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Quality Changes in Traditionally Dried and Smoked Sarangi Fish (*Salmophasia bacaila*) Stored at Ambient and Refrigerated Temperature

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ABSTRACT

The study was conducted during March to April, 2025 at the Department of Fish Harvest and Post-Harvest Technology, LSPN College of Fisheries, Dau Shri Vasudev Chandrakar Kamdhenu Vishwavidyalaya, Kawardha, Chhattisgarh, India to investigate the quality changes in traditionally dried and smoked Sarangi fish (*Salmophasia bacaila*) during 30 days of storage under ambient and refrigerated conditions. Key parameters, including proximate composition, biochemical indices (TVB-N, peroxide value, free fatty acid), microbial load (total plate count), and sensory attributes, were assessed at regular intervals to evaluate the impact of storage environment and processing method on product stability. Results showed a progressive decline in protein and lipid content over time, with more pronounced reductions under ambient storage. Biochemical indicators such as total volatile base nitrogen (TVBN), peroxide value (PV), and free fatty acids (FFA) increased significantly, particularly at ambient temperatures, indicating spoilage and oxidative degradation. Total plate count (TPC) also increased over the storage period, with smoked samples showing higher microbial proliferation than dried samples, especially under non-refrigerated conditions. Sensory evaluation revealed a decline in consumer acceptability in terms of appearance, aroma, texture, and taste, more so in samples stored at ambient temperature. Overall, dried Sarangi exhibited better stability compared to smoked samples, and refrigeration effectively mitigated quality deterioration across all parameters. These findings highlighted the importance of proper storage and processing techniques in maintaining the safety, nutritional value, and sensory quality of traditionally processed fish products.

KEYWORDS: Dried fish, refrigerated storage, smoked fish, storage study

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1. INTRODUCTION

India, blessed with diverse freshwater resources (Ngasotter et al., 2020), supports a variety of small indigenous fish species (SIFs) that are not only culturally significant but also nutritionally rich (Sinha et al., 2024). One such species is *Salmophasia bacaila*, commonly known as Sarangi, which is widely consumed in the eastern and central regions of the country, including Chhattisgarh (Masud and Singh, 2015). Sarangi, being a small cyprinid fish, is an affordable and accessible source of high-quality animal protein, essential fatty acids, vitamins, and minerals, especially for rural and economically disadvantaged populations (Masud and Haldar, 2017; Eti et al., 2019; Hossain et al., 2025). Due to its perishable nature, preservation and value addition of Sarangi through traditional methods like drying and smoking have gained importance for enhancing shelf life, reducing post-harvest losses, and improving marketability (Masud and Haldar, 2017). Drying and smoking are age-old techniques commonly used in fish preservation across India (Thapa, 2016). These methods reduce the water activity in fish, thereby inhibiting microbial growth and enzymatic degradation (Pittia and Antonello, 2016). In Chhattisgarh, dried and smoked Sarangi are popular in local markets due to their unique flavor, ease of storage, and year-round availability. However, quality changes during storage, particularly under varying temperature conditions, remain a significant concern. Improper storage may lead to deterioration in physicochemical characteristics, lipid oxidation, microbial spoilage, and sensory quality loss, ultimately affecting consumer acceptability and food safety (Mafe et al., 2024). Ambient storage, typical in rural and small-scale market settings, often exposes the product to fluctuating temperature and humidity, accelerating quality degradation (Sampels, 2015; Ahmed, 2020). In contrast, refrigerated storage offers a controlled environment that potentially slows down spoilage processes (Sampels, 2015). However, cold storage facilities are not always accessible to marginal fish processors and retailers in regions like Chhattisgarh. Therefore, understanding the comparative effects of ambient and refrigerated storage on the quality of dried and smoked Sarangi is essential for recommending appropriate storage practices, extending shelf life, and ensuring product safety. Previous studies on dried and smoked fish have largely focused on marine or commercially significant freshwater species (Arvanitoyannis and Kotsanopoulos, 2012; Fitri et al., 2022; Venkatesh et al., 2024), with limited research on SIFs like Sarangi. The findings were expected to provide scientific insights into the shelf stability of traditionally processed Sarangi and guide stakeholders, from small-scale processors to policymakers, in adopting effective post-harvest handling and storage strategies to preserve the quality and safety of this nutritious fish product. By addressing this gap, the study contributed to the broader understanding of post-harvest quality management for SIFs, which were often overlooked in mainstream research. Moreover, the outcomes might aid in developing cost-effective storage recommendations tailored to resource-limited regions, ensuring that the nutritional and economic value of Sarangi was retained throughout its marketing and consumption cycle. This was particularly crucial for enhancing food security, reducing waste, and supporting rural livelihoods in inland regions like Chhattisgarh where traditional fish products played a vital role in the daily diet. This research aimed to fill that gap by evaluating the physicochemical, microbial, and sensory attributes of dried and smoked Sarangi during storage at ambient and refrigerated temperatures.

