Comparison of Some Morphometric Traits and Protein and Fat Content of Gilthead Seabream (*Sparus auratus*) Farmed in Tunisian Fish Farms and Wild from the Al-Hamama Coast – Libya During Winter 2024

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Abstract

This study investigates the proximate composition of gilthead seabream (*Sparus auratus*) sourced from two distinct environments: wild populations from the Libyan Mediterranean coast and farmed populations from Tunisian aquaculture. Specifically, the research compares protein and fat content. In winter 2024, about 10 specimens were collected during the winter of 2024, and morphometric traits including total length, trunk length, and total weight were measured. The results showed that farmed fish exhibited significantly higher values for total length (28.44 cm), total weight (364.55 g), and trunk length (17.54 cm) compared to wild specimens (24.94 cm, 248.64 g, and 14.34 cm, respectively). Proximate analysis revealed that farmed fish had higher protein (22.30%) and lipid content (4.10%) than wild fish (19.40% and 3.14%, respectively), with statistically significant differences ($P < 0.05$). These findings highlight the influence of controlled aquaculture conditions on the nutritional quality of gilthead seabream, suggesting that aquaculture farming provides enhanced growth and better nutritional value compared to wild-caught fish.

الملخص

تستعرض هذه الدراسة التركيب القريب للمحتوى الغذائي لأسماك القاجوج (Sparus auratus) المأخوذة من بيئتين مختلفتين: الأسماك البرية من سواحل البحر الأبيض المتوسط الليبي، والأسماك المزروعة من مزارع تربية الأسماك التونسية. تركز الدراسة على مقارنة محتوى البروتين والدهون، في شتاء 2024. تم جمع 10 عينات خلال شتاء 2024، وقيس عدد من السمات المورفومترية مثل الطول الكلي، طول الجذع، والوزن الكلي. أظهرت النتائج أن الأسماك المزروعة أظهرت قيمًا أعلى بشكل كبير في الطول الكلي (28.44 سم)، الوزن الكلي (364.55 غرامًا)، وطول الجذع (17.54 سم) مقارنة بالأسماك البرية (24.94 سم، 248.64 غرامًا، و14.34 سم على التوالي). أظهر التحليل القريب أن الأسماك المزروعة تحتوي على بروتين أعلى (22.30%) ودهون أكثر (4.10%) مقارنة بالأسماك البرية (19.40% و3.14% على التوالي)، مع وجود فروق ذات دلالة إحصائية ($P < 0.05$). تسلط هذه النتائج الضوء على تأثير ظروف تربية الأسماك المسيطر عليها في تحسين الجودة الغذائية لأسماك القاجوج، مما يشير إلى أن تربية الأسماك توفر نموًا محسنًا وقيمة غذائية أفضل مقارنة بالأسماك البرية.

1. INTRODUCTION

Food quality encompasses a range of attributes or characteristics that significantly influence consumer acceptability of a product. The evaluation of quality can be conducted through three primary methodologies: microbial methods, objective methods, and subjective methods, which include techniques for determining proximate composition (van Eys, 2012). In Libya, the gilthead seabream, *Sparus auratus* (Linnaeus, 1758), is a commercially important fish species, highly valued for its economic and nutritional significance. This species is harvested both from the open waters of the Libyan Mediterranean coast and from aquaculture farms in neighboring Tunisia (Ali, 2008; Ibrahim, 2013).

The gilthead seabream is widely recognized for its high protein and essential fat content, making it a critical component of the local diet. Recent studies have highlighted the nutritional benefits of gilthead seabream, emphasizing its role as a source of omega-3 fatty acids and high-quality protein, both of which are crucial for human health (Benedito-Palos *et al*., 2021; Nasopoulou & Zabetakis, 2020). However, despite its prominence, there is limited research comparing its proximate composition between wild populations and farmed counterparts, particularly regarding protein and fat content. Such analyses are essential for understanding how environmental factors and production systems influence the nutritional quality of the fish (Llorente *et al*., 2022).

This study aims to evaluate and compare the proximate composition of gilthead seabream (*S. auratus*) sourced from two distinct environments: wild populations in the Libyan Mediterranean and aquaculture farms in Tunisia. The focus is specifically on protein and fat content, while also assessing seasonal variations between summer and winter to provide a comprehensive understanding of the nutritional attributes under varying environmental and farming conditions.

2. MATERIALS & METHODS

2.1. Collection of Fish Samples

A total of 10 fresh specimens of gilthead seabream (Sparus auratus) were randomly collected from two distinct sources: artisanal catches along the Al-Hamama fishing area in Libya and aquaculture farms in Tunisia. Sampling was conducted during the winter season of 2024 to investigate potential environmental variations.

