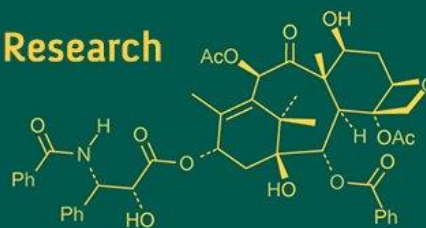


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Influence of turmeric (*Curcuma longa*) extract treatment on microbial load, lipid oxidation, and sensory attributes of Nile tilapia steaks during refrigerated storage

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Abstract

Fish is a vital part of a balanced diet, rich in essential nutrients that support good nutritional status and overall health. Tilapia is a significant freshwater species for aquaculture production in various regions worldwide. Due to its biochemical composition, tilapia can spoil rapidly. The aim of the present study was to investigate the effect of an aqueous turmeric (*Curcuma longa*) extract on the biochemical, microbiological, and organoleptic changes in Nile tilapia steaks during chilled storage at $4 \pm 1^\circ\text{C}$. Fishes were divided into four different groups: Control (Tu0), 1% turmeric extract (Tu1), 1.5% turmeric extract (Tu2) and 2% turmeric extract (Tu3). Based on organoleptic, biochemical, microbiological, and proximate analyses, samples treated with turmeric extract (Tu1, Tu2, Tu3) exhibited an extended shelf life of 15 days, compared to the control group (Tu0), which remained acceptable for only 9 days. However, the Tu2 treatment group revealed the highest organoleptic score for overall acceptability at the end of the 15-day storage period. This study demonstrates that turmeric extract treatment is an effective method for extending the shelf life of Nile tilapia steaks during chilled storage.

Keywords: Preservation, turmeric extract, tilapia fish, air packaging, chilled temperature

Introduction

Fish is one of the most important foods for human society because it provides a high amount of nutrition and can be found in every corner of the world in different forms. Polyunsaturated fatty acids (PUFA), proteins, and other components vital to human health are prevalent in fish. (Sreelakshmi *et al.* 2019) [18]. Tilapia are the most widely cultivated species in the world due to their exceptional adaptability to a wide range of physical and environmental conditions, capacity for reproduction in captivity, relative resistance to managing stress and disease-causing agents in comparison to other species of cultured finfish, high-quality flesh, low trophic level feeding, and exceptional growth rate on a wide range of natural and artificial diets (Welker, 2014) [21]. According to the FAO's Nile tilapia (*Oreochromis niloticus*) production data, around 5.3 million tons were recorded in 2022 (FAO, 2024) [6].

Fresh fish is one of the most perishable commodities because of its high protein and fat content, which can allow bacteria to develop quickly. For both industry and customers, the quality of fresh fish is a crucial concern (Rezaei and Hosseini, 2008; Valu *et al.* 2026) [16, 20]. Because consumers have a great preference for very fresh fish, freshness is one of the most significant factors in fish (Mohamed and Ammar, 2021) [9].

Globally, there is now widespread and significant concern among consumers, the food industry, and government agencies about the safety and quality of food products (Bhor *et al.* 2025) [3]. A major trend has emerged favouring minimally processed foods and those preserved with natural additives over products containing artificial preservatives (Khalafalla *et al.* 2015) [8]. Around the world, food preservatives have been used for centuries to maintain the edible quality of food (Padghan *et al.* 2025) [11].

Turmeric (*Curcuma longa*) is a key ingredient in many Indian cuisine recipes (Rajasekar *et al.*, 2020) [16]. India is the largest producer and exporter of turmeric in the world.

In Asian countries, turmeric is utilized in various forms, such as whole, dry, or fresh, and turmeric powder is combined with other spices to prepare vegetable and meat products as well as soup-like dishes (Peter, 2012) ^[12]. Turmeric is commonly employed as a preservative, colorant, antiseptic, anticancer, wound healing, and antibacterial agent in various biological systems worldwide (Arulkumar *et al.* 2017) ^[2].