2. MATERIALS AND METHODS

2.1. Sample collection

The study was conducted during March to April, 2025 at the Department of Fish Harvest and Post-Harvest Technology, LSPN College of Fisheries, Dau Shri Vasudev Chandrakar Kamdhenu Vishwavidyalaya, Kawardha, Chhattisgarh, India. Dried and smoked samples of Sarangi (*S. bacaila*) were collected from local fish vendors at the Kawardha fish market in Chhattisgarh, India (Figure 1). The samples were aseptically packed in sterile zip-lock pouches, transported to the laboratory, and stored under both ambient and refrigerated conditions. All subsequent analyses were performed on the 0^{th}, 15^{th}, and 30^{th} day (Figure 2).

2.2. Proximate composition analysis

The sample's proximate composition, including moisture, protein, lipid, and ash, was assessed using standard methods outlined in Anonymous (2005). The results were reported as g 100 g^{-1} (wet weight basis).

2.3. Biochemical analysis

The estimation of Total Volatile Base Nitrogen (TVB-N), Peroxide Value (PV), and Free Fatty Acids (FFA) was carried out following the standard procedures outlined by the Association of Official Analytical Chemists (Anonymous, 2005). TVB-N was determined to assess the degree of protein degradation and spoilage by quantifying volatile nitrogenous compounds such as ammonia, dimethylamine, and trimethylamine. PV was measured to evaluate the extent of primary lipid oxidation by quantifying the amount of peroxides formed, which are early indicators of rancidity. FFA content was analyzed to determine the level of hydrolytic rancidity, indicating the release of free fatty acids due to enzymatic or microbial lipolysis.

2.4. Microbial analysis

The microbial quality of the samples, specifically the

Figure 1: Images of Sarangi fish (*Salmophasia bacaila*) samples collected from local vendors at Kawardha fish market in Chhattisgarh: (A) smoked and (B) dried forms

Total Plate Count (TPC), was assessed according to the protocols described in the Bacteriological Analytical Manual (Anonymous, 2024). Briefly, 5 g of each sample was homogenized with 45 ml of sterile saline solution to obtain the initial dilution. Serial tenfold dilutions were then prepared up to 10^{-5} by transferring 1 ml of the previous dilution into 9 ml of sterile saline under aseptic conditions. From each dilution, 0.1 ml was spread onto nutrient agar plates and incubated at 37 °C for 18–24 h. Colony-forming units (CFUs) were enumerated, and results were expressed as log CFU g^{-1} of the sample.

2.5. Sensory analysis

The sensory evaluation of the samples was carried out by a semi-trained panel consisting of 20 members, including students and faculty from LSPN College of Fisheries, Kawardha, who were accustomed to consuming smoked and dried fish. The panelists, selected based on their familiarity with such products, assessed the organoleptic qualities of the samples. The samples were served on clean plates under hygienic conditions. Sensory attributes such as color, odor, taste, texture, flavor, appearance, and overall acceptability were evaluated using a 9-point hedonic scale, following the method outlined by Das et al. (2023).

