FUDMA Journal of Agriculture and Agricultural Technology
ISSN: 2504-9496
Vol. 11 No. 4, December 2025: Pp. 86-94

https://doi.org/10.33003/jaat.2025.1104.11

Comparative Analysis of Preservation Techniques on Nutritional Quality and Shelf Life of Shellfishes (*Penaeus monodon* and *Farfantepenaeus notialis*) in Nigeria.

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ABSTRACT

Fresh tiger prawn (*Penaeus monodon*) and southern pink shrimp (*Farfantepenaeus notialis)* were collected from Igbokoda Market in Ondo State, Nigeria, and preserved using freezing (–15ºC), smoking (105–110ºC), oven drying (80ºC for 10 h), and salting (360 g/L brine). The study evaluated how these methods influenced nutrient quality by analyzing proximate composition, free fatty acid (FFA), and total volatile nitrogen (TVN) levels over eight weeks. Results revealed notable differences in nutrient retention across preservation techniques. In the first week, frozen shrimp showed the lowest protein levels (35.18 ± 1.97% for *P. monodon* and 45.06 ± 1.34% for *F. notialis*), whereas the oven-dried samples recorded the highest values (74.86 ± 0.17% and 70.92 ± 1.19%, respectively. Moisture content was highest in frozen shrimp (46.18%) and lowest in oven-dried samples (5.38%), highlighting the role of dehydration in limiting spoilage. FFA levels increased progressively, indicating lipid oxidation, with oven-dried samples maintaining the lowest FFA and thus better oil stability. TVN values, a measure of protein degradation, also rose with storage duration, peaking in smoked samples, while frozen shrimp exhibited the lowest TVN levels. Among the preservation methods studied, oven drying proved most effective for maintaining protein quality, minimizing moisture uptake, and reducing spoilage, while freezing better preserved freshness in *F. notialis*. Smoking and salting were less effective due to higher TVN and FFA accumulation. These findings suggest oven drying as the most reliable preservation technique in resource-constrained settings, with potential to reduce post-harvest losses and enhance the commercial value of prawns.

Keywords: Seafood preservation, Shellfishes, *Penaeus monodon*, *Farfantepenaeus notialis*, Moisture, Food security.

INTRODUCTION

Shellfishes, particularly prawns and shrimps such as tiger prawn (*Penaeus monodon)* and southern pink shrimp *(Farfantepenaeus notialis)* play a vital role in global and regional fisheries and aquaculture. They support food security, nutrition, employment, and economic growth, especially in developing regions (Ajibare *et al*, 2017., Okayi *et al*, 2012) Globally, shrimp aquaculture has expanded rapidly, with production projected to reach 6 million metric tons in 2025, valued at billions of USD, though it grapples with stagnation from environmental and management issues (FAO, 2002). Recent data indicate a rebound, with farmed shrimp production reaching about 5.6 million metric tons in 2023, projected to grow by 4.8% to 5.88 million metric tons in 2024 and potentially 6 million metric tons in 2025, driven by key producers like Ecuador but tempered by sustainability concerns. In Nigeria, these crustaceans abound in freshwater and brackish systems, including rivers, reservoirs, and coastal ecosystems like the Asejire Reservoir in Oyo State, the Lower Benue and Niger Rivers, and the Oluwa and Osse Rivers in Ondo State, where they sustain artisanal fisheries and local livelihoods amid declining wild stocks (Ajibare *et al*., 2020; Okayi *et al*., 2012). Despite their biological suitability for aquaculture, evidenced by negative allometric growth patterns, healthy condition factors (ranging from 1.875 to 3.330), and adaptability to diverse environments, the sector remains underdeveloped, with experimental efforts dating back to the late 1970s and limited commercial progress (Ajibare *et al*., 2020; Okayi *et al*., 2012). Recent studies underscore opportunities in the Niger Delta for shrimp farming, though challenges like disease outbreaks, feed shortages, and climate impacts hinder expansion (Ogunji and Wuertz, 2023. Environmental threats, including mangrove degradation from farming activities, pollution, and climate change-induced flooding, further complicate

sustainability (Nirmal et al., 2025; Akintola & Fakoya, 2020)

