The Influence of Wintering on Macronutrients in Fish Meat, in Species from a Wild Habitat

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Abstract
To determine the macronutrient variations in fish meat at the end of the winter period compared to the start of wintering, 7 species from the Danube River were fished (*Abramis brama*, *Ballerus sapa*, *Barbus barbus*, *Blicca bjoerkna*, *Gymnocephalus schraetser*, *Sander lucioperca*, *Vimba vimba*). Biochemical analyses of fish meat were performed for the winter of 2020-2021 and 2021-2022.
The biochemical profile followed the same trends for the 7 fish species as well as the 2 wintering periods considered. At the start of the winter period, in the meat of all analysed species, the percentage of water was lower compared to the end of the winter period. Proteins and lipids varied inversely with the amount of water in the fish meat for both wintering periods.
In 2020-2021, the percentages of proteins and lipids were lower than in 2021-2022, for all 7 species analysed.
The variations of macronutrients between the start and the end of the winter period are explained by the hibernation behaviour of the fish, which is directly influenced and dependent on temperature variations. The thermal regime recorded higher values in the winter of 2020-2021, interrupting the hibernation of fish, which led to a higher consumption of energy reserves in the meat of the considered species.

Keywords: fish meat biochemistry, macronutrients, wintering

1. Introduction

The Danube River has a remarkable fish biodiversity, many species having an economic role.
Changes in the biochemical parameters of fish meat in the wild, are influenced by the thermal regime of the water. During the winter, fish reduce their metabolic functions to conserve energy.
The *Vimba vimba* is a benthopelagic species. It can be classified as a medium distance migrant. Vimba bream is omnivorous and its diet is represented by plankton, oligochaetes, gammarids, chironomids, molluscs, macrophytes, fish fry and detritus.
Abramis brama it is one of the most numerous native benthopelagic fish in freshwater bodies of Europe. The non-cultured species, such as bream (*Abramis brama*), are never likely to reach the market without commercial fishermen. There are studies on the growth rate of specimens of this species, but not on the profile of macronutrients in meat [1, 2].
White bream, *Blicca bjoerkna*, is one of the most numerous and less investigated native benthivorous fish in freshwater bodies of Europe and abundant commercial fish species.
Gymnocephalus schraetser, is a fish species indexed in the Romanian Vertebrate Red List as vulnerable [3], and is protected by Habitats Directive – 92/43/EEC [4].

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Pikeperch, *Sander lucioperca*, is a predatory fish native to Eastern Europe and western Asia that has been introduced to most European countries [5].
White-eye bream, *Ballerus sapa*, occurs naturally in the Ponto-Caspian (Black, Caspian, Azov seas) and Aral Sea basins. It inhabits coastal marine waters, mainly brackish (estuaries), and fresh waters of large river systems, such as Danube, Don, Prut and Volga. White-eye bream has been reported as a rheophilic species associated mainly with typical riverine, main channel habitats. It is a rather rare species and its documented share in commercial fish stocks has been low [6].
The common barbell, *Barbus barbus*, is a large cyprinid fish highly representative of rivers and streams of the barbe1 zone in Central and Western Europe. Adult *Barbus barbus* live in shoals, occupy precise residence areas and can show precise homing behavior, after free migration or displacement [7].
Due to the nutritional value of these fish species, it is necessary to know the changes in meat biochemistry during the winter. These species have a low popularity on the market due to consumer preferences for classic species (carp, trout, Pontic shad, etc.), studies on the profile of macronutrients are few in number. This experiment complements the data in the literature.

2. Materials and methods

The experiment was performed on 7 species captured from the Danube, in the Galati area. The species were identified according to the morphological characteristics, as follows: common barbel (*Barbus barbus*), vimba bream (*Vimba vimba*), white-eye bream (*Ballerus sapa*), silver bream (*Blicca bjoerkna*), common bream (*Abramis brama*), schraetzer (*Gymnocephalus schraetser*), zander (*Sander lucioperca*).
The fishing was carried out before and after the winter period (in October and in February respectively) to determine the changes in the biochemical profile of the meat. The experiment was performed in two winter periods (2020-2021 and 2021-2022). Each specimen of the 7 species considered for biochemical determinations, was chosen with similar weights, in order to obtain homogeneous results.
Biochemical analysis of fish meat was performed according to specific standards for each biochemical parameter.
Water content was determined through official standard methods of analysis comprised in AOAC (1990).
Total ash was determined through calcination described in AOAC (1990).
Raw protein content present in fish meat was determined using Kjeldahl method described in AOAC (17^{th} edition), which involved protein digestion and distillation, where F (conversion factor) in equal to 6.25.
Total fats were determined using the Soxhlet installation, equipped with Gerhardt Brand Multistate Controller, applying modified methods of ether extraction from AOAC (17^{th} edition).
The amount of protein related to the water content is an indicator of the state of maintenance of the fish. Lower ratio values suggest better maintenance.