Materials and Methods

Raw material

The fresh Nile tilapia (Average weight and size of 210 ± 18 g and 16 ± 0.52 cm, respectively) were bought from a Ratnagiri fish market, Maharashtra. After getting cleaned, the fish were promptly placed in a 1:1 insulated box with crushed ice and transported to the College of Fisheries Ratnagiri's fish processing hall. Determined the fish's weight and length. Chlorinated water was used for washing the entire fish. Fish steaks measuring 1.5 to 2.0 cm in thickness were made after the fish was descaled, its fins removed, and its head trimmed off, as reported by Bhor *et al.* (2025) ^[3]. With a few simple modifications, the turmeric extract was made using the Hosea *et al.* (2018) ^[7] methodology. To eliminate the raw smell, the turmeric rhizomes were thoroughly rinsed with clean water and then steam-cooked for 15 minutes. The sample was dried for 15 hours at 55 °C in a hot air oven and subsequently crushed into a powder before passing through a sieve with a nominal mesh size of 2 mm. After dissolving 30 grams of *Curcuma longa* in 150 ml of sterile distilled water, the mixture was allowed to soak for a whole day. The entire mixture was filtered through Whatman's filter paper No. 1. The turmeric extract was kept at a cold temperature in airtight glass bottles.

The Nile tilapia fish steaks were separated into four groups and soaked for 20 minutes in varying percentages of turmeric extract, viz., 0%, 1%, 1.5%, and 2%. All Nile tilapia fish steaks were packaged in 30 × 20 cm High-Density Polyethylene (HDPE) bags following appropriate draining. Every sample of air-packed Nile tilapia fish steaks was classified as treated with 0% turmeric extract (Tu0), 1% turmeric extract (Tu1), 1.5% turmeric extract (Tu2), and 2% turmeric extract (Tu3). Every single sample of Nile tilapia fish steaks were stored in a refrigerator with a temperature of 4 ± 1 °C as soon as they were packaged. For the purpose of evaluation, sampling was performed at two-day intervals to conduct organoleptic, biochemical, and microbiological analyses.

Proximate composition

Moisture, protein, fat, and ash content were analyzed in the control and turmeric extract-treated Nile tilapia samples using standard AOAC (2005) ^[1] methods.

Organoleptic evaluation

The different organoleptic characteristics served as the basis for the organoleptic evaluation. During the refrigerated storage, samples of Nile tilapia fish steaks are subjected to an organoleptic study by a panel of 10 judges. The samples were assessed using a hedonic scale with 1 to 9 points (Poste *et al.* 1991) ^[14].

Chemical analysis

Analytical-grade chemicals were used for all experimental procedures in this study. To assess the biochemical quality

of Nile tilapia fish steaks treated with varying percentages of turmeric extract, measurements of pH, peroxide value (PV), and total volatile basic nitrogen (TVB-N) were carried out. The AOAC (2005) ^[1] technique was used to determine the pH (using a pH meter) and peroxide value. The Conway (1950) ^[4] method was applied to measure the TVB-N content of the samples.

Microbiological evaluation

A microbiological analysis was conducted to enumerate the total plate count (TPC) using the spread plate method on Tryptone Glucose Beef Extract (TGBE) Agar (USFDA, 2022) ^[19].

Statistical analysis

The results from the quality analysis of Nile tilapia fish steaks were evaluated using appropriate statistical methods (Snedecor and Cochran, 1967) ^[17]. Significant differences among treatments were assessed by one-way analysis of variance (ANOVA).

Results and Discussion

Proximate composition of fresh Nile tilapia fish meat

The analysis showed that fresh Nile tilapia was composed of approximately 79.58% moisture, 16.42% crude protein, 2.95% fat, and 1.05% ash (Fig. 1, Table. 1). The proximate composition determined in this study closely aligns with the values of 79.85% moisture, 15.50% protein, 1.37% fat, and 1.37% ash previously recorded by Dhanpal *et al.* (2016), with only minor variations. Variations in the proximate composition of tilapia have been documented. Aktaruzzaman *et al.* (2022) recorded a proximate composition of 77% moisture, 19.28% protein, 2.74% fat, and 2.25% ash in tilapia steaks. The result is consistent with those reported by Bhor *et al.* (2025) ^[3], who found similar proximate composition where 76.84% moisture, 17.90% crude protein, 4.13% fat and 1.13% ash were observed in Nile tilapia steaks. The natural variation in the proximate composition of fish is well-documented and is influenced by a number of factors. These include the species, diet, season, geographic location of the catch, and the sex and maturity of the specimen.