However, the high perishability of prawns and shrimps poses a critical challenge to their utilization, particularly in post-harvest phases, where inadequate preservation and storage lead to substantial economic losses, reduced market value, and threats to consumer health (Ajibare *et al*., 2020). Spoilage occurs rapidly due to bacterial proliferation, enzymatic autolysis, and insect infestation, resulting in the formation of volatile compounds such as trimethylamine (TMA), which serves as a key indicator of quality degradation in fishery products, even under optimal chilling conditions, these delicacies lose their flavor and freshness within 2–4 days post-capture, exacerbating issues in regions like Ondo State, where infrastructural deficits and artisanal handling practices amplify post-harvest losses (Ajibare *et al*., 2020), which are practically due to poor transportation, storage, and processing (Kyari, 2025; Akintunde *et al*., 2024, Nirmal *et al*., 2025). Causes include lengthy fishing cycles, lack of ice, and animal predation (Nyiawung *et al*., 2022)

This vulnerability is compounded by environmental pressures, overexploitation, and the interplay of rising domestic demand with dwindling captures, underscoring the urgent need for effective preservation techniques to enhance shelf life, minimize waste, and support sustainable commercialization (Okayi *et al*., 2012; Ajibare *et al*., 2020).

This study explores preservation and storage methods for prawns and shrimps in the context of Nigerian fisheries, with a focus on Ondo State, aiming to identify strategies that mitigate spoilage, improve quality retention, and foster sector growth while drawing on insights from biological assessments and global best practices. By addressing these gaps, the research seeks to bolster food security, economic viability, and resource management in developing aquaculture landscapes.

MATERIALS AND METHODS

EXPERIMENTAL SITES

This study was conducted to explore different methods for preserving and storing shellfish especially prawns and shrimps, specifically *Penaeus monodon* and *Farfantepenaeus notialis*, to reduce spoilage and extend shelf life. The experiments took place in two laboratories: one at Department of Biology Laboratory, Adeyemi Federal University of Education (AFUED) in Ondo and the Food Science and Technology laboratory at the Federal University of Technology, Akure (FUTA), Nigeria for 8 (eight) weeks. The research focused on analyzing the prawns' chemical composition through tests like proximate analysis, free fatty acid (FFA) determination, and total volatile nitrogen (TVN) measurement to assess their quality before and after preservation (AOAC, 1996).

Fresh prawns and shrimps were collected from Igbokoda Market in Ondo State. Immediately after collection, the prawns and shrimps were stored in an ice chest and moved to a refrigerator with a stable power supply to maintain freshness. They were then transported to the laboratories at AFUED and FUTA for analysis. The body weight was measured to the nearest 0.1 g using a Mettler weighing balance. In the laboratory, the prawns were divided into four groups with the same 200grams for each treatment of A, B, C, and D for different preservation treatments for the 8 weeks:

- **Group A**: Frozen at -15°C in a freezer for 8 weeks.
- **Group B**: Oven-dried at 80°C for 10 hours until a constant weight was achieved, then pulverized, packed in polythene bags, and stored at room temperature (25–27°C) for eight weeks.
- **Group C**: Smoked at FUTA's fish farm using FUTA model smoking kiln at 105–110°C for 5 hours with coal as fuel, then milled, wrapped in cellophane bags, and stored for eight weeks.
- **Group D**: Salted by soaking in a brine solution (360 g of salt dissolved in 1 liter of water) for 4 days, then removed for analysis.

Every two weeks, samples from each group were tested for chemical changes using methods outlined by the Association of Official Analytical Chemistry (AOAC, 1996).

Proximate Analysis

Proximate analysis measured the prawns' crude protein, moisture, fat, ash, and crude fiber content before and after preservation according to AOAC (1996). For the Moisture Content: 2–3 g of the

samples were weighed, placed in a crucible, and dried in an oven at 105°C for 24 hours until their weight stabilized. The moisture percentage was calculated as:

% moisture = loss of weight during drying/weight of sample before drying x 100

Lipid (Fat) Content: A Soxhlet apparatus extracted fat from 2 g samples using hexane at 40–60°C for 8 hours. After evaporating the solvent, the remaining fat was weighed, and the percentage was calculated as:

% Fat = weight of crude fat/weight of sample used x 100

Ash Content: The residue from moisture analysis was pre-ashed and heated in a muffle furnace at 560°C for 3 hours. After cooling in a desiccator, the ash weight was calculated as:

%Ash=Loss in weight due to ashing / Weight of original sample×100\%

Protein Content: Using the Micro-Kjeldahl method, 1 g of sample was digested with a selenium catalyst and 5 ml of concentrated sulfuric acid, converting nitrogen to ammonium sulfate. The mixture was distilled with 40% sodium hydroxide to release ammonia, which was trapped in a boric acid solution. The solution was titrated with 0.1 M hydrochloric acid, and the nitrogen percentage was calculated as:

$$\% \text{ Nitrogen} = \frac{\text{Titre value} \times \text{molarity of HCL} \times 50\text{ml} \times 100}{\text{Weight of sample}}$$

$$\% \text{ Protein content} = \% \text{ Nitrogen} \times 6.25$$

The crude protein was then determined by multiplying % Nitrogen by 6.25.

