ASSESSMENT OF MINERAL SUBSTANCES PROFILES IN WILD VERSUS FARMED CATFISH

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Abstract: *This study presents a comparative analysis of the mineral composition in different anatomical parts of wild and farmed catfish (Silurus glanis), aiming to evaluate differences in micro- and macroelement profiles that may influence nutritional quality and consumer health. Samples from both environments were analyzed using X-ray fluorescence (XRF) spectroscopy to quantify essential minerals. The results revealed variations in mineral concentrations between wild and aquaculture-sourced catfish, with the highest levels observed for K, Ca, and Fe in muscle from both fish species. Among the trace elements, all samples showed low concentrations of Pb (3–6 ppm), while Cd was undetectable in most samples. The Hg levels ranged from 0.3 to 3 ppm, with the highest concentration found in the head and skin of wild catfish. These findings underscore the impact of habitat, diet, and farming practices on the nutritional value of fish and provide valuable insights for consumers, nutritionists, and aquaculture professionals seeking to optimize dietary recommendations and production strategies.*

Key words*: catfish, mineral substances, farm fish, wild fish, spectrometric techniques*

INTRODUCTION

Fish constitutes one of the most significant and readily available sources of animal protein, being extensively consumed across both rural and urban populations worldwide owing to its high nutritional value and associated health benefits [1,13]. The proteins derived from fish are characterized by superior biological quality, high digestibility, and a substantial contribution to the daily intake of essential amino acids required for human physiological functions [2,8]. Minerals, as indispensable elements for optimal human health, play critical roles in metabolic regulation, maintenance of ionic equilibrium, and structural integrity of tissues. In this context, fish is widely acknowledged as a valuable source of bioavailable minerals, notably calcium, phosphorus, magnesium, potassium, iron, zinc, and selenium [3,4]. The mineral and nutrient composition of fish exhibits considerable variability, being influenced by species-specific biological characteristics, environmental parameters, dietary inputs, water type, and overall habitat quality [5,14,17]. Consequently, distinctions in nutritional profiles are often observed between wild-caught and aquaculture-raised fish, reflecting the influence of naturally available resources in the former and the reliance on formulated feeds in the latter [6,10,12]. The European catfish (Silurus glanis), a species of considerable relevance within both natural European ecosystems and aquaculture systems, is recognized for its high nutritional value and notable adaptability to diverse rearing conditions [5,7,15]. The biochemical composition of its flesh, particularly with respect to protein and mineral content, has been extensively investigated, with multiple studies underscoring its substantial contribution of high-quality proteins and essential minerals to the human diet [8,9]. In natural ecosystems, fish acquire minerals primarily from water, sediments, and naturally available dietary sources, whereas in aquaculture systems these elements are predominantly derived from formulated feeds and controlled water quality management. The divergence between these sources exerts a substantial influence on the mineral composition of fish, with consequential implications for human nutrition, optimization of feeding strategies in aquaculture, and the overall quality of the final product [6,11,16]. Investigations into the nutritional composition and mineral content of fish are critical for generating contemporary evidence that informs consumers, nutritionists, and domain specialists in evaluating its implications for human health and global food security [1,2,18].

MATERIALS AND METHODS

In the present study, specimens of wels catfish (*Silurus glanis*) were collected from both natural habitats and aquaculture systems in order to conduct a detailed comparative assessment of their mineral composition. Biological samples were obtained from multiple anatomical parts, including liver, muscle, skin, bone, fins, and head, to provide a comprehensive evaluation of mineral distribution across distinct anatomical structures. Following collection, all samples underwent standardized drying and homogenization procedures to ensure consistency and reliability of subsequent analyses. The quantification of macro- and microelements was performed using X-ray fluorescence (XRF) spectrometry, a highly precise and non-destructive analytical technique capable of detecting minerals at trace concentrations [10,19]. Results were expressed in parts per million (ppm) and systematically compared between wild-caught and farmed individuals, thereby elucidating potential differences and similarities in mineral profiles attributable to environmental and rearing conditions.

RESEARCH RESULTS

The mineral profile of anatomical parts of wild and aquaculture catfish are presented in Table 1-6.

Table 1.

Mineral composition of liver wild catfish and aquaculture catfish (ppm)

Element	K	Ca	Fe	Cu	Mn	Zn	Co	Cr	Pb	Hg	Cd	U	As	Se
Liver of wild catfis	34303	1487	1491	45	14	220	41	ND	9	0,3	ND	ND	-	18
Liver of aquaculture catfish	36153	883	8815	56	10	276	36	-	-	2,2	19	0,4	-	18

The analysis of minerals in the liver of catfish (*Silurus glanis*) showed that the predominant elements were potassium (K) and iron (Fe). K measured in aquaculture fish liver was approximately 1.05 times higher than that measured in wild fish liver, indicating a relatively stable level of this macroelement essential for cellular functions. Fe reached 8815 ppm in aquaculture fish this value being approximately 5.91 times higher than that registered in wild fish liver, highlighting the significant impact of the aquaculture environment and diet on the accumulation of this microelement. The elements with the lowest concentrations were mercury (Hg) and manganese (Mn). The level of Hg detected in wild fish liver was 7.3 times higher than that detected in aquaculture fish liver, while Mn in aquaculture fish liver was 1.4 times lower than the levels determined in wild fish liver.

