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Study of the Organoleptic, Chemical and Microbiological Quality of the Marinade, Sausage and Meat Ball of *Tympanotonus Fuscatus*

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Abstract

This research focuses on studying the organoleptic, chemical, and microbiological quality of *Tympanotonus fuscatus*. It aims to explore potential processing techniques for this species and diversify culinary offerings. *T. fuscatus* is abundant in Senegalese waters but is largely

unknown or underutilized in local cuisine. The choice of this species for the study is motivated by its lack of recognition in Senegal, despite the country's ongoing fish product scarcity and the growing demand for animal proteins. The primary objective of this research is to propose methods for the valorization of *T. fuscatus* to improve its inclusion in the population's diet. To ensure the safety of the products, they underwent chemical, microbiological, and sensory analyses. The results of the sensory evaluation revealed that 80% of the participants were satisfied with the marinades. Regarding the mollusk meatballs and sausages, 90% of evaluators expressed satisfaction with the meatballs, while 50% were satisfied with the sausages. However, 40% of participants reported significant dissatisfaction with the sausages. The results from the chemical analyses indicate that the finished products (marinades, meatballs, and sausages) are of good quality based on the measured parameters. For the marinades, the Total Volatile Basic Nitrogen (TVBN) value was 0.837 mg/100g, with moisture content at 90%, NaCl at 0.550%, and acidity at 10 mmol/l. For the *T. fuscatus* meatballs, TVBN was 1.675 mg/100g, moisture content was 45.247%, fat content was 10.39%, and NaCl was 2.303%. For the sausages, TVBN was 1.390 mg/100g, moisture content was 48.795%, fat content was 10.08%, and NaCl was 1.422%. The microbiological results were also satisfactory, with the desired bacterial levels being met.

Keywords: *Tympanotonus fuscatus*, Marinade, Donuts, Sausages, Quality, Technology

1. Introduction

Fisheries play a pivotal role in Senegal's socioeconomic fabric, contributing substantially to poverty alleviation, food security, and foreign exchange generation (Diedhiou & Yang, 2021; Lovei & Ndiaye, 2016). The sector supports millions of livelihoods and supplies approximately 75% of the animal protein consumed by the population (Ndiaye, 2002; UNDP, 2002). However, Senegal's fishery resources are facing mounting pressure, resulting in a significant decline in marine yields. This trend is primarily driven by overfishing, illegal, unreported, and unregulated (IUU) fishing, and inadequate governance mechanisms for sustainable resource management (Thiao et al., 2018; FAO, 2023a).

These pressures are intensifying food insecurity, especially for low-income households. In 2018, an estimated 38% of the population lived on less than 1,000 CFA francs per day, limiting their access to protein-rich foods such as fish (ANSD, 2018; Thiao et al., 2018). Moreover, public policies favoring the export of high-value species like sardinella and demersal fish have further restricted the availability of fish products on the domestic market (Diedhiou & Yang, 2021; FAO, 2023a). Concurrently, climate change, coastal erosion, and population growth are aggravating the vulnerability of marine and coastal ecosystems (World Bank, 2016; FAO, 2023b).

In this context, it is urgent to explore sustainable, locally sourced alternatives to conventional fish proteins. Underutilized aquatic species—particularly non-conventional mollusks—offer promising opportunities. *Tympanotonus fuscatus*, a brackish water gastropod abundant in Senegalese mangroves, has been identified as one such candidate (Sakho et al., 2020; FAO, 2023b). Despite its availability and traditional use in some West African communities, this species remains marginal in Senegalese diets due to limited awareness, food preferences, and

absence from structured markets (Thiao et al., 2018; Sakho et al., 2020).

To address these barriers, this study investigates the potential of *T. fuscatus* as an alternative protein source. Specifically, it aims to develop and evaluate processed food products such as marinades, sausages, and meatballs derived from this species. Through assessments of chemical composition, microbiological safety, and sensory attributes, the study seeks to demonstrate the feasibility of integrating *T. fuscatus* into local diets. The overarching goal is to contribute to national food security strategies and promote the sustainable valorization of underexploited marine resources.

2. Materials and methods

2.1 Tympanotonus fuscatus Processing Methods

Senegal is part of fishing zone number 34, as classified by the FAO (2001). The primary supply area for *Tympanotonus fuscatus* is Mbassiss log, located in Fatick region, specifically within the department of Foundiougne and the commune of Mbam. Upon receiving fresh *T. fuscatus* products, they are processed into marinades, meatballs, and sausages, as illustrated in Figures 1, 2, and 3, which show their respective manufacturing processes.

- ***Tympanotonus fuscatus marinade***

The ingredients used for the marinade of *Tympanotonus fuscatus* are shown in Table I below.

Table I. Ingredients for the preparation of the marinade

ELEMENTS	**Weight in grams (g)**	**% of each Ingredients**	**% of ingredients in solution**
Carrot	8	32	3.2
Turnip	8	32	3.2
Onion	3.35	13.4	1.34
Garlic	2.5	10	1
Pepper	2.5	10	1
Bay leaves	0.4	1.6	0.16
Black pepper	0.25	1	0.1
Total	**25**	**100**	**10**

These quantities are made for 1 kg of *Tympanotonus fuscatus* flesh and each jar contains 10% ingredient, 50% flesh and 40% brine.

The process of transformation of the marinade of *Tympanotonus fuscatus* is represented in the diagram below (Figure 1).