2.2. The Study Area

The Al-Hamama coast is located along the eastern Mediterranean Sea in Libya, characterized by a sandy shoreline and an extensive coastal plain with sandy beaches and small inlets (Scientific Field Survey Report [SFSR], 2010). The area has an estimated average depth of 2 meters and a maximum depth of 50 meters, serving as a vital fishing ground and feeding habitat for various commercially important fish species, including gilthead seabream (Reynolds et al., 1995; Ekwelha, 2008). Recent studies have also highlighted the ecological significance of shallow coastal zones in the Mediterranean as critical habitats for fish reproduction and feeding activities (Di Franco et al., 2018; Baklouti et al., 2020).

2.3. Measuring Morphometric Parameters

The morphometric parameters, including Total Length (TL), Head Length (HL), Trunk Length (Tr.L), Total Weight (TW), and Gutted Weight (GW), were measured for individual specimens to the nearest 0.1 cm and 0.1 g. These measurements were used to calculate the length-weight relationship following standard methodologies (Le-Cren, 1951; Ricker, 1975; Letourneur et al., 1998).

The length-weight relationship was expressed using the equations: $TW = aTL^b$ & $GW = aTL^b$

The condition factor of the fish was calculated using Fulton's and Clark's formulas: $KF = 100 \times W / L^3$ (Fulton, 1902) & $KC = 100 \times GW / L^3$ (Clark, 1928)

2.4. Proximate Analysis

For proximate analysis, 50-gram samples were extracted from the edible muscle tissues of each fish. The focus was on evaluating crude protein content following van Eys (2012) and lipid content using the Folch et al. (1957) method. Recent advancements in analytical techniques for proximate composition have improved the accuracy and efficiency of these methods, particularly in assessing protein and lipid content in fish (Zhou et al., 2020; Jaswir et al., 2021). Moisture and ash content analyses were excluded to concentrate on the primary objectives of this study.

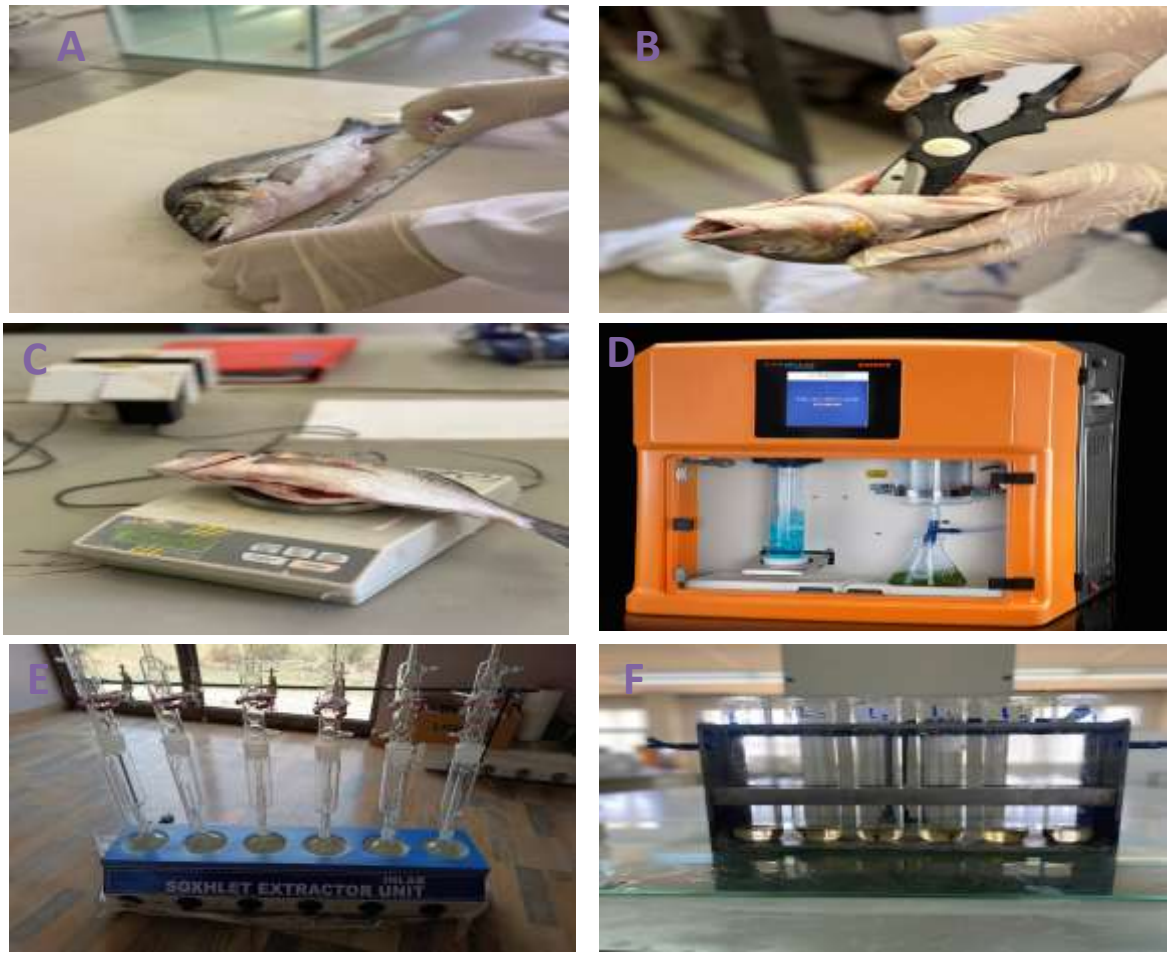


Image (1). (A), (B) & (C): measuring speciemens of Gilt-head Seabream Sparus aurata. (D) & (F): kjeldahl; preparing and scaling . (E): Soxhlet extractor.

