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Meat Technology — Special Issue 66/3

www.meatcon.rs ▪ www.journalmeattechnology.com

UDK: 614.31:664.953

ID: 179666185

https://doi.org/10.18485/meattech.2025.66.3.82

Original Scientific Paper

Characterization of commercial fish *pâtés*: toward the development of novel fish-based spreads

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ARTICLE INFO

Keywords:
Fish pâté
Sensory analysis
Texture
Product development

ABSTRACT

This study evaluated the textural and sensory properties of commercial fish *pâtés* available on the Serbian market to identify differences in quality and consumer-relevant characteristics. 14 *pâté* samples made from marine (tuna, salmon, mackerel, hake) and freshwater (trout) fish were analyzed. Texture profile analysis included measurements of firmness and work of shear, while sensory evaluation was conducted by a trained panel, focusing on hardness, spreadability, graininess, color uniformity, taste, and smell. Significant variability ($p<0.05$) was observed among the samples, indicating diverse formulation strategies. Tuna- and salmon-based *pâtés* achieved the highest overall acceptability due to their appealing flavor and appearance. In contrast, trout-based *pâtés* exhibited more balanced texture attributes, with sensory and instrumental data aligning closely with ideal values. These findings provide useful guidance for the development of novel fish *pâtés* using underutilized species such as freshwater bream (*Abramis brama*), which have been identified as key low-trophic species within the HEU project IMPRESS. The results highlight the importance of optimizing textural properties to enhance consumer acceptability.

1. Introduction

The global *pâté* market was valued at US$ 1.74 billion in 2023 and is projected to grow at a compound annual growth rate (CAGR) of 4.9% from 2024 to 2030, reaching an estimated US$ 2.44 billion by 2030 (*Grand View Research*, 2024). This growth is driven by evolving consumer preferences for convenient, ready-to-eat foods, the rise of snacking culture, and the increasing adoption of diverse culinary trends (*Engelen & de Wijk*, 2012). In Serbia, the *pâté* and spread category recorded a 1% increase in volume and a 6.3% increase in value between March 2024 and February 2025, with 43% of total sales generated through promotional activities. Notably, fish *pâtés* account for 11% of total volume sales but contribute 18% to total value sales, indicating strong market potential for premium fish-based products (*Retail Zoom*, 2025).

Fish *pâtés* offer significant nutritional benefits compared to meat-based alternatives. These attributes make them a valuable addition to diets, particularly in regions with low fish consumption. Given that consumers with a strong interest in food quality perceive fish more positively than meat in terms of freshness, taste, and safety (*Torrissen & Onozaka*, 2017), the development of premium fish *pâtés* may

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Paper received August 8th 2025. Paper accepted August 25th 2025.
The paper was presented at the 63rd International Meat Industry Conference "Food for Thought: Innovations in Food and Nutrition" – Zlatibor, October 05th-08th 2025.
Published by Institute of Meat Hygiene and Technology – Belgrade, Serbia.

particularly appeal to this market segment. However, the Serbian market is predominantly supplied with marine fish *pâté*s (e.g., tuna – *Thunnus albacares*, hake – *Merluccius hubbsi*, salmon – *Salmo salar*, Atlantic mackerel – *Scomber scombrus*) and freshwater (trout – *Oncorhynchus mykiss*), while low-trophic species such as bream (*Abramis brama*) and roach (*Rutilus rutilus*) remain underutilized. According to the Food and Agriculture Organization, global per capita fish consumption surpassed 20.6 kg in 2021, more than doubling since the 1960s (*FAO*, 2024). In contrast, fish intake in Serbia remains significantly lower, averaging approximately 7 kg per person annually. Marine fish and seafood accounted for 92.80% of the total fish and fish product supply on the Serbian market, whereas freshwater fish represented only 7.14% (*Janjić et al*., 2024). Freshwater fish, although less studied than marine species, are a valuable nutritional source due to their lower fat and sodium content, lower mercury risk, and richness in high-quality proteins and micronutrients. These attributes make them a safe and nutritionally beneficial choice for diverse populations (*Lámfalusy et al*., 2025; *Regal Springs*, 2025; *Ahmed et al*., 2022; *Mielcarek et al*., 2020).

This study aimed to conduct an evaluation of sensory and textural properties of 14 commercial fish *pâté*s available on the Serbian market to identify their "strengths and weaknesses". The results will serve as a basis for developing of an innovative fish spread from underutilized species (freshwater bream) by guiding the optimization of its formulation and processing parameters in accordance with consumer preferences and current market trends.