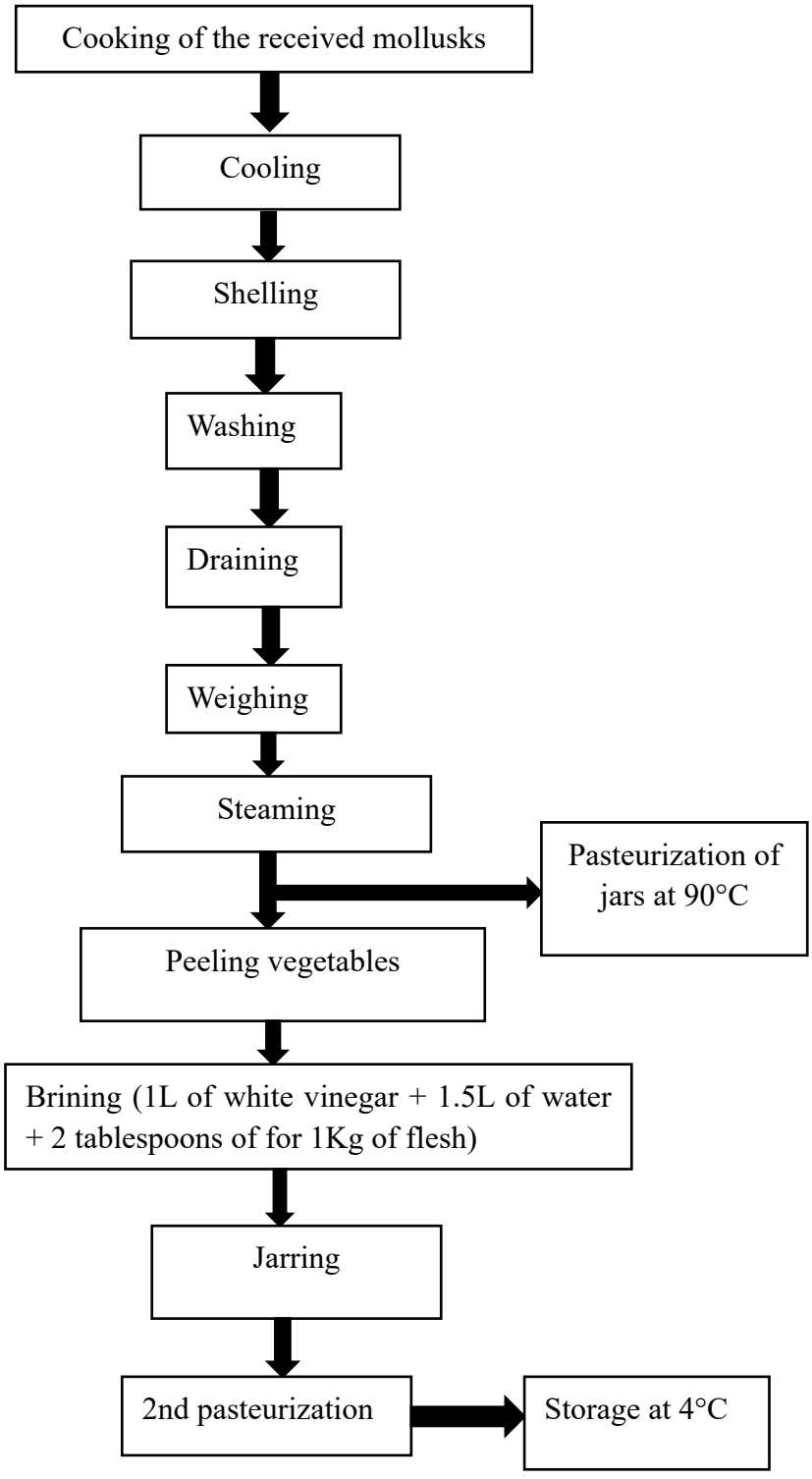

Figure 1. Transformation diagram of the marinade of *Tympanotonus fuscatus*

2.2 Meatballs of Tympanotonus fuscatus

Meatballs made from this mollusk offer a creative and flavorful way to integrate it into the population's eating habits. Below is the typical preparation process, which follows all the necessary unit operations as illustrated in the diagram.