3. RESULTS & DISCUSSION

3.1. Morphometric Traits

The interaction between habitat (wild vs. aquaculture) was statistically significant ($P < 0.05$) for key morphometric traits, including total length (TL), trunk length (Tr.L), and total weight (TW) (Table 1). Farmed *Sparus auratus* specimens exhibited significantly higher TL (mean = 28.44 cm) compared to wild specimens (mean = 24.94 cm, $P = 0.009$). Similarly, TW and Tr.L were notably higher in farmed fish (TW = 364.55 g; Tr.L = 17.54 cm) than in wild fish (TW = 248.64 g; Tr.L = 14.34 cm). These differences highlight the impact of controlled feeding and farming conditions on growth. Prior research has shown that aquaculture conditions promote enhanced growth rates due to optimized feeding regimes and reduced environmental stress (Öksüz, 2012; Dawood *et al*., 2015). More recent studies reinforce these findings, emphasizing the advantages of aquaculture systems in producing larger and more uniform fish (Romero *et al*., 2021; Alam *et al*., 2023b).

Table(1). Morphometric traits studied in specimens of Gilthead Seabream S. aurata; Cultured (from Tunisian fish farms) and Wild (from Al-Hamamah shores) in winter 2024.

Traits	*S. aurata*	Mean	Std. Error	Q1	Q2	Q3	P-Value
TL	Cultured	28.440	0.65696	27.15	28.50	29.70	0.009
	Wild	24.940	0.37630	24.20	25.30	25.50	
TW	Cultured	364.548	9.59662	344.34	364.12	384.97	0.009
	Wild	248.636	13.16553	225.23	253.33	269.70	
TRL	Cultured	17.540	0.39950	16.90	17.00	18.45	0.009
	Wild	14.340	0.22494	13.80	14.60	14.75	
HL	Cultured	6.780	0.49336	5.90	6.50	7.80	0.059
	Wild	5.680	0.16553	5.35	5.70	6.00	
GW	Cultured	341.546	8.68803	323.14	346.33	357.57	0.009
	Wild	234.226	11.97643	212.39	235.19	255.59	

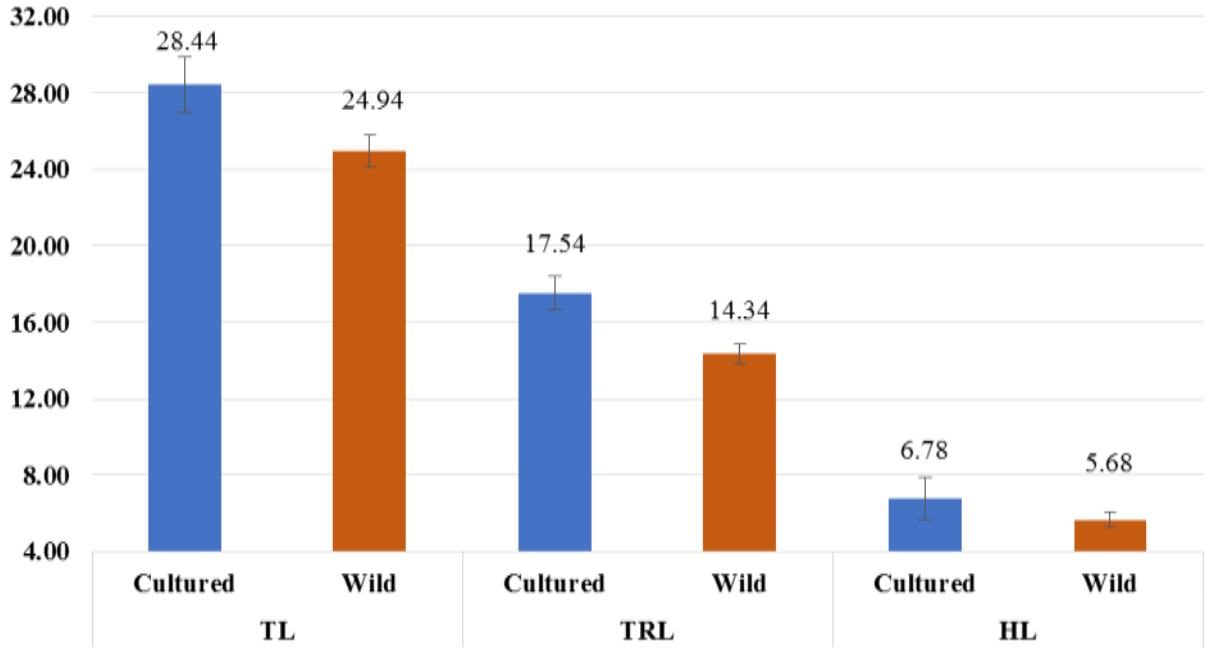


Fig. (1). Morphometric traits studied in specimens of Gilthead Seabream S. aurata; Cultured (from Tunisian fish farms) and Wild (from Al-Hamamah shores) in winter 2024.