2. Materials and methods

2.1.1. Sample collection

A total of 14 commercial fish *pâté* samples were collected from retail markets in Serbia between March and April 2025. The samples were selected to represent a diverse range of products available on the Serbian market, including both marine (tuna – *Thunnus albacares*, hake – *Merluccius hubbsi*, salmon – *Salmo salar*, Atlantic mackerel – *Scomber scombrus*) and freshwater (trout – *Oncorhynchus mykiss*) fish-based *pâté*s. Selection criteria were product availability in major retail channels (hypermarkets, supermarkets, and medium-sized stores), popularity based on sales data (*Retail Zoom*, 2025), and variation in fish species and brands.

2.1.2. Sensory evaluation

Sensory evaluation was conducted by 10 trained assessors (ISO 8586:2023 ; Sensory analysis, 2023) in a standardized sensory lab (SRPS EN ISO 8589:2015 ; Sensory analysis, 2015), using seven-point (7) scales (SRPS ISO 4121:2013 ; Sensory analysis, 2013) to assess color uniformity, taste, smell, surface homogeneity, spreadability, graininess, hardness, and overall acceptability, following the protocol described by *Nikolić et al*. (2018).

2.1.3. Textural analysis

Texture analysis of the top-rated sensory samples was performed using a TA.XT Plus Texture Analyzer (Stable Micro Systems, UK), following the Margarine Spreadability protocol (MAR4_SR.PRJ), as described by *Županjac et al*., 2023. A Spreadability Rig HDP/SR was used at 22 °C with a 5 kg load cell. Test speeds were set to 1.0 mm/s (pre-test), 3.0 mm/s (test), and 10.0 mm/s (post-test). Firmness and shearing work were determined based on the force during probe penetration.

2.1.4. Statistical analysis

Statistical analysis was done using One-way ANOVA (Statistica 14.0.0.15, TIBCO Software Inc., USA). Duncan's post hoc test was performed for comparison of mean values. Differences were considered significant at $p<0.05$.

3. Results and discussion

Statistically significant differences ($p< 0.05$) were observed among the *pâté* samples in both firmness and work of shear (Table 1), indicating a broad textural range among the commercial products. Sample 139 (salmon *pâté*) exhibited the highest firmness (414±16.9 g) and work of shear (417±22.7 g sec), suggesting a dense and cohesive texture that may hinder spreadability. In contrast, sample 571 (tuna and mackerel) had the lowest values (firmness, 49.4±0.52 g; work of shear, 38.1±1.80 g sec), reflecting a very soft and easily spreadable product. The variability in firmness and spreadability among *pâté* samples can be attributed to differences in protein content and composition (*Trindade et al*., 2023; *Zheng et al*., 2022; *Zhang et al*., 2010), fat content and structure (*Martínez et al*., 2025 ; *Botella-Martínez et al*., 2024; *Lima et al*., 2022; *Tiensa*

et al., 2017), water content (*Mancera-Rodriguez et al*., 2022), use of different emulsifiers (*Baechle et al*., 2025; *Youssef & Barbut*, 2011; 2010), and processing methods (*Pětová et al*., 2024; *Lazárková et al*., 2023; *Aydin et al*., 2020), as well as storage and serving temperature, which have been shown to significantly affect the rheological and sensory characteristics of high-fat emulsified products (*Yang et al*., 2024). Proteins derived from different fish species (*Yi-Li et al*., 2025; *Fernandes et al*., 2024; *Traina et al*., 2024; *Ahmed et al*., 2022; *Tilami et al*., 2018) exhibit distinct gelation behavior, emulsifying capacity, and water-holding ability, which significantly influence the texture of fish-based spreads. Higher protein and fat levels generally contribute to a denser and more cohesive texture, while increased moisture and finer particle size favor softer and more easily spreadable products.

Samples 383, 428, and 329 exhibited intermediate firmness (276±16.1 to 288±7.73 g) and work of shear (274±13.4 to 291±15.2 g sec), likely indicating a balanced texture that aligns with typical consumer expectations.

Sample 555, although soft (146± 24.7 g), exhibited high work of shear (245.51 ± 33.93 g sec), indicating a soft yet less spreadable pâté touch (*Di Monaco et al*., 2008; *Szczesniak*, 2002). This is often linked to cohesive or elastic matrices that increase resistance to deformation, as confirmed in studies on fish pâtés and fat-based products (*Ranilović et al*., 2020; *Lončarević et al*., 2013).