Carbohydrate Content (Nitrogen-Free Extract): This was calculated by subtracting the sum of moisture, ash, protein, and fat percentages from 100:

= 100 - (% moisture content + % Ash + % Crude protein + % Fat content).

Total Volatile Nitrogen (TVN)

TVN, an indicator of protein breakdown and spoilage, was measured using a modified Lucke and Geidel macro distillation method (Vyncke, 1983). A 10 g minced prawn sample was mixed with 300 ml of water, 2 g of magnesium oxide, and an anti-foaming agent in a distillation flask. The mixture was boiled for 10 minutes and distilled for 25 minutes. The distillate, collected in 25 ml of 2% boric acid with a methyl red indicator, was titrated with 0.05 M sulfuric acid. The TVN (in mg N per 100 g of flesh) was calculated by multiplying the titration value by 14.

Free Fatty Acid (FFA)

FFA was determined by dissolving 1–10 g of oil or melted fat in a neutral solvent (25 ml ether, 25 ml 95% ethanol, 1 ml 1% phenolphthalein) and titrating with 0.1 M potassium hydroxide until a pink color persisted for 15 seconds. The acid value, expressed as oleic acid equivalent, was calculated as:

$$\text{Acid value mg/ KOH/g} = \frac{\text{Titre value} \times \text{0.1M KOH} \times 56.10}{\text{Weight of sample (g)}}$$

Statistical Analysis

The data from these experiments were analyzed using the SPSS software package to identify significant differences in the prawns' chemical composition across the preservation methods.

RESULTS AND DISCUSSION

Table 1 presents the yield composition of frozen, smoked, oven-dried, and salted shrimp products, revealing variations in proximate composition due to species differences and preservation methods for *P. monodon* and *F. notialis*.

Table 1: Proximate Composition of *P. monodon* and *F. notialis*

Preservative Method	Species	Week	%moisture	%ash	%fat	%protein	%CHO
FROZEN	*F.notialis*	Initial	32.41±0.08	6.53±0.04	2.23±0.04	45.71±0.23	13.12±0.07
		2	36.04±1.45	1.63±0.71	1.5±0.71	43.65±1.49	17.18±4.36
		4	41.14±0.91	2.01±0.01	1.56±0.07	40.28±0.78	15.01±0.21
		6	46.18±1.38	1.44±0.01	1.55±0.16	35.18±1.97	15.65±0.75
	P.monodon	initial	31.07±1.74	7.73±1.74	2.69±0.67	52.59±1.63	5.92±2.31
		2	33.39±2.76	2.49±0.01	2.67±0.66	50.19±1.39	11.26±4.81
		4	35.12±3.70	2.32±0.03	2.02±1.42	46.68±0.81	13.86±5.96
		6	45.28±0.09	1.27±0.03	1.86±0.44	45.06±1.34	6.53±1.90
SMOKED	*F.notialis*	initial	11.41±0.79	14.15±0.21	1.73±0.69	61.73±0.81	10.98±1.12
		2	11.59±1.55	14.67±0.70	1.23±0.03	56.10±1.53	16.41±2.35
		4	12.97±0.94	13.6±1.56	1.16±0.07	52.29±2.26	19.98±4.83
		6	14.14±0.90	10.06±0.78	1.07±0.03	50.98±0.54	23.75±0.85
	P.monodon	initial	12.19±0.32	13.24±1.05	1.14±0.06	65.08±1.39	8.35±3.25
		2	11.86±0.93	12.65±0.72	1.17±0.04	63.94±5.98	10.38±7.59
		4	13.21±1.53	12.7±0.91	1.15±0.12	60.72±0.20	12.22±2.52
		6	14.57±0.64	9.05±0.70	1.06±0.08	56.09±1.10	18.78±0.96
OVEN-DRIED	*F.notialis*	initial	7.45±0.06	10.77±0.10	1.27±0.36	70.92±1.19	9.59±1.51
		2	6.87±1.36	11.65±0.77	1.58±0.03	67.35±0.71	12.55±2.82
		4	6.53±1.88	11.90±1.12	1.61±0.71	65.03±0.66	14.93±1.62
		6	9.06±0.21	10.63±0.72	1.02±0.01	62.34±0.13	16.95±0.40
	P.monodon	initial	5.38±1.66	14.71±0.71	1.63±0.69	74.86±0.17	3.42±1.53
		2	5.95±1.05	15.38±0.58	1.13±0.01	72.64±1.51	4.90±3.15
		4	6.65±0.06	14.75±0.78	1.13±0.04	70.18±0.62	7.29±1.491
		6	8.88±0.75	10.74±0.90	1.09±0.01	67.98±0.79	11.39±0.95
SALTED	*F.notialis*	initial	19.48±2.09	8.94±1.31	1.19±0.28	47.07±1.42	23.32±5.19
		2	22.66±0.78	20.07±0.18	132±011	45.88±0.88	10.07±1.59
		4	25.35±0.34	15.62±2.11	1.33±0.13	40.86±0.33	16.84±62.4
		6	30.16±0.86	12.95±0.77	1.05±0.01	35.11±2.84	20.73±4.48
	P.monodon	initial	21.99±1.05	16.88±0.52	1.70±0.44	50.73±0.65	8.70±1.78
		2	23.95±0.77	16.95±1.55	1.80±0.58	47.69±0.02	9.61±1.76
		4	23.89±0.84	15.69±0.83	1.26±0.07	45.62±0.83	13.54±2.57
		6	27.99±0.62	11.71±0.62	1.13±0.03	35.57±0.88	23.60±0.33