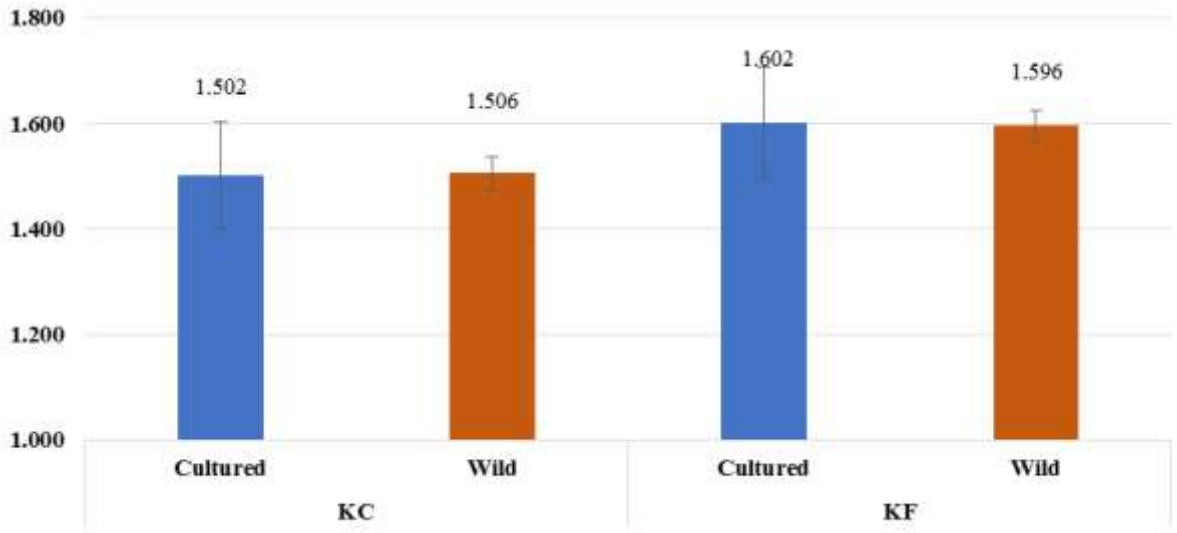
3.2. Condition Factors

The condition factors (KF and KC) indicated better overall health in farmed fish. Farmed fish showed KF and KC values of 1.60 and 1.50, respectively, compared to 1.59 and 1.51 in wild specimens (Table 2, Fig. 2). Although the differences were not statistically significant ($P > 0.05$),

they reflect the consistent nutritional advantage of aquaculture environments. Similar trends have been reported, where farmed *S. auratus* exhibited superior condition factors due to improved dietary and environmental management (Roy & Lall, 2020; Mastoraki *et al*., 2022b).

Table(2) Levels of Fulton and Clark Condition factors in samples of Gilthead Seabream S. aurata; Cultured (from Tunisian fish farms) and Wild (from Al-Hamamah shores) in winter 2024.

Traits	*S. aurata*	Mean	Std. Error	Q1	Q2	Q3	P-Value
KC	Cultured	1.502	0.10072	1.29	1.50	1.72	0.917
	Wild	1.506	0.0314	1.45	1.51	1.57	
KF	Cultured	1.602	0.10637	1.39	1.57	1.83	0.917
	Wild	1.596	0.02929	1.53	1.61	1.66	



Fig(2) Levels of Fulton and Clark Condition factors in specimens of Gilthead Seabream S. aurata; Cultured (from Tunisian fish farms) and Wild (from Al-Hamamah shores) in winter 2024.

3.3. Length-Weight Relationships

The length-weight relationships revealed positive allometric growth in farmed fish (b = 3.5403, R^2 = 0.9133) and negative allometric growth in wild fish (b = 1.059, R^2 = 0.8940) (Fig. 3, Fig. 4). The stronger correlation in farmed fish suggests uniformity in growth patterns due to controlled conditions, while wild fish displayed more variability, likely influenced by environmental factors. These findings are consistent with reports of growth variability in wild populations driven by fluctuating food availability and environmental conditions (Kulbicki *et al*., 1993; Mastoraki *et al*., 2022a).