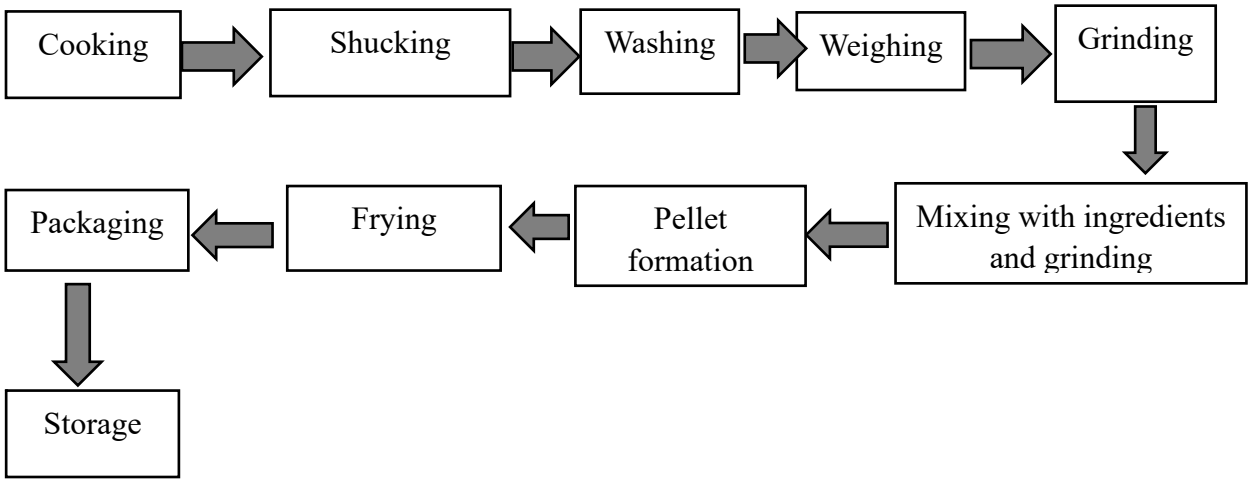

Figure 2. *Tympanotonus fuscatus* meatballs manufacturing diagram

The ingredients used in the manufacture of mangrove snail meatballs of *Tympanotonus fuscatus* are listed in Table 2.

Table 2. Ingredients for the preparation of doughnuts

Ingredients	**Quantities per 2Kg of Tympanotonus fuscatus flesh**
Garlic	8 pods
Black pepper	3g
Thyme oregano	½ tablespoon
Spicy thyme	½ tablespoon
Salt	½ tablespoon
Egg	4
Wheat flour	250g
Oil	1 L

Honey	2 tablespoon
Tapioca	2 tablespoon
Pepper	3 pods
Ginger powder	10g
Onion	½ pods
Parsley	1 bunch

2.3 Sausages of Tympanotonus fuscatus

The process of making *Tympanotonus fuscatus* sausages is shown in the Figure 3.

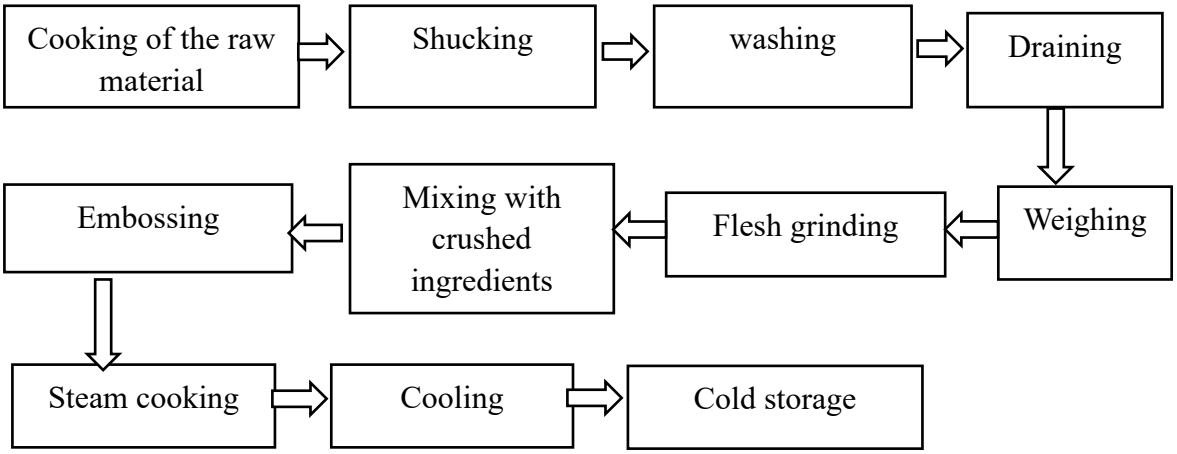

Figure 3. Transformation diagram of *Tympanotonus fuscatus* sausages

Table 3 below shows the ingredients used in the manufacture of mangrove snail sausage *Tympanotonus fuscatus*.

Table 3. Ingredients for the preparation of sausage

Ingredients	**Quantities per 1kg of flesh**
Garlic	8 gousses
Ginger	25g
Black Pepper	6g
Oil	0.5 l
Thyme oregano	1 tablespoon
Spicy thyme	1 tablespoon
Paprika	1 tablespoon
Salt	20g
Breadcrumbs	1 Pack of 500g

The binders are shown in Table 4 below.

Table 4. Binders used

Binders	**Quantities**
Milk	250g
Eggs	3
Wheat flour	250g
Oil	20ml

Mangrove snail (*Tympanotonus fuscatus*)

Mangrove snail meat (*Tympanotonus fuscatus*)

Marinades **Meatballs** **Sausages**

Figure 4. Products made from mangrove snail *Tympanotonus fuscatus*

2.4 Sampling Methods

The sampling methods involved aseptic collection of two jars: one for chemical tests and the other for microbiological tests, as well as samples of 300g meatballs and 300g sausages. These samples were stored in a cooler under aseptic conditions and transported to the National Laboratory for Analysis and Control (LANAC) for chemical and microbiological analyses.

For the organoleptic analyses, a jar of marinade, a tube of sausage, and 15 mangrove snail balls were sampled. The sausage tube was then sliced into several rounds. These products were given to 15 individuals familiar with consuming mollusks products, who used a pre-prepared analysis sheet to evaluate the organoleptic parameters. The parameters assessed included smell, texture, taste, acidity (for the marinade), and color. Based on the evaluation of each parameter, the participants provided an overall satisfaction score for each product.