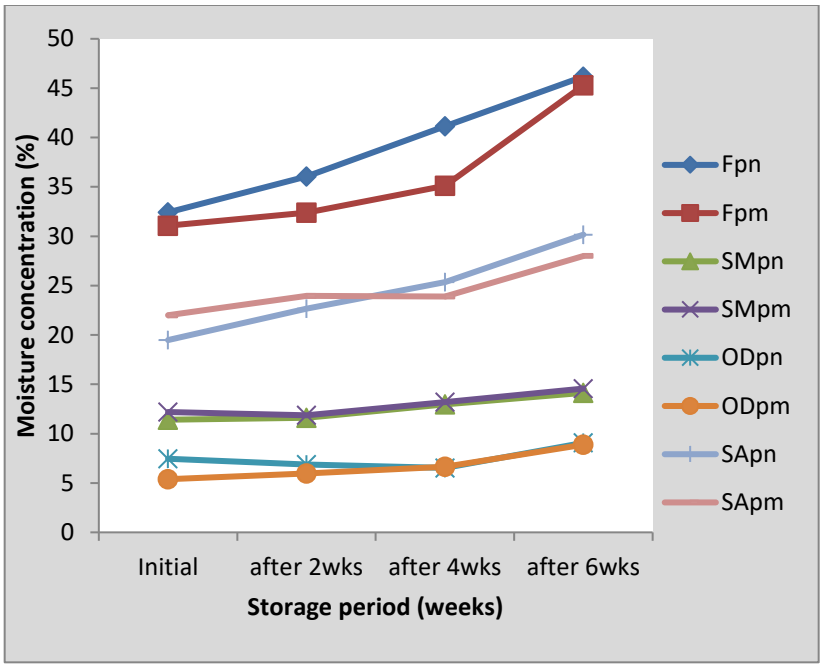

Fig 1: The trend of moisture content during the storage period

The study evaluated the efficacy of four preservation methods: freezing, smoking, oven drying, and salting on the quality attributes of two prawn species, *Penaeus monodon* and *Farfantepenaeus notialis*, over an eight-week storage period. Key parameters assessed included proximate composition (protein, moisture, lipid, and ash content), free fatty acid (FFA) levels, and total volatile nitrogen (TVN) as indicators of spoilage. The results revealed distinct trends across these methods, highlighting their impacts on nutritional value, shelf life, and overall product quality, which align with broader literature on seafood preservation in tropical regions (Ajibare *et al*., 2020; Okayi *et al.,* 2012). Moisture content, conversely, displayed an increasing trend in all treated samples (Figure 1), with fresh prawns exhibiting the highest initial levels (31.07 ± 1.74% for *P. monodon* and 32.41 ± 0.08% for *F. notialis*). Frozen samples showed the most significant rise (from 31.07% to 45.28% in *P. monodon* and 32.41% to 46.18% in *F. notialis*), likely due to ice crystal formation and subsequent thawing effects that promote water absorption during storage. Oven-dried samples maintained the lowest moisture variation (5.38% to 8.88% in *P. monodon* and 7.45% to 9.06% in *F. notialis*), reflecting effective dehydration that inhibits microbial growth (FAO, 1986).