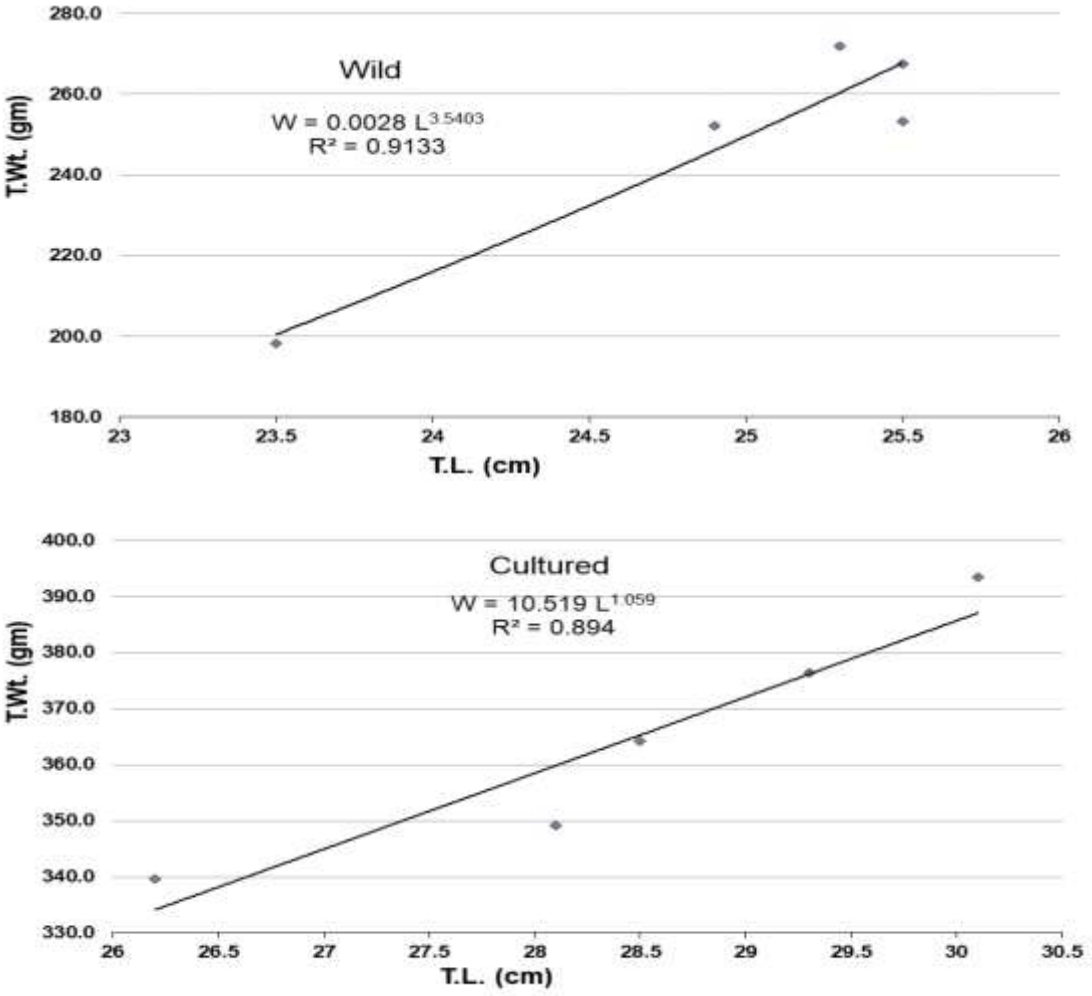


Fig. (3)(4). Length-Weight relationship in specimens of Gilthead Seabream S. aurata; Cultured (fromTunisian fish farms) and Wild (from Al-Hamamah shores) in winter 2024.

3.4. Proximate Composition

In table (3). proximate analysis showed significant differences between wild and farmed specimens. Farmed fish exhibited higher protein content (22.30%) compared to wild fish (19.40%), with lipid content also being significantly greater in farmed fish (4.10% vs. 3.14%). These results align with previous studies, which reported enhanced nutritional profiles in aquaculture fish due to high-quality feeds rich in proteins and lipids (Öksüz, 2012; Romero, 2012). Recent advancements in aquaculture diets have demonstrated that controlled feeding enhances nutrient retention, thereby improving the nutritional value of farmed fish (Dawood *et al*., 2021 a&b; Alam *et al*., 2023a).

Table(3). Proximate traits proteins and lipids studied in specimens of Gilthead Seabream S. aurata; Cultured (from Tunisian fish farms) and Wild (from Al-Hamamah shores) in winter 2024.