Variations in firmness and spreadability were also observed within the same fish *pâté* types. For example, significant differences ($p<0.05$) in firmness and work of shear were observed among tuna *pâté* samples, with firmness ranging from 167±7.11g to 327±21.4 g. Higher values of both parameters indicate a denser, more cohesive texture that may reduce spreadability, while lower values suggest a softer, more easily spreadable product. These variations likely reflect different formulation and processing approaches (*Pětová et al*., 2024; *Lazárková et al*., 2023). Similarly, mixed fish *pâté*s made from tuna and mackerel (samples 149 and 571) showed statistically significant differences ($p<0.05$). Sample 149 exhibited high firmness and work of shear values (310±28.9 g and 301±35.7 g sec, respectively), indicating a dense and cohesive texture, while sample 571 had the lowest values (49.4±0.52 g and 38.1±1.80 g sec, respectively), reflecting a very soft and easily spreadable product. These differences highlight the impact of ingredient ratios and processing methods, emphasizing the need for formulation standardization to optimize textural properties (*Martínez et al*., 2025; *Botella-Martínez et al*., 2024; *Mancera-Rodriguez et al*., 2022; *Tiensa et al*., 2017). Among the salmon *pâté*s, samples 857 (firmness 295±4.55 g; work of shear 262±6.90 g sec) and

Table 1. Texture (firmness and work of shear) for fish *pâté* samples

Sample	Firmness (g)	Work of Shear (g sec)
139 - salmon	414±16.^{9g}	417±22.7^{g}
428 - tuna	276±16.1^{d}	274±13.4^{def}
571 - tuna and mackerel	49.4±0.52^{a}	38.1±1.80^{a}
965 - trout	151±7.11^{b}	152±8.03^{b}
711 - tuna	327±21.4^{f}	335±1.80^{f}
383 - tuna	288±7.73^{de}	286±12.6^{ef}
627 - tuna	172±15.3^{b}	163±20.4^{b}
334 - tuna	167±7.11^{b}	169±13.2^{b}
555 - trout	146±24.6^{c}	245±33.9^{c}
149 - tuna and mackerel	310±28.9^{ef}	301±35.6^{f}
314 - salmon	229±7.25^{c}	223±7.38^{c}
857 - salmon	295±4.5^{5d}e	262±6.90d^{e}
222 - tuna	284±8.13^{de}	299±12.4^{f}
329 - hake	281±12.2^{d}	291±15.2^{ef}

Legend: ^{a,b,c,d,e,f,g} Different letters in the column mean that pâtés are statistically different

314 (firmness 229±7.25 g; work of shear 223±7.38 g sec) showed similar texture and spreadability, while sample 139 (firmness 414±16.92 g; work of shear 417±22.7 g sec) exhibited significantly higher firmness and shear work, indicating a denser and less spreadable product.

Sensory evaluation is a valuable tool for predicting the overall acceptability of spreadable food products. It has been widely applied in the assessment of fish-, meat-, and plant-based spreads (*Mancera-Rodriguez et al*., 2022; *Ranilović et al*., 2020; *Branciari et al*., 2019; *Difonzo et al*., 2019; *Kim et al*., 2018). Figure 1 (panels A-C) presents the sensory evaluation findings described in the following section. Overall scores ranged from 4.4 (samples 329, 571) to 6.4 (222, 428), with tuna and salmon pâtés rated highest, aligning with previous findings on consumer preferences (*Nguyen et al*., 2023; *Budhathoki et al*., 2022).

Texture attributes varied: sample 139 showed slightly excessive hardness (5.4) and spreadability (5.1), while sample 571 had notably low scores (1.3), indicating an overly soft texture and poor homogeneity (2.3). Graininess was near optimal for most, though 383 (4.3) was slightly coarse, and 571 overly smooth (1.9). Color uniformity was generally high, with 139 scoring 7.0, though some samples, like 329 and 627, showed minor surface heterogeneity.

Lightness varied; 329, 383, and 571 appeared too light, suggesting possible dilution, while 334, 428, and 857 were slightly darker. Taste and smell were scored highest for 139, 314, and 965 (≥6.6), especially trout pâtés (555, 965), which also showed ideal hardness and spreadability, though with slightly lower overall acceptability compared to marine fish pâtés (*Lámfalusy et al*., 2025; *Stojanovska et al*., 2022).

Results highlight that, while marine fish pâtés, particularly tuna and salmon, had higher overall acceptability, the freshwater trout pâtés excelled in textural and flavor attributes important for consumer satisfaction.