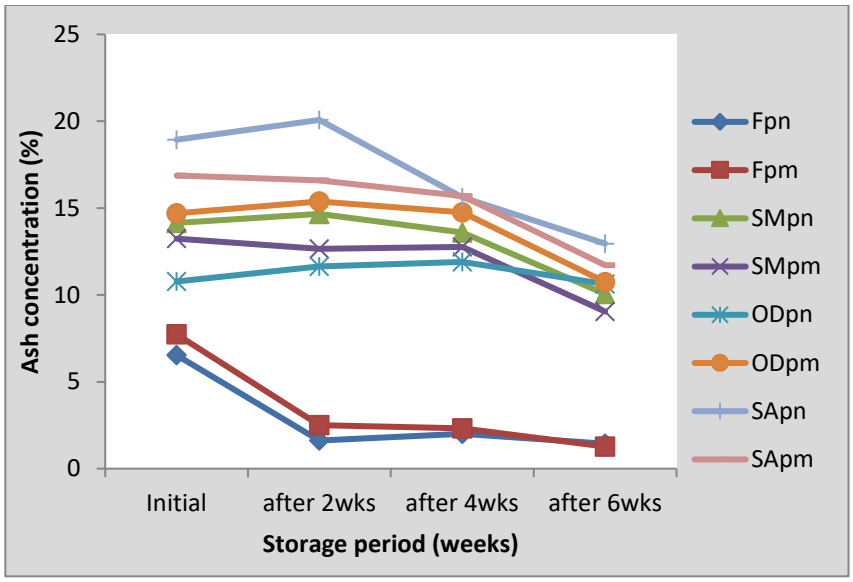

Fig 2: The trend of ash content during the storage period

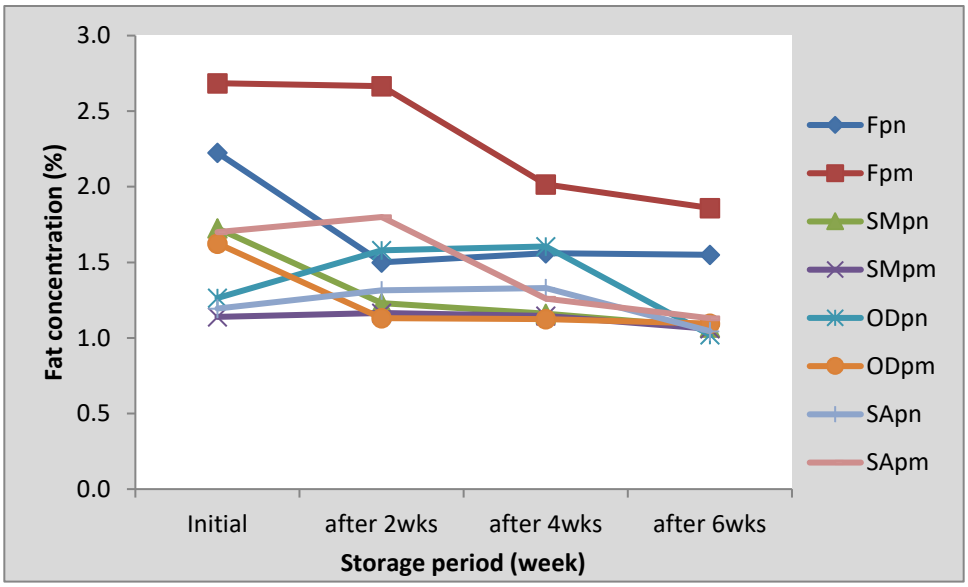

Fig 3: The trend of fat content during the storage period

Lipid and ash contents both decreased over time, varying by species and method (Figures 2 and 3). Ash content ranged from 16.88% to 11.71% in salted *P. monodon* and showed an exceptional increase in salted *F. notialis* (8.94% to 12.95%), possibly due to salt mineral accumulation. Lipids declined across all groups, driven by oxidation of polyunsaturated fatty acids (PUFAs) in prawn oils, which produces rancid flavors and diminishes nutritional value. The fatty acid composition influences lipid stability, with higher melting points offering better resistance to oxidation. Oven-dried samples exhibited slower lipid degradation, aligning with studies on dried shrimp where low moisture limits oxidative rancidity.