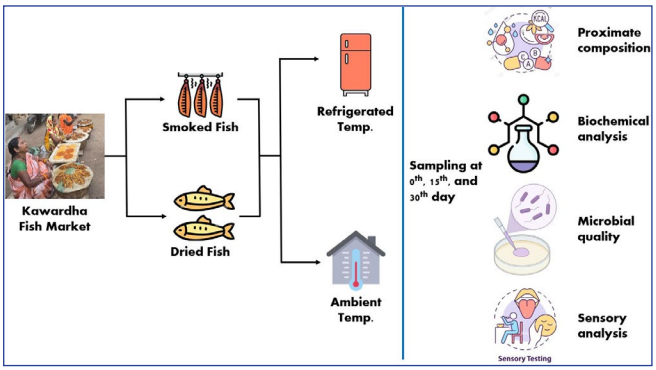

Figure 2: Schematic representation of the experimental methodology employed for the storage study, illustrating sampling intervals, storage conditions, and analytical procedures

3. RESULTS AND DISCUSSION

3.1. Proximate composition

The proximate composition of smoked and dried Sarangi fish, presented in Table 1 and Table 2, respectively.

3.1.1. Protein

A gradual decline in protein content was observed in both smoked and dried Sarangi samples over the storage period, with more pronounced reductions under ambient conditions

Table 1: Proximate composition of smoked Sarangi stored at an ambient and refrigerated temperature on 0th, 15th, and 30th day. Data are expressed as mean±standard deviation (n=3)

	Moisture (%)	Protein (%)	Lipid (%)	Ash (%)
Smoked sarangi ambient				
0th Day	18.5±0.4^{a}	56.6±0.3^{c}	13.5±0.3^{a}	5.4±0.1^{a}
15th Day	20.8±0.3^{b}	55.5±0.3^{b}	11.9±0.2^{b}	6.4±0.2^{b}
30th Day	21.7±0.5^{c}	53.6±0.1^{a}	10.4±0.3^{c}	5.7±0.2^{a}
Smoked sarangi refrigerated				
0th Day	18.5±0.4^{a}	56.6±0.3^{b}	13.5±0.3^{c}	5.4±0.1^{a}
15th Day	19.5±0.3^{b}	55.5±0.3^{a}	12.7±0.3^{b}	5.9±0.1^{b}
30th Day	20.7±0.2^{c}	54.9±0.4^{a}	11.9±0.3^{a}	5.6±0.2^{a,b}

Different superscript letters in the same column indicate significant difference (p<0.05)

Table 2: Proximate composition of dried Sarangi stored at an ambient and refrigerated temperature on 0th, 15th, and 30th day. Data are expressed as mean±standard deviation (n=3)

	Moisture (%)	Protein (%)	Lipid (%)	Ash (%)
Dried sarangi ambient				
0th Day	12.8±0.3[a]	58.5±0.1[c]	14.4±0.3[c]	7.6±0.1[c]
15th Day	13.6±0.1[b]	57.5±0.2[b]	12.6±0.3[b]	6.5±0.2[b]
30th Day	14.8±0.3[c]	55.9±0.3[a]	11.4±0.3[a]	5.5±0.3[a]
Dried sarangi refrigerated				
0th Day	12.8±0.3[a]	58.5±0.1[c]	14.4±0.3[c]	7.6±0.1[a]
15th Day	13.5±0.2[a]	56.8±0.5[b]	13.5±0.4[b]	7.8±0.2[a]
30th Day	15.7±0.5[b]	55.2±0.5[a]	12.7±0.3[a]	7.5±0.2[a]

Different superscript letters in the same column indicate significant difference (p<0.05)

(p<0.05). In smoked samples, protein content decreased from 56.6% to 53.6% at ambient temperature, while a smaller decline to 54.9% occurred under refrigeration. Similarly, dried samples showed a reduction from 58.5% to 55.9% (ambient) and 55.2% (refrigerated). A similar trend was observed in previous studies (Farid et al., 2014; Ikutegbe and Sikoki, 2014), which reported that protein content in smoked-dried and sun-dried fishes decreases progressively with extended storage duration.