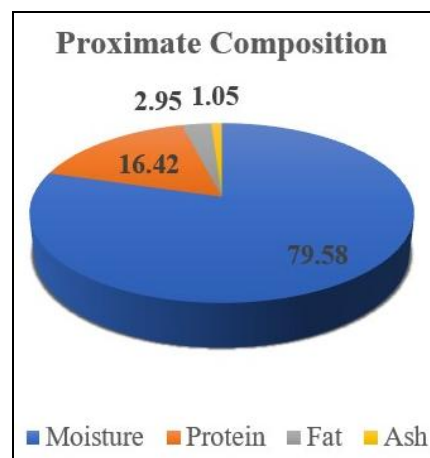


Fig 1: Proximate composition of fresh Nile tilapia (*Oreochromis niloticus*) fish meat

Organoleptic evaluation

The findings of the study revealed that the Nile tilapia steaks treated with turmeric extract show a significant difference

for all attributes such as appearance, colour, odour, texture and overall acceptability. At the end of the 9th day, the overall acceptability of Tu0 (0%) showed a decreasing trend from an organoleptic score of 8.8 to 4.5. At the end of 15 days, the overall acceptability score of Tu1 (1%) and Tu3 (2%) falls from 8.8 to 4.4 and 8.8 to 4.2, respectively. The organoleptic score for overall acceptability for the sample of Tu2 (1.5%) showed a decrease from 8.9 on the initial day to 4.4 on the 18th day of the chilled storage study (Fig. 2, Table 2). Similar results were found for *Sillago sihama* treated with turmeric powder at chilled storage conditions, the

overall acceptability for the sample treated with 5 % turmeric powder was recorded as the highest score of 3.6 (just acceptable) on the day 14th, however, the control group was just acceptable on the 8th day of the storage period (Rajasekar *et al.* 2020) [16]. Arulkumar *et al.* (2017) [2] also observed similar results for cuttlefish (*Sepia brevimana*) treated with turmeric during chilled storage, where the quality index method (QIM) score for control samples reached 14.1 on the 12th day and samples treated with turmeric extract received good quality scores and reached rejection QIM score (13.4) on day 15

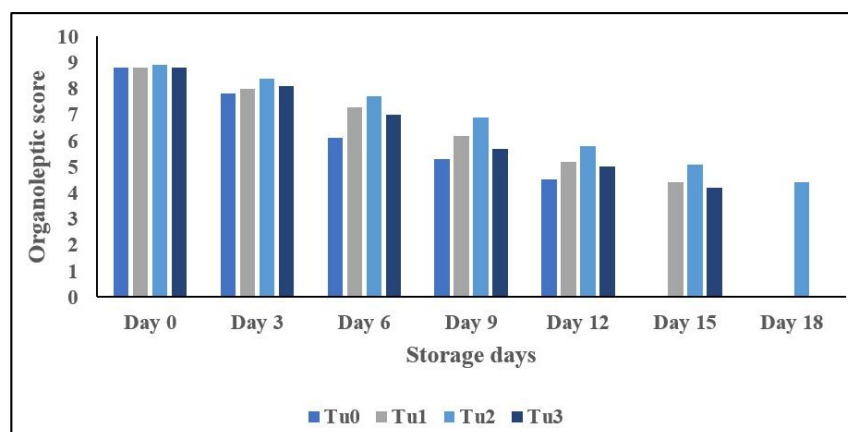


Fig 2: The organoleptic score for overall acceptability of Nile tilapia fish steaks treated with different % of turmeric extract during chilled storage

Biochemical analysis

Changes in the pH during chilled storage

In the present study, the pH values of all samples increased gradually with an increase in storage days. The pH value of Tu0 (0%) increased from 6.37 on the initial day to 6.85 on the 18th day. The pH of sample Tu1 (1%) and Tu2 (1.5%) increased from 6.32 and 6.30 to 6.69 and 6.67, respectively at the end of the 18th day. The pH value of sample Tu3 (2%) increased from 6.25 at the beginning to 6.57 at the 18th day of chilled storage (Fig. 3, Table 3). In this experiment, on the 18th day of the storage period, Tu3 shows a significant

difference from Tu0, Tu1 and Tu2 samples. Significantly lower pH values were observed in the Tu3 samples at the end of the chilled storage study. The increased pH may be due to microbial spoilage. The results align with Rajasekar *et al.* (2020) [16] for *Sillago sihama* treated with turmeric and seaweed powder. The pH values ranged between 6.6 and 6.8 on the initial day of the storage study and gradually increased as the storage period progressed. By day 14, the control samples had a pH of 7.7, while the samples treated with turmeric and seaweed powder had pH values around 7.2.