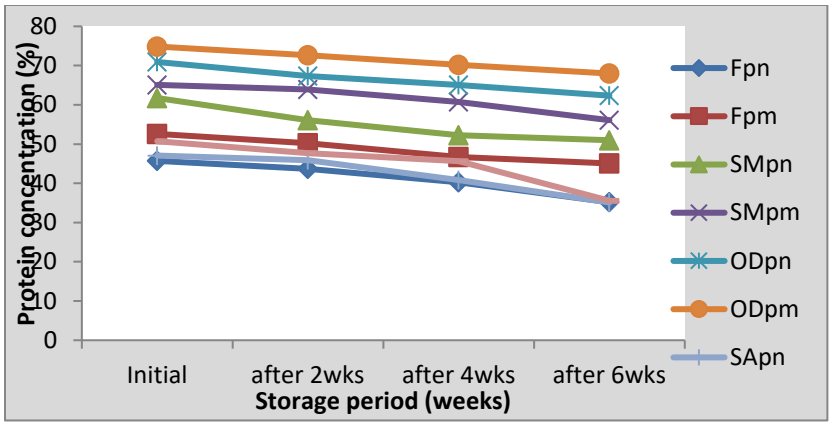

Fig 4: The trend of protein content during the storage period

Protein content exhibited a consistent decreasing trend across all preservation methods and both species throughout the storage period (Figure 4). Initially, oven-dried samples recorded the highest crude protein values (74.86 ± 0.17% for *P. monodon* and 70.92 ± 1.19% for *F. notialis*), while frozen samples had the lowest (35.18 ± 1.97% and 45.06 ± 1.34%, respectively). This decline can be attributed to protein denaturation, particularly during freezing, where low temperatures disrupt protein structures, leading to reduced solubility and nutritional quality. In contrast, oven drying concentrates nutrients by removing moisture, resulting in elevated protein levels, as supported by studies on dried shrimp where similar increases in protein concentration were observed due to dehydration. Smoking also preserved relatively high protein initially but showed faster degradation over time, possibly due to heat-induced Maillard reactions and oxidative stress (Tao & Linchun, 2008). These findings highlight the superiority of oven drying in maintaining protein integrity, which is crucial for prawns as a high-protein food source in Nigerian diets (Ajibare *et al*., 2020).

Smoked and salted samples had intermediate increases, with salting providing better moisture control through osmotic dehydration. An inverse relationship between moisture and fat content was evident, as higher water levels facilitate lipid hydrolysis and oxidation, reducing fat stability This pattern is consistent with reports on smoked fish where moisture uptake during ambient storage exacerbates spoilage, emphasizing the need for low-humidity environments in regions like Ondo State, where post-harvest losses are prevalent (Ajibare *et al*., 2020).

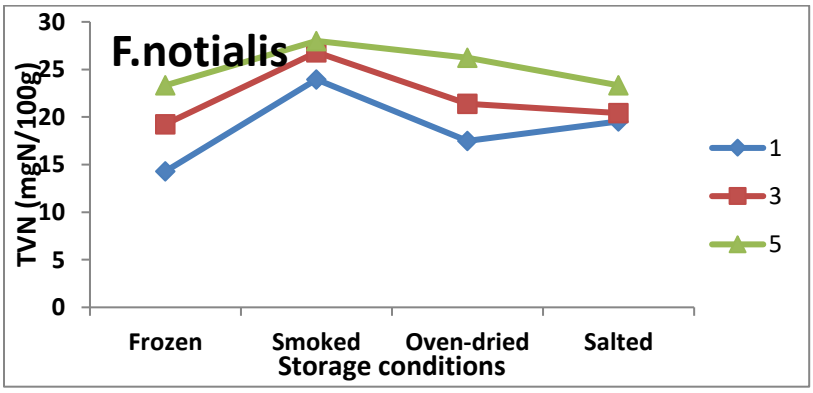

Fig 5: The trend of total volatile nitrogen in *F.notialis* during the storage period