4. Results and Discussion

4.1 Presentation of the Results

4.1.1 Organoleptic Analyses

- **Colour of finished products**

Figure 5 shows the results of the color assessment of the finished products (marinade, meatballs and sausages):

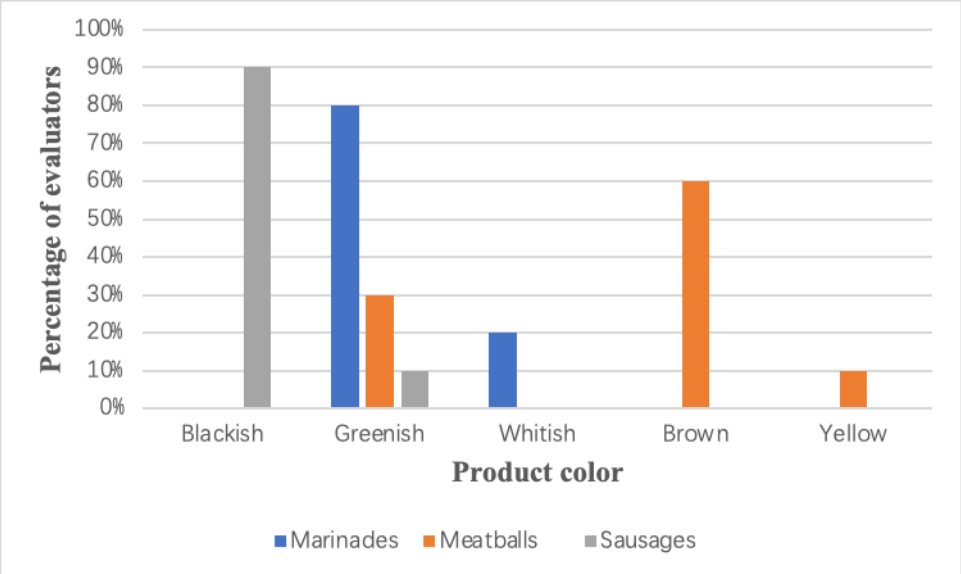

Figure 5. Product colors assessment results

The analysis of Figure 5 shows that with regard to the color of the finished products (marinade, meatballs and sausage):

- 80% of tasters concluded that the marinades are greenish in color compared to 20%

who judged the product to be whitish in color.

- 30% of meatballs evaluators opted for the greenish color, the majority i.e. the 60% of reviewers concluded that they are brown in color and 10% of tasters said that their color is yellowish.
- 90% of the tasters said that the sausages were blackish in color and the 10% judged the product to be greenish.

❖ **Product smell**

The results relating to the assessment of the smell of the finished products (meatball and sausage marinade) are described in Figure 6 below:

Figure 6. Product Smell assessment results

The analysis in Figure 6 shows that:

-100% of tasters say marinades and donuts smell good;

- And for sausages, 60% of tasters judged that the product was good, 30% said that the smell was not as good and 10% of tasters showed that the smell was bad.

❖ **Product texture**

The results relating to the assessment of the texture of the finished products (marinade, meatball and sausage) are described in Figure 7.

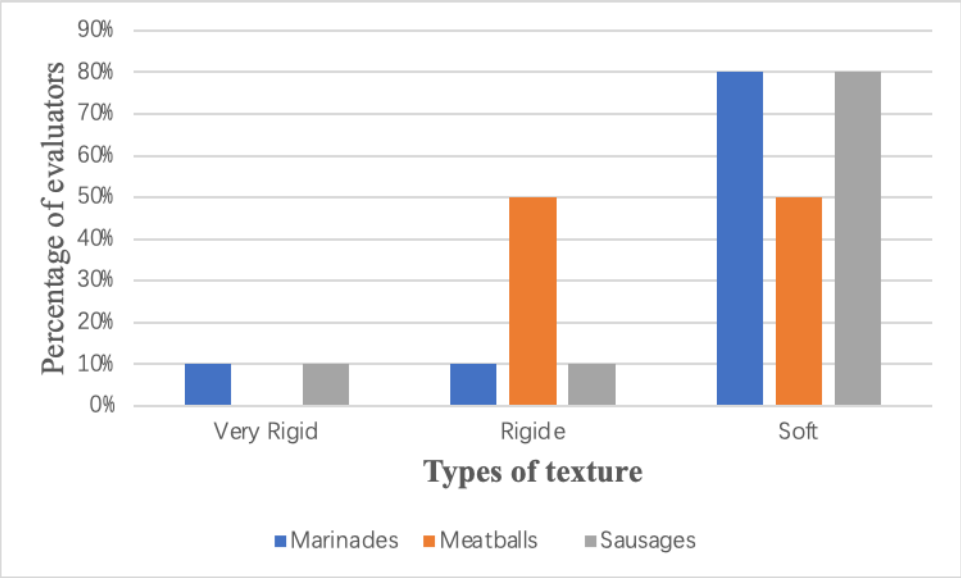

Figure 7. Product texture assessment results

The analysis in Figure 7 shows that:

- For marinades and sausages, 80% of tasters said that their texture is soft, 10% revealed that the products are very rigid and the 10% of tasters said that the products are rigid.
- For meatballs, 50% of tasters concluded that doughnuts are soft and 50% of tasters said that the product was rigid.