Table 2.
Mineral composition of bones widl catfish and aquaculture catfish (ppm)

Element	K	Ca	Fe	Cu	Mn	Zn	Co	Cr	Pb	Hg	Cd	U	As	Se
Bones of wild catfish	13870	83624	305	-	8	116	-	ND	3	1,7	ND	0,3	-	-
Bones of aquaculture catfish	20922	61833	368	ND	5	96	ND	ND	-	1,5	ND	0,5	ND	-

The mineral analysis of catfish (Silurus glanis) bones revealed that calcium (Ca) and potassium (K) were the predominant elements. The concentration of Ca in wild fish bones was approximately 1.35 times higher than that observed in farmed fish, underscoring its fundamental structural role in bone tissue and the enhanced accumulation under natural environmental conditions. Conversely, the concentration of K in aquaculture fish bones was 1.51 times higher than that measured in wild specimens, indicating notable differences in the deposition of this macroelement between the two groups. With respect to elements present at the lowest concentrations, manganese (Mn) and cobalt (Co) were detected only in trace amounts. Mn was measured at 5 ppm in farmed fish bones and 8 ppm in wild fish bones, while Co was virtually undetectable or present at minimal levels in bones from both environments, reflecting the limited incorporation of these microelements into bones tissue.

Table 3.
Mineral composition of head wild catfish and aquaculture catfish (ppm)

Element	K	Ca	Fe	Cu	Mn	Zn	Co	Cr	Pb	Hg	Cd	U	As	Se
Head of a wild catfish	28983	3931	-	13	12	156	-	ND	3	3	3	3	ND	5
Head of aquaculture catfish	41335	2701	-	ND	6	146	-	ND	4	2,3	ND	ND	-	3

The mineral analysis of the skin of wels catfish (*Silurus glanis*) indicated that potassium (K) and zinc (Zn) were present at the highest concentrations. The concentration of K in aquaculture specimens was 1.01 times higher than that measured in wild fish, reflecting a relatively stable level of this macroelement, which plays a critical role in maintaining ionic balance and cellular function. Zinc, an essential element involved in enzymatic activity and metabolic regulation, was quantified at 244 ppm in cultured fish and 164 ppm in wild fish, with the concentration in aquaculture specimens being 1.49 times higher, suggesting that environmental conditions and diet influence the accumulation of this microelement. At the lowest concentrations, selenium (Se) and cobalt (Co) were detected. Se exhibited comparable values across both groups, indicating a uniform and stable distribution of this essential microelement, while Co was present only in trace amounts.

Table 5.
Mineral composition of the muscle of wild and aquaculture catfish (ppm)

Element	K	Ca	Fe	Cu	Mn	Zn	Co	Cr	Pb	Hg	Cd	U	As	Se
Muscle of wild catfish	56914	2763	-	ND	11	77	-	-	ND	2,7	-	-	0	6
Muscle of aquaculture catfish	48489	2185	-	-	6	76	ND	ND	6	2,2	2	ND	-	5

The analysis of mineral composition in the muscle of catfish (*Silurus glanis*) revealed that potassium (K) and calcium (Ca) were the most abundant elements. The concentration of K in wild specimens was 1.17 times higher than that in aquaculture fish, suggesting a greater accumulation of this macroelement under natural environmental conditions. Similarly, Ca levels in wild fish muscle were 1.27 times higher, underscoring a significant difference between the two groups with respect to this essential element. At the lowest concentrations, selenium (Se) exhibited comparable values across both groups, indicating a relatively stable distribution. In contrast, manganese (Mn) levels in wild fish muscle were 1.83 times higher than those measured in aquaculture specimens, highlighting a marked difference in the accumulation of this microelement.

Table 6.

Mineral composition of fins wild catfish aquaculture catfish (ppm)

Element	K	Ca	Fe	Cu	Mn	Zn	Co	Cr	Pb	Hg	Cd	U	As	Se
Fins of wild catfish	5299	43092	256	25	11	203	-	ND	ND	2,1	ND	0,5	1	6
Fins of aquaculture catfish	5411	47344	412	ND	9	210	ND	ND	-	2,6	ND	0,5	0	3

The mineral analysis of catfish (*Silurus glanis*) fins indicated that calcium (Ca) and potassium (K) were the most abundant elements. The concentration of Ca in aquaculture fish was 1.10 times higher than that measured in wild specimens, suggesting a more pronounced accumulation of this macroelement under aquaculture conditions. On the other hand, the level of K in wild fish fins was 1.02 times higher, reflecting a relatively stable distribution of this essential element across both environmental origins. Arsenic (As) and selenium (Se) were detected only in trace amounts. As was absent in cultured fish (0 ppm) and minimally present in wild fish (1 ppm), rendering it practically undetectable. In contrast, Se concentrations were twice as high in the fins of wild catfish, underscoring a clear difference between the two groups in the accumulation of this essential microelement.

CONCLUSIONS

The study revealed distinct differences in mineral composition between wild and aquaculture catfish (*Silurus glanis*), reflecting the influence of environmental conditions, diet, and farming practices. K and Ca were the most abundant elements across tissues, with variable accumulation patterns underscoring their essential roles in cellular and structural functions. Significant group differences were observed for trace elements such as Fe, Mn, and Zn, highlighting the impact of feed formulations and natural resource availability on microelement deposition. Potentially toxic elements as Hg, Pb, Cd, As were generally present at low levels, with Cd often undetectable. However, elevated Hg concentrations in certain wild fish tissues underscore the importance of ongoing food safety monitoring.

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