The high protein content observed in dried and smoked fish was largely due to the dehydration process, which concentrated proteins and promoted their aggregation (Linus-Chibuezeh et al., 2022). The decline in protein content during storage might be due to the leaching of soluble protein fractions and the breakdown of protein molecules into volatile compounds such as Total Volatile Bases (TVB), hydrogen sulphide, and ammonia (Daramola et al., 2007; Ikutegbe and Sikoki, 2014; Ayeloja et al., 2020).

3.1.2. Lipid

A decline in lipid content was observed in both smoked and dried Sarangi across the storage period, with a more significant reduction under ambient conditions (p<0.05). In smoked fish, lipid levels decreased from 13.5% to 10.4% under ambient storage and to 11.9% under refrigerated storage. Similarly, dried fish showed a reduction in lipid content from 14.4% to 11.4% under ambient conditions and to 12.7% under refrigeration. The observed lipid loss was likely attributable to oxidation and hydrolysis of some of the lipid fractions (Daramola et al., 2007; Farid et al., 2014; Ikutegbe and Sikoki, 2014; Ayeloja et al., 2020), which progressed more rapidly at ambient temperatures.

3.1.3. Moisture

The primary objective of smoking and drying fish was to reduce moisture content to levels that inhibited the growth of spoilage microorganisms. In the present study, the initial moisture content of smoked and dried Sarangi was 18.5% and 12.8%, respectively. However, an increase in moisture content was observed in both products over the storage period. After 30 days, moisture levels in smoked Sarangi rose to 21.7% under ambient conditions and 20.7% under refrigeration. Similarly, in dried Sarangi, moisture content increased to 14.8% (ambient) and 15.7% (refrigerated). These observations aligned with previous findings, which also reported increased moisture uptake during storage of smoked and dried fish products (Ikutegbe and Sikoki, 2014; Farid et al., 2014; Ayeloja et al., 2020). This moisture gain was likely due to the hygroscopic nature of dried fish products, which readily absorbed moisture from the surrounding environment (Olayemi et al., 2015).

3.1.4. Ash

Ash content remained relatively stable throughout the storage period, exhibiting only minor fluctuations. In smoked fish, the ash content ranged between approximately 5.4% and 6.4%. In dried fish, a slight decrease was observed, which was similar to the findings of Olayemi et al. (2015).

3.2. Biochemical changes

3.2.1. Total volatile base-nitrogen

TVB-N, which served as a reliable indicator of protein degradation and microbial spoilage (Bekhit et al., 2021), increased progressively with storage time (Figure 3). At the beginning of the storage period (0th day), TVB-N levels were 8.5 mg N 100 g^{-1} in smoked fish and 6.5 mg N 100 g^{-1} in dried fish. As storage progressed, TVB-N values increased significantly, with higher levels recorded under ambient conditions compared to refrigeration. After 30 days, smoked fish stored at ambient temperature exhibited a TVB-N

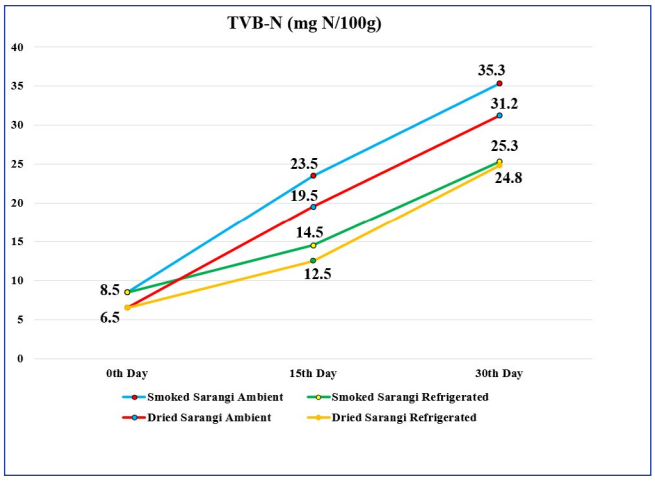

Figure 3: Changes in TVB-N values of smoked and dried Sarangi fish over time under ambient and refrigerated storage conditions