❖ **Taste of the products**

The results relating to the assessment of the taste of the finished products (marinade, meatball and sausage) are described in Figure 8 below:

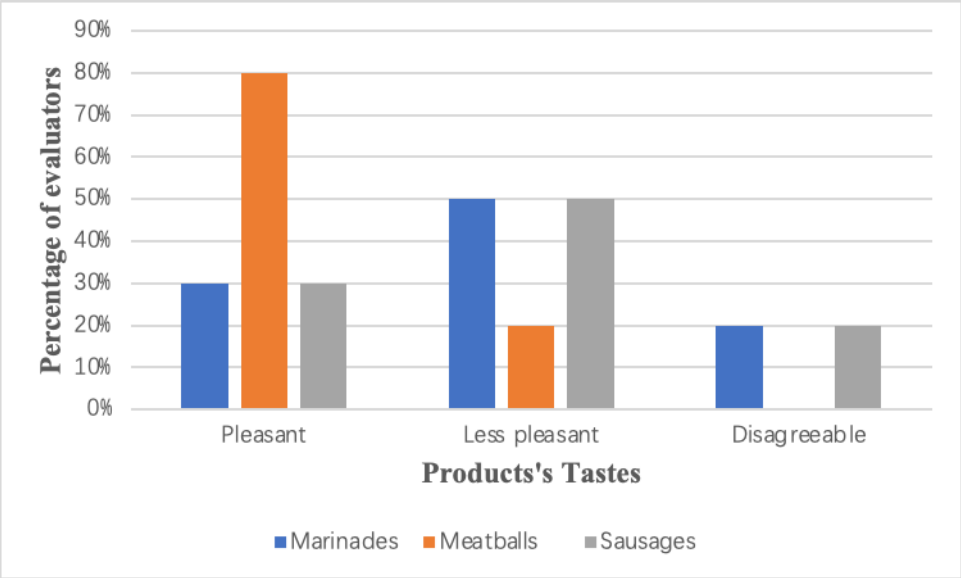

Figure 8. Product taste results

The analysis of Figure 8 shows that:

-For marinades and sausages after tasting, 30% of tasters concluded that the products were pleasant, 50% of tasters said that the product was less pleasant and 20% of tasters judged that the products were unpleasant.

- Regarding the meatballs, the 80% of tasters judged that the product was pleasant and the 20% of the tasters felt that the product was less pleasant.

❖ **Acidity of the marinade**

The results of the assessment of the acidity of the marinade are described in Table V below:

Table V: Results on the acidity of the marinade

	Very acidic (%)	**Slightly acidic (%)**	**Bland (%)**	**Bitter (%)**
Marinade	0	70	30	0

The analysis of Table V shows that after tasting 70% of assessors revealed that the product was slightly acidic and 30% of the evaluators judged the product to be bland.

❖ **Product satisfaction level**

The results on the level of satisfaction with the products are shown in Figure 8.

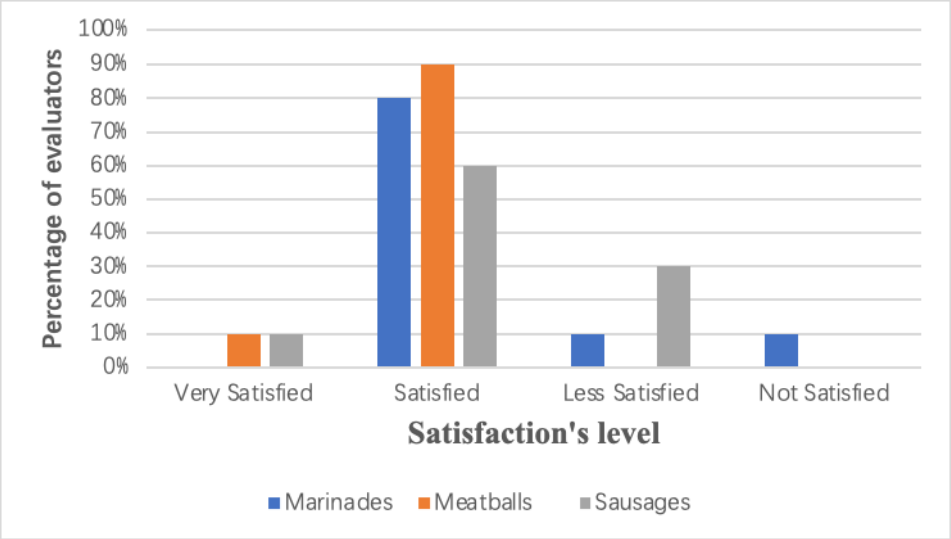

Figure 9. Evaluator satisfaction levels on finished products

The analysis in Figure 9 shows that:

- ✓ For the level of satisfaction, meatballs are in first place, with 90% satisfaction and 10% very satisfied with the product.
- ✓ For marinades, 80% of assessors said they were satisfied with the product, 10% of tasters rated the product as less satisfactory and 10% of tasters said the product was unsatisfactory.
- ✓ For sausages, 60% of panelist expressed their satisfaction with this product, 30% of tasters said they were less satisfied with this product and 10% of tasters were very satisfied.

1.1.1. Results of Chemical Analyses

The results of the chemical analyses of the raw material and finished products are recorded in Tables VI and VII.

Table 11. Biochemical results of the *Tympanotonus fuscatus* meat

	Ash (%)	**Crute protein (%)**	**Crude fat (%)**	**Crude fiber (%)**
Tympanotonus fuscatus	16.58	49.41	2.66	0.20

LANAC (2024)

The analysis in Table VI *Tympanotonus fuscatus* exhibits a very high protein content (49.41%), making it an excellent source of animal protein. Its high ash content (16.58%) indicates a rich supply of essential minerals. The low-fat content (2.66%) makes it suitable for low-fat diets. The negligible fiber content (0.20%) is typical for animal-derived foods. This nutritional profile highlights its potential role in addressing malnutrition in Senegal.