4. Conclusion

This study provided a detailed evaluation of the textural and sensory properties of commercial fish pâtés available on the Serbian market. The results revealed substantial variability among products, reflecting heterogeneity in formulation strategies and a general lack of standardization regarding texture and consumer-relevant attributes. Instrumental measurements of firmness and spreadability

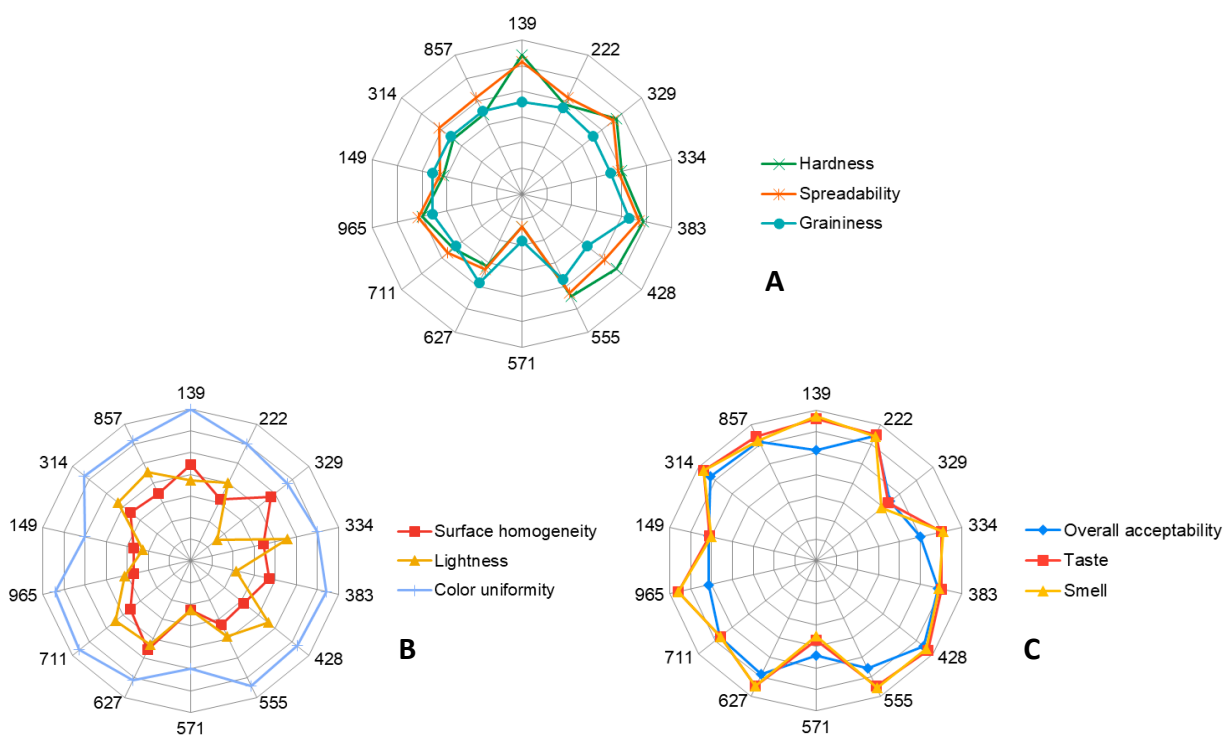

Figure 1. A) Hardness, spreadability and graininess; B) Surface homogeneity, lightness and color uniformity; C) Overall acceptability taste and smell (222 – Tuna; 383 – Tuna; 334 – Tuna; 428 – Tuna; 627 – Tuna; 711 – Tuna; 329 – Hake; 139 – Salmon; 314 – Salmon; 857 – Salmon; 571 – Tuna and Mackerel; 149 – Tuna and Mackerel; 555 – Trout; 965 – Trout.)

showed significant differences between the samples, being largely in agreement with sensory perceptions of hardness and ease of spreading. Marine fish pâtés, particularly those made from tuna and salmon were generally rated higher in terms of overall acceptability, primarily due to favorable taste, aroma, visual appeal, and consumer familiarity with these species. However, pâtés made from freshwater trout demonstrated more balanced textural characteristics, with sensory and instrumental data indicating desirable levels of hardness and spreadability.

These findings offer valuable insights for the development of novel fish pâtés based on freshwater bream *(Abramis brama)*, an underutilized species in food production. Drawing inspiration from the favorable texture profiles observed in trout-based products, freshwater bream pâtés could be formulated to achieve optimal consistency and sensory appeal. Such an approach would not only enhance product quality but also support the sustainable valorization of local freshwater fish through the creation of convenient, ready-to-eat food products.

Funding: This study is supported by project IMPRESS that has received funding from the European Union's Horizon Europe programme (GA No. 101084437).

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