level of 35.3 mg N 100 g^{-1}, while samples stored under refrigeration reached 25.3 mg N 100 g^{-1}. Similarly, dried fish showed increases to 31.2 mg N 100 g^{-1} (ambient) and 24.8 mg N 100 g^{-1} (refrigerated). These values, particularly those exceeding 30 mg N 100 g^{-1}, approach or exceed the commonly accepted spoilage limit of 30–35 mg N 100 g^{-1}, as set by the European Commission (Anonymous, 1995; Bekhit et al., 2021). This indicated substantial protein degradation and declining freshness. Although refrigeration was effective in slowing the accumulation of volatile nitrogenous compounds, it did not completely prevent spoilage over prolonged storage. Previous studies have similarly reported a progressive increase in TVB-N levels in smoked and dried fish during storage (Al-Reza et al., 2015; Mosarrat et al., 2016; Ayeloja et al., 2020).

3.2.2. Peroxide value

The peroxide value (PV), an indicator of primary lipid oxidation products (Zhang et al., 2021), increased during storage, with higher levels observed in samples stored at ambient temperature (Figure 4). Initially, PVs for smoked and dried fish were 1.85 and 1.65 meq kg^{-1}, respectively. After 30 days, PV in smoked fish increased to 10.2 meq kg^{-1} under ambient storage, whereas refrigerated samples reached 5.33 meq kg^{-1}. In dried fish, PV increased to 9.5 meq kg^{-1} (ambient) and 6.3 meq kg^{-1} (refrigerated). This upward trend reflected ongoing lipid peroxidation, with oxidative spoilage more pronounced in samples stored at ambient temperature due to elevated reaction rates at higher temperatures. Peroxide values exceeding 10–20 meq kg^{-1} were generally considered indicative of the onset of rancidity and diminished sensory quality in fish and fish products (Raeisi et al., 2016; Barros et al., 2023). The results underscored the importance of low-temperature storage in mitigating lipid oxidation and preserving product quality during extended storage periods.

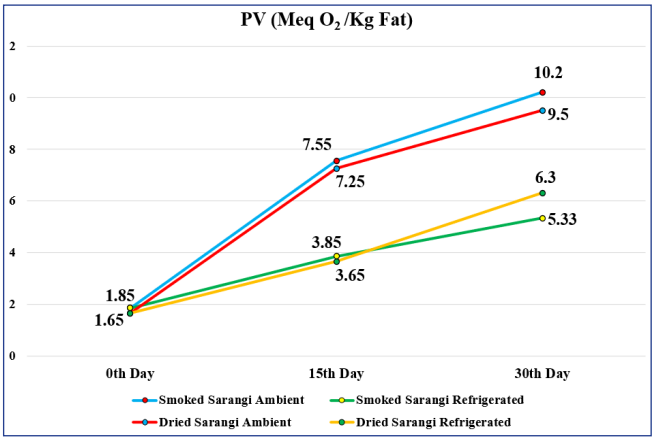

Figure 4: Changes in PV values of smoked and dried Sarangi fish over time under ambient and refrigerated storage conditions

3.2.3. Free Fatty Acids

Free fatty acid (FFA) levels, which served as indicators of lipid hydrolysis and the onset of rancidity (Daramola et al., 2007; Tenyang et al., 2020), exhibited a consistent upward trend throughout the storage period (Figure 5). On day 0, FFA values were 0.45% and 0.25% oleic acid for smoked and dried fish, respectively. After 30 days, FFA in smoked fish increased to 2.85% under ambient conditions, while refrigerated storage limited the rise to 1.3%. Similarly, FFA values in dried fish reached 2.61% under ambient storage and 2.30% under refrigeration. A similar increase in FFA values during storage of smoked and dried fish has been reported in earlier studies (Daramola et al., 2007; Ayeloja et al., 2020).