Table 12. Chemical results of finished products

Samples Germs	Marinade	Meatball	Sausage	Value of reference (unit)
Humidity	90%	45,247%	48,795%	Max 85 (%)
TVBN	0.837mgN/100g	1.675mgN/100g	1.390mgN/100g	20 max
Fat	-	10,39%	10,08%	Max 12 (%)
NaCl	0.559%	2.303%	1.422%	-
Acidity	10mmol/l	-	-	-

Source LANAC (2024)

The analysis of Table VII shows that:

- For the marinade, the values of 0.837mg/100g for ABVT, 90% for moisture, 0.550% NaCl and 10 mmol/l acidity were obtained.
- For meatballs, the values of 1.675mg/100g for ABVT, 45.247% moisture, 10.39% fat and 2.303% NaCl were obtained.
- For sausages, the values of 1.390mg/100g for ABVT, 48.795% moisture, 10.08% fat and 1.422 NaCl were obtained.

1.1.2. Microbiological test results

In the course of the experiment, various germs were searched for and the results obtained are recorded in Table 13.

Table 13. Microbiological analysis results of finished products

	Marinades	Meatballs	Sausages
TAMF / VF	2.6 10^3/g VF : 10^4 – 10^5g	1.3 10^3/g VF : 10^4-10^5g	5.9 10^2 g VF : < 10^{6g}
Total Coliforms / VF	ND VF : ND/g	ND VF : 10^2-10^3g	ND VF : <50/g
***Staphylococcus aureus* /VF**	ND VF : ND/g	ND VF : 10^2-10^3g	ND VF : < 10^2/g
***E. coli* / VF**	ND VF : ND/g	ND VF : 10.10^2g	ND VF : <10/g
ASR / VF	ND VF : ND/g	ND VF : < 10g	ND VF : <30/g
***Salmonella* / VF**	ND VF : ND/25g	ND VF : ND/	ND VF : ND/25g
***Clostridium perfringens* / VF**	ND VF : ND/g	ND VF : < 10/g	ND VF : <30/g
Yeast and mold / VF	3.1 10^{-2}g VF : < 10^3g	ND VF : <10^3/g	ND VF : <10^3g

Source LANAC (2024)

ND: non detected; **TAMF**: Total Aerobic Mesophilic Flora; **SRA**: Sulfito-Reducing Anaerobic; **VF:** Reference Value

The analysis presented in Table VIII shows the absence of *E. coli*, total coliforms, Staphylococci, ASR, *Salmonella*, yeast, mold, and *Clostridium perfringens* in both meatballs and sausages. While TAMF was detected in these products, the levels were below the reference values (10^4–10^5/g for meatballs and <10^6/g for sausages). Yeasts and molds, as well as TAMF, were detected in the marinade, but their concentrations did not exceed the reference values (<10^3/g for yeast and mold, and 10^4–10^5/g for TAMF), indicating compliance with safety standards.

4. Discussion

Organoleptic analysis is used to assess the color, smell, texture, acidity, and overall satisfaction of the finished products. The color of the raw material influences the final product, with a greenish hue dominating 80% of mangrove snail marinades. This contrasts with the results of Gomis (2024), who reported 70% white, 10% yellow, and 20% beige-brown for the Murex marinade. For *Tympanotonus fuscatus* meatballs, 60% of assessors noted a brown color, likely due to the use of breadcrumbs after cooking, while 30% observed a white color, reflecting the product's interior. *T. fuscatus* sausages were primarily reported as black by 90% of evaluators, with only 10% judging them to be greenish.

Marinades and meatballs were highly rated by 100% of evaluators for their sensory qualities, with their pleasant aroma suggesting that the ingredients and processing methods met consumer expectations. These products did not present any sensory issues or anomalies, which is a positive indicator of quality. However, 30% of tasters noted a less pleasant smell, and 10% found sausages to have unpleasant odors, raising potential concerns. These odors could be due to manufacturing defects or individual preferences. Sausages were rated as satisfactory by 60% of reviewers, indicating that the majority of samples met the expected quality criteria, although differences in satisfaction should be considered.

The texture of the marinades and sausages was described as tender by 80% of tasters, which aligns with their expected suppleness. These results differ from those of Gomis (2024), who reported that 100% of panelists found the Murex marinade to be stiff, likely due to the product's nature. Badji (2022) found 100% of tasters rated catfish sausages as rigid, which may be attributed to the flesh. For *T. fuscatus* meatballs, 50% of reviewers found the texture tender, while the other 50% considered it stiff.

Opinions on the taste of the marinades were divided, with 50% of panelist finding it pleasant and the other 50% rating it as less pleasant. Furthermore, 20% of evaluators found the marinade unpleasant, suggesting a need for improvement. Mangrove snail meatballs were the most popular product, with 80% of participants finding them delicious. The "unpleasant" rating for doughnuts was low (20%), indicating only minor room for improvement.