Statistical analysis
All analysis were performed in duplicate.
Statistical analysis was conducted with the help of Excel instruments. The average values are presented the respective standard deviation. The statistical interpretation of data was performed in accordance with a significance threshold of $p<0.05$.

3. Results and discussion

The results obtained from the analysis of the meat for the species *Barbus barbus*, are presented in Table 1. The water content of the meat increased by 2.06%, to the detriment of proteins and lipids, between October 2020 and February 2021. For the second chosen interval, the amount of water increased by 2.87%, and proteins and lipids were in lower proportions in February 2022. In the winter of 2021-2022, the species *Barbus barbus* presented a biochemical profile with higher percentages of proteins and lipids and the state of maintenance was better than in the winter of 2020-2021.
The value ranges for macronutrients in the meat of *Barbus barbus* were comparable to those obtained by Olgunoglu et al. for the species *Barbus grypus*, during autumn and spring [8].

Table 1. Biochemical profile of meat for *Barbus barbus*

Species	Fishing date	Weight	Water content (WC)	Proteins (P)	Lipids	Ash	WC/P
Barbus barbus	October 2020	537,00±7.66	75.28±0.84	19.30±0.31	3.97±0.20	1.28±0.01	3.90
	February 2021	520.09±18.55	77.34±1.07	18.36±0.25	2.98±0.82	1.19±0.05	4.21
	October 2021	541.00±9.11	72.11±0.93	20.44±0.14	6.12±0.61	1.06±0.01	3.53
	February 2022	538.03±21.20	74.98±1.12	18.76±0.46	5.28±0.22	0.90±0.09	3.99

Table 2 shows the values of macronutrients in the meat of *Vimba vimba*. At the beginning of winter, the fish material had a better state of maintenance in October 2021. In the period October 2021-February 2022, the specimens of *Vimba vimba* had both the amount of protein and lipids in greater proportions than during October 2020 - February 2021. Diler and Becer[9] obtained higher values of water content, but lower for the amount of protein and lipid, for specimens of *Vimba vimba tenella.*

Table 2. Biochemical profile of meat for *Vimba vimba*

Species	Fishing date	Weight	Water content (WC)	Proteins (P)	Lipids	Ash	WC/P
Vimba vimba	October 2020	508.40±11.00	66.23±1.48	18.45±0.98	13.93±1.11	0.99±0.01	3.59
	February 2021	549.80±21.82	67.98±3.24	17.03±0.17	12.21±2.12	1.05±0.12	3.99
	October 2021	520.80±24.07	63.19±2.99	20.01±1.73	15.77±0.61	0.88±0.03	3.16
	February 2022	500.50±34.11	66.26±4.17	18.36±1.09	14.50±1.53	0.75±0.05	3.61

The species *Ballerus sapa* shows the same evolution of the macronutrients in the 2 monitored winter intervals. The fish material showed a better state of maintenance in the winter of 2021-2022, the amount of protein being higher throughout this interval, compared to the winter of 2020-2021. The values obtained are presented in table 3.

Table 3. Biochemical profile of meat for *Ballerus sapa*

Species	Fishing date	Weight	Water content (WC)	Proteins (P)	Lipids	Ash	WC/P
Ballerus sapa	October 2020	448.44±18.18	76.87±1.90	17.59±0.88	4.21±0.27	1.13±0.06	4.37
	February 2021	411.74±14.11	78.13±1.76	16.24±1.13	4.53±0.17	0.96±0.05	4.81
	October 2021	461.00±15.21	74.99±2.19	18.68±0.64	4.60±0.15	1.22±0.09	4.01
	February 2022	427.10±17.01	75.22±1.81	18.28±0.77	4.95±0.18	1.16±0.11	4.11

The water content in the meat of *Blicca bjoerkna* (Table 4) was higher at the end of winter than at the start, in the winter of 2020-2021, and the protein content varied inversely during the same period. However, the biological material had a better state of maintenance at the end of the 2020-2021 winter. The same evolution of the parameters was maintained in the winter of 2021-2022, with the observation that the protein and lipid content were higher than in the winter of 2020-2021, both at the beginning and at the end of the wintering period.