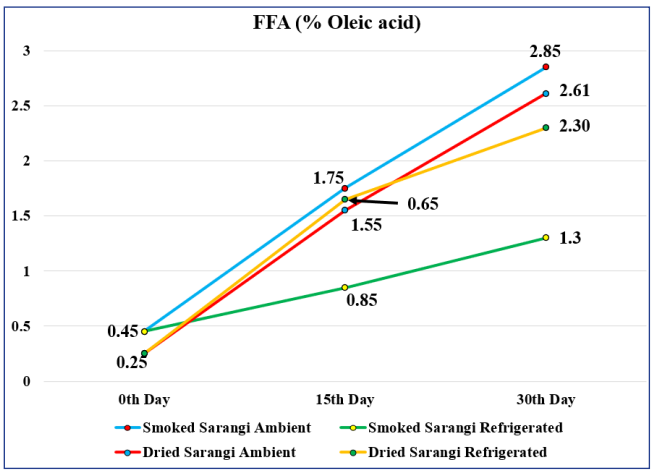

Figure 5: Changes in FFAs values of smoked and dried Sarangi fish over time under ambient and refrigerated storage conditions

Although lipid degradation was evident in both treatments, the slower rate of FFA accumulation in refrigerated smoked samples suggested that lower storage temperatures effectively suppressed microbial and enzymatic lipolysis (Suárez-Medina et al., 2024). Importantly, FFA values between 0.5% to 1.5% oleic acid have noticeable rancidity (Daramola et al., 2007), leading to off-flavors and reduced consumer acceptability in fish products. These findings underscored the role of temperature control in extending the shelf life and preserving the sensory quality of smoked and dried fish during storage.

3.3. Microbial changes

The initial total plate count (TPC) for dried Sarangi was 4.21 log CFU g^{-1}, while smoked Sarangi exhibited a higher baseline of 5.25 log CFU g^{-1}. Throughout the 30-day storage period, microbial loads increased in all samples; however, the extent of microbial proliferation varied notably depending on the processing technique and storage conditions (Table 3). Dried Sarangi demonstrated relatively better microbial stability, with TPC increasing moderately to 5.09 log CFU

Table 3: Changes in microbial quality of smoked and dried Sarangi at an ambient and refrigerated temperature on 0th and 30th day

Day	Dried (log CFU g^{-1})	Smoked (log CFU g^{-1})
Ambient temperature		
0	4.21	5.25
30	5.09	8.01
Refrigerated temperature		
0	4.21	5.25
30	5.03	7.21

g^{-1} under ambient conditions and to 5.03 log CFU g^{-1} under refrigeration. This stability can be attributed to the lower water activity in dried fish, which inhibited microbial growth more effectively (Fitri et al., 2022).

In contrast, smoked Sarangi showed a more pronounced increase in microbial load, with TPC values rising to 8.01 log CFU g^{-1} under ambient conditions and 7.21 log CFU g^{-1} under refrigerated storage. The higher microbial proliferation in smoked samples, particularly under ambient conditions, suggested that smoking alone does not provide sufficient preservation without supplementary storage interventions. According to microbiological guidelines for fish and fishery products, TPC levels exceeding 5 log CFU g^{-1} were generally considered the threshold for potential spoilage and reduced consumer acceptability in dried and smoked fishery products (Anonymous, 2023). The observed TPC values in smoked Sarangi stored at ambient temperature surpassed this limit, indicating potential microbial spoilage and compromised product safety. Overall, drying proved to be more effective than smoking in limiting bacterial proliferation, and refrigeration played a significant role in mitigating microbial increase in both products.