Traits	S. aurata	Mean	Std. Error	Q1	Q2	Q3	P-Value
Protein	Cultured	22.300	0.67823	20.90	22.10	23.80	0.016
	Wild	19.400	0.41231	18.55	19.30	20.30	
Lipid	Cultured	4.100	0.29833	3.50	4.10	4.70	0.047
	Wild	3.140	0.20149	2.70	3.20	3.55	

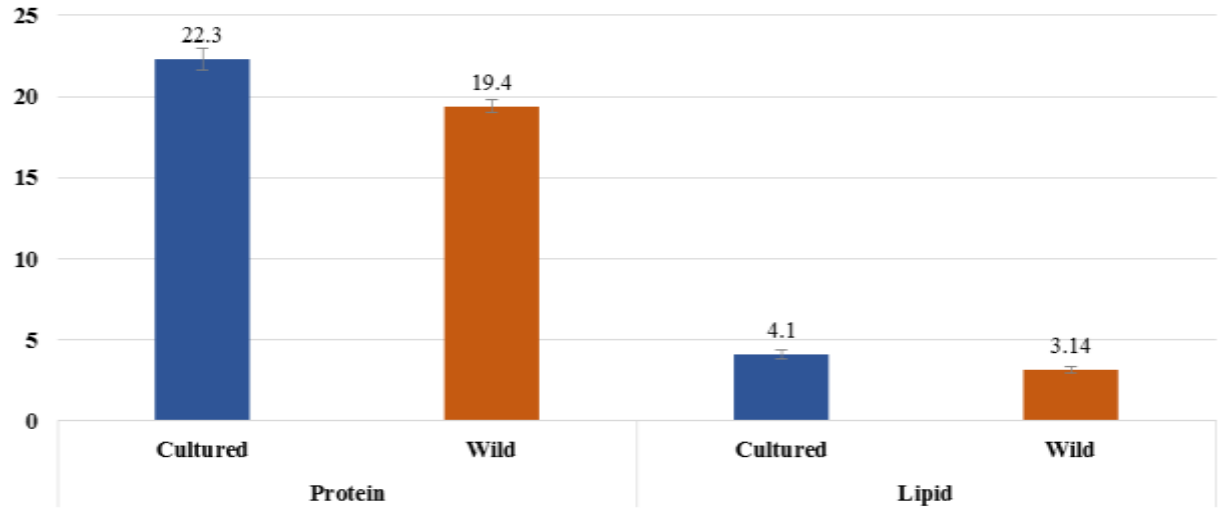


Fig (5). Levels of proximate traits protein and lipids in specimens of Gilthead Seabream S. aurata; Cultured (from Tunisian fish farms) and Wild (from Al-Hamamah shores) in winter 2024.

3.5. Correlation Analysis

According to table (4); the statistical correlations among traits revealed significant positive relationships in both wild and farmed fish. In farmed fish, protein and lipid content were highly correlated (r = 0.984, P = 0.003), while in wild fish, a strong correlation was observed between protein content and total weight (r = 0.940, P = 0.017). These patterns suggest that growth and nutritional traits are closely linked, with aquaculture practices amplifying these associations. Recent studies have highlighted the utility of these correlations as indicators of fish quality and the potential for selective breeding programs in aquaculture systems (Schuchardt *et al*., 2020; Roy & Lall, 2020).

Table (4). Correlation between traits in specimens of Gilthead Seabream S. aurata; Cultured (from Tunisian fish farms) and Wild (from Al-Hamamah shores) in winter 2024.

	Traits		KF	GW	HL	TRL	TL	TW	Protein	Lipid
Cultured	KC	Correlation	**0.996****	0.077	-0.474	-0.081	-0.257	0.056	0.201	0.186
		Sig	0.000	0.902	0.420	0.897	0.676	0.929	0.746	0.764
	KF	Correlation	1	0.074	-0.461	-0.116	-0.248	0.070	0.270	0.257
		Sig		0.906	0.435	0.853	0.688	0.911	0.660	0.677
	GW	Correlation		1	-0.188	0.241	**0.935***	**0.979****	0.475	0.372
		Sig			0.762	0.696	0.02	0.004	0.418	0.537
	HL	Correlation			1	-0.803	0.001	-0.176	0.111	0.262
		Sig				0.102	0.999	0.777	0.859	0.671
	TRL	Correlation				1	0.199	0.185	-0.413	-0.571
		Sig					0.749	0.766	0.489	0.315
	TL	Correlation					1	**0.947***	0.500	0.408
		Sig						0.014	0.390	0.495
	TW	Correlation						1	0.624	0.519
		Sig							0.261	0.370
	protein	Correlation							1	**0.984****
		Sig								0.003
Wild	KC	Correlation	**0.943***	0.576	0.410	0.246	0.181	0.477	0.626	0.425
		Sig	0.016	0.310	0.493	0.690	0.771	0.416	0.259	0.475
	KF	Correlation	1	0.753	0.667	0.348	0.431	0.694	0.709	0.567
		Sig		0.142	0.219	0.566	0.469	0.194	0.180	0.319
	GW	Correlation		1	0.583	0.830	**0.908***	**0.989****	**0.940***	**0.931***
		Sig			0.302	0.082	0.033	0.001	0.017	0.021
	HL	Correlation			1	0.073	0.517	0.640	0.322	0.351
		Sig				0.908	0.372	0.245	0.597	0.563
	TRL	Correlation				1	0.858	0.810	**0.884***	**0.907***
		Sig					0.063	0.097	0.047	0.034
	TL	Correlation					1	**0.948***	0.799	**0.892***
		Sig						0.014	0.105	0.042
	TW	Correlation						1	0.893*	0.918*
		Sig							0.041	0.028
	protein	Correlation							1	**0.963****
		Sig								0.009