FFA levels increased steadily in all samples (Figure 5), indicating progressive lipid hydrolysis via lipase activity, accelerated by heat, light, and storage conditions (Vyncke, 1983). Salted prawns showed the highest rise (10.75% to 21.88% in *P. monodon* and 11.36% to 22.16% in *F. notialis*), while oven-dried had the lowest (5.30% to 12.06%

and 6.20% to 13.30%), suggesting superior oil quality and edibility. This supports evidence that drying methods reduce FFA accumulation compared to wet preservation techniques, as dehydration inhibits enzymatic reactions. Elevated FFA correlates with rancidity, reducing consumer acceptability and aligning with global standards for edible oils (AOAC, 1996).

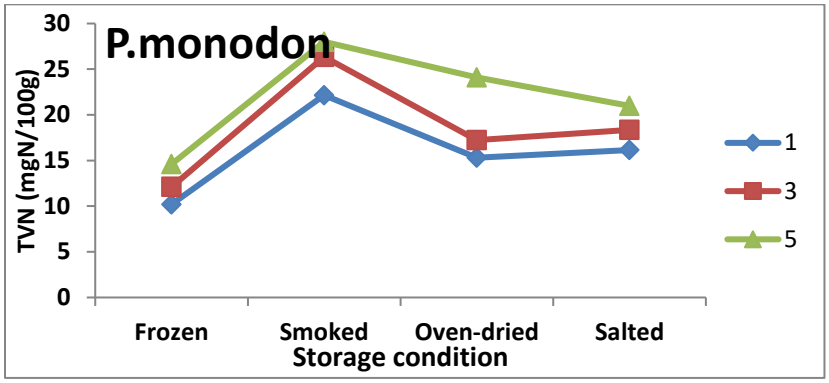

Fig 6: The trend of total volatile nitrogen in *P. monodon*

TVN, a marker of protein breakdown and spoilage, increased across all methods (Figure 6), with smoked samples recording the highest values (23.95% to 28.00% in *P. monodon* and 22.15% to 28.00% in *F. notialis*) and frozen the lowest (14.30% to 23.33% and 10.20% to 14.60%). Using the Lucke and Geidel method, TVN below 20 mg/100g indicates freshness, while >30 mg/100g signals spoilage (Montgomery et al., 1970). In this study, frozen *F. notialis* remained fresh up to week 5 (14.60 mg/100g), whereas smoked samples approached unacceptability by week 5 (28.00 mg/100g). This gradual rise reflects moisture absorption at ambient temperatures, enabling bacterial and enzymatic activity (FAO, 1986). These thresholds are corroborated by literature on shrimp, where TVN limits of 25–30 mg/100g denote spoilage, highlighting smoking's vulnerability due to incomplete moisture removal.

Overall, oven drying emerged as the most effective method, offering high protein retention, low moisture and FFA increases, and moderate TVN rise, making it suitable for extending shelf life in resource-limited settings like Nigeria (Ajibare *et al.,* 2020). Freezing preserved freshness longest for *F. notialis* but was less effective for *P. monodon*, while salting and smoking provided intermediate benefits but risked faster spoilage. These results emphasize the need for tailored preservation strategies to mitigate post-harvest losses, enhance food security, and support commercial aquaculture (*Okayi et al*., 2012). Future studies could explore combined methods or natural preservatives to further optimize quality.

CONCLUSION

This study demonstrated that oven drying is the most effective preservation method for *Penaeus monodon* and *Farfantepenaeus notialis*, outperforming freezing, smoking, and salting. Oven-dried samples retained the highest protein levels (74.86 ± 0.17% and 70.92 ± 1.19%, respectively), showed minimal moisture variation, and exhibited lower rates of free fatty acid (FFA) and total volatile nitrogen (TVN) accumulation over eight weeks, thereby reducing microbial and enzymatic spoilage. While freezing maintained freshness longer for *F. notialis*, it was less effective for *P. monodon*, and both smoking and salting were associated with higher spoilage due to moisture reabsorption and lipid oxidation.

Based on these findings, oven drying is recommended as the primary preservation method for prawns in resource-constrained settings such as Ondo State, Nigeria. Investment in affordable oven-drying infrastructure and training for artisanal processors would enhance product quality, extend shelf life, and reduce post-harvest losses. To further strengthen oxidative stability and support sustainable aquaculture, future research should investigate hybrid preservation strategies, including the integration of natural antioxidants with oven drying.

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