3.4. Sensory changes

The sensory quality of dried and smoked Sarangi fish was assessed using a 9-point hedonic scale, with results indicating significantly higher acceptability scores on day 0 compared to day 30 of storage (Figure 6). At day 0, both product types were rated favorably in terms of appearance, aroma, taste, and texture, reflecting their freshness and desirable organoleptic characteristics. However, a gradual decline in sensory attributes was observed over the 30-day storage period, with a more pronounced deterioration in samples stored under ambient conditions. This reduction in sensory scores can be attributed to biochemical and microbial spoilage, including lipid oxidation, protein degradation, and off-flavor development, which were exacerbated by elevated storage temperatures (Tavares et al., 2021; Pan et al., 2025). In contrast, samples stored under refrigeration retained better sensory quality, likely due to

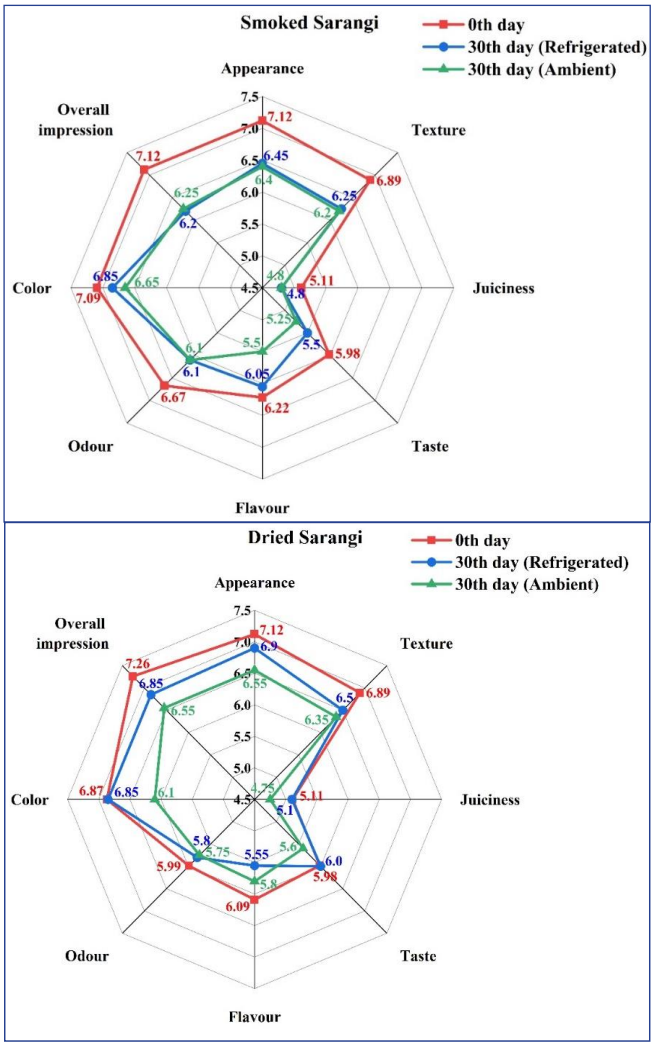

Figure 6: Radar diagram showing sensory attributes of smoked and dried Sarangi fish stored at ambient and refrigerated temperatures on the 0th and 30th day (n=20). Sensory parameters evaluated include appearance, color, odor, texture, taste, and overall acceptability. Values represent mean scores given by panelists on a 9-point hedonic scale

the suppression of microbial activity and slower oxidative processes. These findings emphasized the importance of controlled cold storage in preserving the sensory integrity of smoked and dried fish products, thereby enhancing shelf-life and consumer acceptability.

4. CONCLUSION

Storage temperature significantly influenced the quality of dried and smoked Sarangi. Ambient-stored samples showed increased moisture, accelerated spoilage, and higher protein and lipid degradation. Spoilage indicators like TVB-N, PV, and FFA exceeded safe limits, and microbial loads surpassed safety thresholds by Day 30. In contrast, refrigerated storage maintained all quality parameters within acceptable limits. Sensory quality also declined rapidly

under ambient conditions, while refrigeration preserved acceptability. Overall, refrigerated storage proved more effective in maintaining the product's quality during storage.

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