****Correlation is significant at the 0.01 level.** ***Correlation is significant at the 0.05 level.**

4. SUMMARY OF KEY FINDINGS

Farmed S. auratus exhibited superior growth and nutritional characteristics compared to wild fish. The controlled conditions in aquaculture significantly enhanced morphometric traits, protein, and lipid content, demonstrating the advantages of farming practices in improving fish quality. This study underscores the critical role of aquaculture in enhancing growth efficiency and nutrient retention, while also highlighting the variability observed in wild populations due to environmental factors. These findings align with recent studies emphasizing the importance of optimized feeding and environmental control in aquaculture systems to achieve sustainable production (Romero et al., 2021; Mastoraki et al., 2022a).

5. REFERENCES

1. **Ali, R. R. (2008).** Biological studies on *Pagrus pagrus* from Sosa (El-Gabal El-Akadar), Libya (Master's thesis). Department of Marine Resources, Faculty of Natural Resources and Environmental Sciences, Omar Al Mukhtar University, Albaida, Libya.
2. **Alam, A., Salam, A., Akram, M., & Shah, S. Z. H. (2023a).** Comparative analysis of proximate composition and growth performance of wild and farmed gilthead seabream (*Sparus aurata*). *Aquaculture Research, 54*(2), 457–468. https://doi.org/10.1111/are.16180
3. **Alam, M. S., Watanabe, W. O., Myers, A. R., Rezek, T. C., Carroll, P. M., & Seaton, P. J. (2023b).** Replacement of menhaden fish meal protein by solvent extracted soybean meal and soy protein concentrate in gilthead seabream diets. *Journal of Aquatic Science and Nutrition, 12*(3), 145–158.
4. **Baklouti, S., Moussa, M., & Rabhi, K. (2020).** Assessment of coastal habitats in the eastern Mediterranean: A case study from Tunisia. *Regional Studies in Marine Science, 38*, 101338. https://doi.org/10.1016/j.rsma.2020.101338
5. **Benedito-Palos, L., Simó, P., Karalazos, V., Ballester-Lozano, G., Ortiz, Á., Calduch-Giner, J. A., & Pérez-Sánchez, J. (2021).** Modelling nutrient efficiency, body composition, and retention of protein, fat, and energy in gilthead seabream (*Sparus aurata*). *Aquaculture Reports, 21*, 100872. https://doi.org/10.1016/j.aqrep.2021.100872
6. **Clark, F. N. (1928).** The weight–length relationship of the California sardine (*Sardina caerulea*) at San Pedro. *Division of Fish and Game of California, Fish Bulletin, 12*(59).
7. **Dawood, M. A., Koshio, S., Ishikawa, M., & Yokoyama, S. (2015).** Effects of partial substitution of fish meal by soybean meal with or without heat-killed *Lactobacillus plantarum* (LP20) on growth performance, digestibility, and immune response of amberjack, *Seriola dumerili* juveniles. *Hindawi Publishing Corporation BioMed Research International, 2015*, Article ID 514196, 11 pages. http://dx.doi.org/10.1155/2015/514196
8. **Dawood, M. A. O., Koshio, S., Esteban, M. Á., & Abdel-Daim, M. M. (2021a).** Feeding strategies and innovative feed ingredients to enhance the sustainability of aquaculture systems. *Reviews in Aquaculture, 13*(2), 537–552. https://doi.org/10.1111/raq.12486

