscles. In winter, the values are higher with an average of 31.03 g/100 g DM, and, in the summer, the total lipid were around 17.27 g/100 g DM. This difference may be associated with higher energy expenditure in the summer, possibly due to the physiological requirements of the largemouth bass breeding season that occurs between March and June, compared to the accumulation of lipids in the winter (Figure 1). Concerning to protein, significant differences (*p=0.001)* between winter and summer were observed being the values higher in summer than winter.

Concerning to lipid profile, our results revealed that season factor (*p=0.001*) had a significant effect on edible muscle fatty acids classes and fatty acid profile under analysis (Figure 2). Season factor affects more polyunsaturated fatty acids (PUFA, *p=0.001* and eta=62.8%), followed by saturated fatty acids (SFA, *p=0.001* and eta=28.0%) and highly unsaturated fatty acids (HUFA, *p=0.002* and eta=23.7%), being the monounsaturated fatty acids (MUFA, *p=0.016* and eta=15.1%) the less effected class (Figure 2).

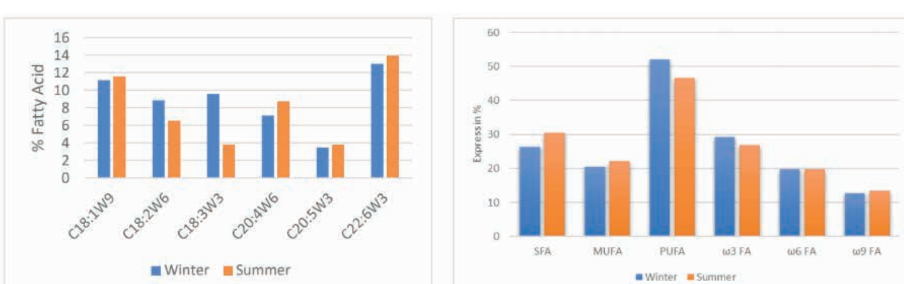

Figure 2 – Fatty acid classes and fatty acid profile of edible muscle of individuals captured in Póvoa e Meadas Reservoir in winter and summer seasons. Fatty acids values are expressed in percentage of total identified fatty acids.

Apart from PUFA and ω3 family, all fatty acid classes showed higher values in the summer season relative to winter. The most expressive SFA are palmitic acid (C16:0) and stearic acid (C18:0). C16:0 is a ubiquitous fatty acid that is synthesized by most part of organisms including all groups of algae. Concerning to MUFA, the dominant fatty acid is oleic acid (C18:1ω9), representing 10% of the total fatty acids. This result it is also a strong indicator of carnivory because C18:1ω9 it is the major monounsaturated FA in most aquatic and marine animals (Falk-Petersen *et al.*, 1990). The PUFA class, showed both EFA C18:2ω6c and C18:3ω3c fatty acids as predominant PUFA and despite the significant differences in PUFA between winter and summer, it was found that there were no significant differences for C20:5*ω*3 (EPA) and C22:6*ω*3 (DHA) between seasons ($p=0.147$ and $p=0.145$, respectively). This makes it possible to mention that these two fatty acids are preserved throughout the year and that the PUFA pool undergoes oscillations based on the remaining fatty acids (Table 1).

Fatty Acids	Winter	Summer
C9:0	0,01 ± 0,01	0,03 ± 0,01
C11:0	0,02 ± 0,02	0,02 ± 0,01
C12:0	0,07 ± 0,03	0,13 ± 0,01
C13:0	N.D.	0,03 ± 0,02
C14:0	0,75± 0,21	1,05 ± 0,49
C15:0i	0,16 ± 0,13	0,40 ± 0,17
C15:0a	N.D.	0,05 ± 0,02
C15:0	0,26 ± 0,08	0,59 ± 0,12
C16:0i	0,14 ± 0,12	0,21 ± 0,06
C16:0	14,91± 1,48	13,97 ± 1,43
C17:0i	0,52 ± 0,23	0,90 ± 0,22
C17:0a	0,05 ± 0,04	0,32 ± 0,08
C17:0	1,05 ± 0,13	1,33 ± 0,16
C18:0i	0,03 ± 0,01	0,07 ± 0,02
C18:0-a	0,02 ± 0,02	0,42 ± 0,30
C18:0	8,49 ± 0,42	10,05 ± 0,69
C19:0i	0,05 ± 0,02	0,05 ± 0,02
C19:0	0,36 ± 0,06	0,37 ± 0,08
C20:0	0,28 ± 0,25	0,37 ± 0,06
C22:0	0,05 ± 0,01	0,06 ± 0,02
C23:0	0,06 ± 0,02	0,06 ± 0,03
C24:0	0,05 ± 0,02	0,07 ± 0,03
ΣSFA	**26,33 ± 3,31**	**30,48 ± 2,86**
C16:1 ω9c	0,46 ± 0,12	0,71 ± 0,22
C16:1 ω7c	2,95 ± 0,54	2,99 ± 1,29
C16:1 ω7t	0,26 ± 0,06	0,48 ± 0,12