The majority of participants (80%) expressed satisfaction with the marinades, with 90% rating them as either "very satisfied" or "satisfied." In contrast, there was a significant level of dissatisfaction with the sausages, with 40% of participants expressing dissatisfaction. The *T. fuscatus* marinade was preferred as slightly acidic by 70% of raters, a characteristic commonly used in culinary preparations to enhance flavor. However, the presence of bland samples suggests that there is potential for improvement in acidity balance. The results from Gomis (2024) were better, with 80% of participants rating the Murex marinade as slightly acidic, likely due to differences in the product or the proportion of flesh used in the jars.

Biochemical analysis of the raw flesh of *T. fuscatus* shows satisfactory results, with a protein content of 49.41% and 16.58% ash. These results are better than those reported by Davies and Jamabo (2016), who obtained protein content of 23.7% and ash content of 2.73%. This difference can be explained by variations in the study areas and water quality.

Regarding the chemical analyses of the finished products, the parameters measured include NaCl, moisture, TVBN, fat, and acidity (for the marinade). The NaCl results for all three products (marinade, meatballs, and sausages) are satisfactory. The marinade's NaCl content (0.559%) is better than that reported by Keneme (2024) and Gomis (2024), who found 2.761% and 1.09% NaCl in oyster and murex marinades, respectively. These differences can be attributed to variations in processing methods, particularly the amount of salt used.

Moisture levels indicate product shelf-life potential. High moisture content suggests shorter storage periods. The marinade in this study has a moisture content of 90%, which is higher than the 89.06% moisture found in Keneme (2024) for oyster marinade. This slight difference

could be due to texture variations, as the product used in this study is softer than the oyster. However, the moisture content (70.1%) in the study by Davies and Jamabo (2016) is lower, possibly due to differences in processing and water absorption during brining.

For meatballs and sausages, the moisture content was 45.247% and 48.795%, respectively. Both are below the reference value of 85%, indicating satisfactory results. The moisture content in sausages (48.795%) is better than that reported by Badji (2022), who found 77.77% moisture in *Clarias gariepinus* sausages. This difference could be attributed to the flesh texture of the product.

TVBN levels, which indicate freshness, were satisfactory for all products (marinade, meatballs, and sausages) at less than 20 mgN/100g. The marinade's TVBN (0.837 mg/100g) is better than the results from Keneme (2024) and Gomis (2024), who found 10.288 mgN/100g in oyster marinade and 1.73 mgN/100g in murex marinade, respectively. These values remain below the reference value and are superior to those of Jorgensen et al. (2005), who reported values of 50 mgN/100g in a mixture of marinade and vegetables.

Fat content was satisfactory in both meatballs (10.39%) and sausages (10.08%). Badji (2022) reported a lower fat content (6.12%) in catfish sausages, likely due to the absence of binders in that study.

Acidity was only measured in the marinade, with a result of 10 mmol/l. This differs from Keneme (2024), who found 47.8 mmol/l in oyster marinade.

Microbiological analyses of the meatballs and sausages revealed a total absence of Total Coliforms, *Staphylococcus aureus*, *E. coli*, ASR, *Salmonella*, *Clostridium perfringens*, and yeast and mold. These results are highly satisfactory and comply with the AFNOR standard (1996) and Senegalese Order No. 14351 of 28 September 2016, which set microbiological criteria for fishery and aquaculture products. However, TAMF was present in both meatballs and sausage samples, with values of 1.3×10^3/g and 5.9×10^2/g, respectively, but these levels are still below the AFNOR standard of 10^5 CFU/g. For sausages, these results are better than those of Badji (2022), which found *E. coli* in raw catfish sausages. This difference can be attributed to steam cooking, which may reduce microbial contamination in fish products.

Even though TAMF was detected, yeast and mold levels did not exceed the reference values, remaining compliant. The marinade results were also in line with the absence of other harmful microbes. These findings align with those of Gomis (2024), who found no *E. coli*, total coliforms, Staphylococci, or *Clostridium perfringens* in the murex marinade. Similarly, Keneme (2024) reported no *E. coli*, *Salmonella*, or *Staphylococcus* in oyster marinade. In contrast, Omorodion and Emmanuel (2022) found high levels of *Salmonella* (12%), *E. coli* (8%), and Staphylococci (8%) in *T. fuscatus*, showing that the bioburden exceeded acceptable limits.

The results of the organoleptic, chemical, and microbiological analyses conducted in this study demonstrate that the marinade, sausage, and meatball methods for processing *T. fuscatus* yield high-quality products that are ready for consumption without further preparation, and are safe for consumers.

5. Conclusion

Seafood, particularly *Tympanotonus fuscatus*, oysters, and gastropods in general, plays a crucial role in providing affordable protein for large segments of the global population. Although seafood is a valuable protein source, it is often associated with foodborne diseases. The primary goal of this study was to promote *T. fuscatus* to improve its valorization, preservation methods, and culinary offerings. The study provided detailed information on the description of *T. fuscatus*, while highlighting key aspects of its safety, composition, and acceptability as a food product.

The organoleptic analysis revealed that the marinade, meatballs, and sausages made from *T. fuscatus* have favorable taste attributes for consumers. Chemically, the data shows that these products maintain a nutritional balance while preserving essential nutrients. The microbiological analysis confirms that when properly prepared and stored, these products are free from harmful microorganisms, ensuring their quality for consumption.

In addition, the study on the marinade, meatballs, and sausages of *T. fuscatus* suggests that this high-quality food product, with attractive sensory qualities, satisfactory nutritional value, and optimal microbiological quality, could become a promising option to diversify the marine products available on the market. This is especially important in the context of declining fishery resources and increasing demand.