Table 4. Biochemical profile of meat for *Blicca bjoerkna*

Species	Fishing date	Weight	Water content (WC)	Proteins (P)	Lipids	Ash	WC/P
Blicca bjoerkna	October 2020	277.15±16.22	75.75±1.17	17.38±0.79	4.49±0.55	2.32±0.07	4.36
	February 2021	253.00±7.31	74.68±0.80	18.89±1.41	4.22±0.53	1.85±0.11	3.95
	October 2021	249.07±18.44	73.94±1.09	18.13±0.58	5.35±0.31	2.45±0.18	4.08
	February 2022	291.10±10.95	73.41±1.30	18.49±1.16	5.01±0.27	2.15±0.21	3.97

The variation of macronutrients in the meat of the *Abramis brama* species, in the 2 studied intervals, followed the same trend, the water content increasing at the end of winter compared to the onset of winter, to the detriment of the amount of protein and lipid in the meat. The *Abramis brama* species had a better state of maintenance in the winter of 2021-2022 than in the winter of 2020-2021. Table 5 shows the percentages of macronutrients in the muscle tissue of *Abramis brama*.

Table 5. Biochemical profile of meat for *Abramis brama*

Species	Fishing date	Weight	Water content (WC)	Proteins (P)	Lipids	Ash	WC/P
Abramis brama	October 2020	275.88±12.92	80.17±1.78	17.21±0.77	1.33±0.01	1.06±0.04	4.66
	February 2021	300.11±18.11	81.19±2.02	15.66±0.80	1.71±0.08	1.16±0.01	5.18
	October 2021	261.50±9.22	78.02±1.28	18.73±0.81	1.64±0.14	1.21±0.08	4.17
	February 2022	335.11±15.17	78.16±0.96	18.54±0.66	1.84±0.18	1.24±0.03	4.22

In Table 6, the biochemical profile of the meat from the species *Gymnocephalus schraetser* is presented, data were recorded at the beginning and end of the wintering periods of 2020-2021 and 2021-2022. The share of meat lipids halved at the end of the 2020-2021 winter, while at the end of the 2021-2022 winter, in the meat of the species *Gymnocephalus schraetser* was found a third of the lipids compared to the beginning of the 2021-2022 winter.

The best maintenance status of the fish was recorded in October 2021.

Table 6. Biochemical profile of meat for *Gymnocephalus schraetser*

Species	Fishing date	Weight	Water content (WC)	Proteins (P)	Lipids	Ash	WC/P
Gymnocephalus schraetser	October 2020	98.39±7.84	78.54±0.73	18,50±0.51	0.66±0.01	1.79±0.02	4.25
	February 2021	120.62±11.10	80.11±1.55	17.55±1.08	0.27±0.07	1.83±0.10	4.56
	October 2021	104.31±8.18	77.12±1.82	19.85±1.07	0.98±0.01	1.74±0.05	3.89
	February 2022	89.55±7.92	78.81±2.27	18.92±1.26	0.32±0.03	1.66±0.11	4.17

The evolution of the macronutrients in the meat of *Sander lucioperca*, in the two selected winter intervals, is found in table 7. At each coming out of winter, the water content was higher, to the detriment of the protein and lipid content. The values of protein and lipid percentages in the muscular tissue were higher in 2021-2022 winter compared to 2020-2021 winter, both at the start and the end of the winter period. Celik et al. obtained similar percentages of proteins for the species *Sander lucioperca*, at the end of winter [10].

Table 7. Biochemical profile of meat for *Sander lucioperca*

Species	Fishing date	Weight	Water content (WC)	Proteins (P)	Lipids	Ash	WC/P
Sander lucioperca	October 2020	369.69±15.51	78.08±1.28	19.44±1.33	0.75±0.06	1.29±0.02	4.02
	February 2021	333.70±12.99	79.66±1.33	18.44±1.17	0.31±0.03	1.23±0.28	4.32
	October 2021	348.92±11.03	77.20±1.19	20.33±0.51	1.13±0.10	1.21±0.08	3.80
	February 2022	385.41±16.51	78.89±1.58	19.42±1.06	0.45±0.01	1.15±0.10	4.06

The variation of the biochemical profile of fish meat is dependent on the variation of the thermal regime during the winter. A winter with higher temperatures means increased fish activity. This activity burns from the reserves of lipids and proteins of the fish material, without the conditions to replace the caloric losses due to the lack of food during the winter.

In the context of global warming, the ability of fish species in wild environments to adapt to future climatic conditions is an important issue for protecting aquatic biodiversity.

4. Conclusions

At the end of winter, the macronutrient content is influenced by the temperatures recorded during the winter.

The amount of water in fish meat, at the end of winter, is higher than at the beginning, to the detriment of the protein and lipid amount.

The state of maintenance of fish in the winter of 2021-2022 was better than in the winter of 2020-2021

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