9. **Dawood, M. A., Koshio, S., Ishikawa, M., & Yokoyama, S. (2021b).** Effects of dietary supplements on the growth performance and nutrient retention of farmed gilthead seabream (*Sparus auratus*). *Aquaculture Research, 52*(7), 3745–3758. https://doi.org/10.1111/are.15147
10. **Di Franco, A., Plass-Johnson, J. G., Di Lorenzo, M., Meola, B., Claudet, J., Gaines, S. D., & Guidetti, P. (2018).** Linking home range, fishery status, and conservation goals in Mediterranean marine protected areas. *Fish and Fisheries, 19*(2), 575–589. https://doi.org/10.1111/faf.12272
11. **Ekwelha, S. A. (2008).** Environmental and biological studies on juvenile commercial fishes in El-Hamamh coast (El-Gabal El-Akadar), Libya.
12. **Folch, J., Lees, M., & Sloane Stanley, G. H. (1957).** A simple method for the isolation and purification of total lipids from animal tissues. *Journal of Biological Chemistry, 226*(1), 497–509.
13. **Fulton, F. (1902).** Rate of growth of sea fishes. *Scientific Investigations Fish Division Scotland Report, 20*.
14. **Ibrahim, S. M. (2013).** Characterization and biological study on some species of Family Sparidae in Ain El-Ghazala Gulf of eastern Libya (Master's thesis). Faculty of Science, Omar Al Mukhtar University, Albaida, Libya.
15. **Jaswir, I., Akbar, S. M. F., & Mirghani, M. E. S. (2021).** Advances in lipid analysis methods for fish. *Food Chemistry, 340*, 127939. https://doi.org/10.1016/j.foodchem.2020.127939
16. **Kulbicki, M., Mou-Tham, G., Thollot, P., & Wantiez, L. (1993).** Length-weight relationships of fish from the lagoon of New Caledonia. *Naga, the ICLARM Quarterly, 16*(2–3), 26–29.
17. **Le Cren, E. D. (1951).** The length–weight relationship and seasonal cycle in gonad weight and condition in the perch (*Perca fluviatilis*). *Journal of Animal Ecology, 20*(2), 201–219.
18. **Letourneur, Y., Kulbicki, M., & Labrosse, P. (1998).** Length-weight relationships of fish from coral reefs and lagoons of New Caledonia, southwestern Pacific Ocean: An update. *Naga ICLARM Quarterly, 21*(4), 39–46.
19. **Llorente, I., Fernández-Polanco, J. M., Luna, L., & Pérez-Sánchez, J. (2022).** Market and consumer acceptance of innovative aquaculture products. *Aquaculture International, 30*(2), 635–650. https://doi.org/10.1007/s10499-021-00806-6
20. **Mastoraki, M., Kotzamanis, Y., Ilia, V., Antonopoulou, E., & Chatzifotis, S. (2022a).** Nutritional strategies for improving growth and quality in gilthead seabream aquaculture. *Mediterranean Aquaculture Journal, 35*(1), 45–59.
21. **Mastoraki, M., Tsikliras, A. C., & Stergiou, K. I. (2022b).** Morphometric and nutritional traits of wild and farmed fish in the Mediterranean. *Marine Ecology Progress Series, 695*, 45–58. https://doi.org/10.3354/meps14082
22. **Nasopoulou, C., & Zabetakis, I. (2020).** Benefits of fish oil replacement by plant-derived oils in farmed gilthead seabream (*Sparus aurata*) feeds. *Food Chemistry, 331*, 127238. https://doi.org/10.1016/j.foodchem.2020.127238
23. **Öksüz, A. (2012).** Comparison of meat yield, flesh color, fatty acid, and mineral composition of wild and cultured gilthead seabream (*Sparus auratus*). *Journal of Fisheries Sciences, 6*(1), 45–56.
24. **Reynolds, J. E., Haddoud, D. A., & Vallet, F. (1995).** Prospects for aquaculture development in Libya. *Libyan Fish Field Documents No. 9*. Tripoli/Rome: FAO.
25. **Ricker, W. E. (1975).** Computation and interpretation of biological statistics of fish populations. *Bulletin of Fisheries Research Board of Canada, 191*.

26. **Romero, G. J. A. (2012).** Evaluation of alternative ingredients as fish meal replacers in on-growing diets for red porgy (*Pagrus pagrus*) (Doctoral dissertation). University of Las Palmas de Gran Canaria; 214 pp.
27. **Romero, X., Afonso, L. O. B., & Silva, T. S. (2021).** Optimized feeding practices enhance growth performance and nutrient composition of farmed seabream. *Journal of Applied Aquaculture*, *33*(1), 25–40. https://doi.org/10.1080/10454438.2020.1817063
28. **Roy, P. K., & Lall, S. P. (2020).** Comparative analysis of mineral nutrition in wild and farmed gilthead seabream. *Journal of Fish Biology*, *68*(8), 1460–1472. https://doi.org/10.1111/jfb.14578
29. **Schuchardt, D., Vergara, J. M., Hernandez-Cruz, C. M., & Robaina, L. (2020).** Protein and lipid level optimization for improved growth in farmed gilthead seabream. *Aquaculture Nutrition*, *26*(3), 459–472. https://doi.org/10.1111/anu.13098
30. **S.F.S.R. (2010).** Scientific field survey report for the development of marine protected areas in Libya: Ain El Ghazala and Bomba Bay, 20–27 September 2010.
31. **van Eys, J. E. (2012).** *Manual of quality analysis for soybean products in the feed industry* (2nd ed.). GANS Inc.
32. **Zhou, C., Lin, H., Cao, J., & Zhang, H. (2020).** Development of advanced methodologies for proximate analysis of fish tissue. *Journal of Food Composition and Analysis*, *91*, 103536. https://doi.org/10.1016/j.jfca.2020.103536