References

AFNOR. (1996). Analyse microbiologique. Tome 2 : Contrôle de la qualité des produits alimentaires. Paris : AFNOR.

ANSD (Agence nationale de la statistique et de la démographie). (2018). La pauvreté multidimensionnelle au Sénégal : Rapport national de présentation de l'indice de pauvreté multidimensionnelle au Sénégal. Dakar, Sénégal.

ANSD. (2018). Rapport de l'Enquête Harmonisée sur les Conditions de Vie des Ménages (EHCVM). Agence Nationale de la Statistique et de la Démographie, Sénégal.

Badji, K. (2022). Rapport de fin d'étude portant sur le processus de fabrication de saucisson de poisson chat (Clarias gariepinus) : étude de la qualité biochimique, microbiologique et organoleptique (p. 35).

Bob-Manuel, F. G. (2012). Tympanotonus fuscatus and Parchymelania aurita at the Rumuolumeni mangrove swamp creek, Niger Delta, Nigeria. *Agriculture and Biology Journal of North America, 3*(4), 265-270. https://doi.org/10.5251/abjna.2012.3.5.265.270

Davies, I. C., & Jamabo, N. A. (2016). Proximate composition of edible parts of shellfishes from Okpoka creeks in Rivers State, Nigeria. *International Journal of Life Sciences Research, 4*(2), 253-258.

Diedhiou, I., & Yang, Z. (2021). Senegal's fisheries policies: Evolution and performance. *Ocean & Coastal Management, 199*, 105394. https://doi.org/10.1016/j.ocecoaman.2020.105394

Egonmwan, R. I. (2008). The ecology and habitats of Tympanotonus fuscatus var. radula (L) (Prosobranchia: Potamididae). *Journal of Biological Sciences, 8*(10), 186-190. https://doi.org/10.3923/jbs.2008.186.190

FAO. (2023a). International fish trade and food security: The case of Senegal. FAO Fisheries Circular No. 1000. http://www.fao.org/3/y4961e/y4961e0i.htm

FAO. (2023b). Analysis of fish consumption in the ECOWAS region and Mauritania: Current constraints and future challenges. *Sustainability, 16*(13), 5429. https://doi.org/10.3390/su16135429

Gomis, T. B. (2024). *Etude de la qualité organoleptique, chimique et microbiologique de la marinade de Murex* (Mémoire TS CNFTPA, p. 45).

Jamabo, N., & Chinda, A. (2010). Aspects of the ecology of Tympanotonus fuscatus var. fuscatus (Linnaeus 1758) in the mangrove swamp of the upper Bonny River, Niger Delta. *Nigerian Journal of Biological Sciences, 2*(1), 42-47.

Jørgensen, J. H., Landry, M. L., & Funke, G. (2015). Dosage du taux de l'ABVT sur quelques espèces de produits halieutiques. *Journal of Food Protection, 56*, 32-44. https://doi.org/10.4315/0362-028X.JFP-15-242

Keneme, M. (2024). Etat des lieux sur les pratiques traditionnelles de valorisation et de conservation des coquillages dans les villages riverains des AMP de Niamoune Kalounayes et Kaalolal Blouf Fogny (Casamance, Sénégal) et leur impact sur la qualité sanitaire des produits (Mémoire Master IUPA/UCAD, p. 55).

Lovei, M., & Ndiaye, M. (2016). Senegal's fisheries sector: Challenges and opportunities. World Bank Feature. Retrieved from https://www.worldbank.org/en/news/feature/2016/08/08

Ndiaye, O. (2002). International fish trade and food security: The case of Senegal. FAO Fisheries Circular No. 1000. Rome: FAO.

Nickles, M. (1950). Mollusques testacés marins de la côte occidentale d'Afrique. Paul Hechevaller Éditeur.

Nnenna, J. O., & Blessing, E. (2022). Microbial diversity and nutritional profile of processed and unprocessed Tympanotonus fuscatus (Periwinkle), Crassostrea gasar (Oyster), and Rapana venosa (Whelk). *World Journal of Biology, Pharmacy and Health Sciences, 10*(01), 115-123. https://doi.org/10.53390/wjbphs.2022.10.01.015

Paul, T., Ekop, I. E., & Simonyan, K. J. (2022). Some physical properties of dried Tympanotonus fuscatus and Pachymelania aurita periwinkle meat. *Journal of Agricultural Engineering and Technology (JAET), 27*(2).

Sakho, I., Diouf, M., Ndiaye, F., & Cissé, I. (2020). Potential for mollusk consumption in Senegal: The case of Tympanotonus fuscatus. *Journal of Food Security and Sustainability, 4*(2), 45-54. https://doi.org/10.22059/jfss.2020.298444.1343

Thiao, D., Leport, J., Ndiaye, B., & Mbaye, A. (2018). Need for adaptive solutions to food vulnerability induced by fish scarcity and unaffordability in Senegal. *Aquatic Living Resources, 31*, 25. https://doi.org/10.1051/alr/2018009

UNDP. (2002). Africa seeks to safeguard its fisheries. Africa Renewal, United Nations. Retrieved from https://www.un.org/africarenewal/magazine/april-2002/africa-seeks-safeguard-its-fisheries

World Bank. (2016). *Senegal takes steps to establish a sustainable and better-governed fisheries sector*. World Bank Feature.