C17:1 ω7c	0,78 ± 0,14	0,65 ± 0,28
C17:1 ω7t	0,08 ± 0,01	0,12 ± 0,04
C18:1 ω9t	0,05± 0,03	0,11 ± 0,05
C18:1 ω9c	11,14 ± 0,90	11,56± 1,39
C18:1 ω7c	3,63 ± 0,37	4,34 ± 0,39
C18:1 ω5c	0,20 ± 0,02	0,17 ± 0,04
C19:1 ω9t	0,05 ± 0,01	0,06 ± 0,02
C19:1 ω9c	0,10 ± 0,08	0,21 ± 0,11
C20:1 ω9c	0,76 ± 0,10	0,71 ± 0,12
C24:1 ω9c	0,11 ± 0,05	0,11 ± 0,06
ΣMUFA	**20,57 ± 2,43**	**22,22 ± 4,13**
C18:2 ω6c	8,83 ± 1,49	6,52 ± 1,06
C18:3 ω6c	0,10 ± 0,03	0,21 ± 0,07
C18:3 ω3c	9,59 ± 1,30	3,77 ± 1,08
C18:4 ω3c	0,38 ± 0,14	0,37 ± 0,24
C20:2 ω6c	0,77 ± 0,49	0,88 ± 0,14
C20:3 ω6c	0,59 ± 0,11	0,52 ± 0,06
C20:4 ω6c	7,12 ± 0,94	8,73 ± 1,30
C20:3 ω3c	1,84 ± 0,22	1,01 ± 0,62
C20:4 ω3c	0,97 ± 0,12	0,58± 0,14
C20:5 ω3c	3,46 ± 0,53	3,78 ± 0,75
C22:2 ω6c	0,06 ± 0,02	N.D.
C22:4 ω6c	0,93 ± 0,25	1,10 ± 0,18
C22:5 ω6c	1,45 ± 0,26	1,83 ± 0,35
C22:5 ω3c	3,04 ± 0,59	3,37 ± 0,37
C22:6 ω3c	12,99 ± 1,63	13,94 ± 2,2
ΣPUFA	**52,12 ± 8,12**	**46,61 ± 8,56**
Σω3	**29,23 ± 4,53**	26,82 ± 3,16
Σω6	19,85 ± 1,05	19,79 ± 1,92
Σω9	12,67 ± 1,29	13,47 ± 1,97

Note: N.D. not detected.

Table 1 - Fatty acids composition of the edible muscle of largemouth bass individuals captured in winter and summer season. Values are expressed as percent of total fatty acids, mean ± SD, n=20

For fatty acids omega families, our results revealed that *ω*6 (*p=0.687*), and *ω*9 (*p=0,115*) families were not significantly affected by season factor but the opposite was observed for the *ω*3 family (*p=0.001*), being the edible portion of largemouth bass muscle higher in *ω*3-fatty acids in winter than summer.

Our results revealed that season factor had no significant effect on AI and h/H indices (*p=0.106* and (*p=0.080*, respectively). However, the TI values showed significantly differences between winter and summer (*p=0.001* and eta=70.1%) (Table 2).

Nutritional Indices	Winter	Summer
TI index	0,06	0,08
AI index	0,29	0,30
h/H index	3,61	3,46
PUFA/SFA	1,33	1,05
ω/ω6 index	1,63	1,37

Table 2 - Values obtained for the nutritional assessment indices – thrombogenicity index (TI), atherogenicity index (IA) and hypocholesterolemic/hypercholesterolemic index (h/h); PUFA/SFA index and ω/ω6 index – in the two seasons analyzed.

Since TI index results from the contribution of the individual effect of each fatty acid, relating the contents of prothrombotic fatty acids with levels of monounsaturated and polyunsaturated acids with anti-inflammatory properties thrombotic, the lower the index value, the better the quality of the lipid fraction of the edible portion.

Season had a significant effect ($p=0.012$ and eta=15.7%) on PUFA/SFA index. Effectively, for the winter season, PUFA/SFA were 1.33 against 1.05 in summer, being the values for largemouth bass edible muscle higher than recommended values for a balanced diet, which range between 0.45 and 1 (Afonso, 2009).

4 I CONCLUSIONS

Proximate composition of edible muscle of wild largemouth bass captured in Póvoa e Meadas Reservoir revealed significant differences between individuals captured in the winter and summer season. The factor gender ($p=0.406$) and the season*gender interaction ($p=0.799$) had no effects significant in the analysed variables.

Winter specimens revealed fillets with significantly higher values for total lipid content and polyunsaturated fatty acids of the $\omega 3$ family. By opposition, summer fillets were characterized by higher values of crude protein. Significant differences for EPA and DHA between the two seasons were not found. This makes it possible to mention that these two fatty acids are preserved throughout the year and that the PUFA pool undergoes fluctuations based on the remaining fatty acids. Concerning the lipid profile, we concluded that the quality of the edible part is higher in the winter season when compared to the summer one, based on a richer PUFA pool and higher omega 3 fatty acid content. In relation to healthy lipid indices, largemouth bass edible portion were characterized by an ω3/ω6 ratio above the recommended level and by thrombogenicity and atherogenicity indices lower than those found in other species of fish in both seasons.

ACKNOWLEDGMENTS

We would like to thank our colleagues Ana Filipa Belo, Ana Filipa Silva, Carlos Pratas, Esmeralda Pereira, Filipe Banha and João Pedro Marques for the help to catch largemouth bass. The authors also wish to thank the Municipality of Castelo de Vide and Grupo Águas de Portugal (through Águas de Santo André and Águas do Alentejo) for the authorizations to conduct fish sampling in the selected reservoirs. This study was part of the project GAMEFISH - Management of Mediterranean reservoirs for the promotion of recreational fishing activities (ALT20-03-0145-FEDER-000016), funded by the European Union, through the European Regional Development Fund and ALENTEJO 2020 Regional Operational Program. Additional support was provided by the Portuguese Science Foundation through the strategy plan for MARE (Marine and Environmental Sciences Centre), via project UIDB/04292/2020, and through the individual contract attributed to Carlos M. Alexandre within the project CEECIND/02265/2018.

CONFLICT OF INTEREST

The author(s) declare(s) that there is no conflict of interest regarding the publication of this paper.

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