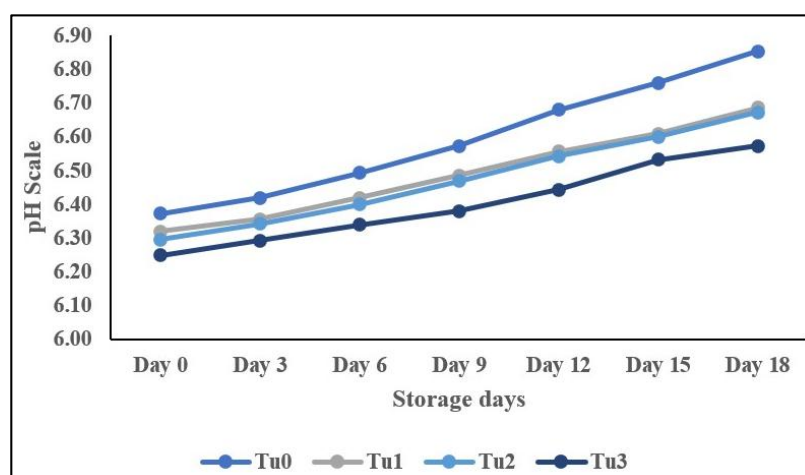


Fig 3: Changes in pH value of Nile tilapia fish steaks treated with different % of turmeric extract during chilled storage. (Values represent Mean $\pm$ SD of three determinants).

Changes in the Peroxide value during chilled storage

In the present study, the results revealed that peroxide values of samples treated with turmeric extract showed an increasing trend with an increased storage period.

Peroxide values of samples Tu0 (0%), Tu1 (1%), Tu2 (1.5%) and Tu3 (2%) were found to increase from 1.56 to 14.21 meq O₂/kg, 1.51 to 12.92 meq O₂/kg, 1.50 to 12.66 meq O₂/kg and 1.48 to 11.57 meq O₂/kg on day 18 respectively at

chilled temperature. The peroxide values of turmeric treated Nile tilapia fish steaks revealed that Tu0 (0%) is more prone to oxidative rancidity development than Tu1 (1%), Tu2 (1.5%) and Tu3 (2%) (Fig. 4, Table 4). Similar results were observed by Arulkumar *et al.* (2017)^[2] for cuttlefish (*Sepia brevimana*) treated with turmeric extract during chilled storage. On the initial day, the PV of samples was 0.56

m.eq./kg, which was increased up to 3.68 m.eq./kg for control and 2.31 m.eq./kg for treated samples on day 18. Pezeshk *et al.* (2011)^[13] also recorded comparable results for vacuum-packaged rainbow trout treated with turmeric, shallot extracts, and their combination. The PV was increased from 0.86 to 6.70 m.eq./kg and 4.67 m.eq./kg for control and treated samples, respectively.

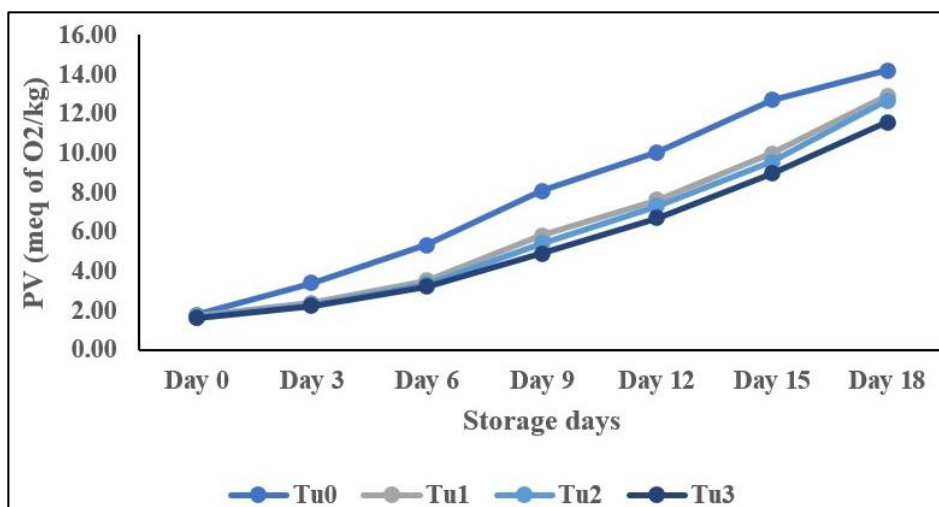


Fig 4: Changes in PV value of Nile tilapia fish steaks treated with different % of turmeric extract during chilled storage. Values represent Mean $\pm$ SD of three determinants.

Changes in the Total Volatile Base Nitrogen (TVB-N) during chilled storage

Total volatile basic amines are one of the most widely used indicators of fishery product quality (Mugahi *et al.* 2022)^[10]. In the current investigation, the Total Volatile Base Nitrogen (TVB-N) content increased with increased storage time. The TVB-N content of Tu0 (0%) increased from 4.62 to 43.82 mg/100 g, Tu1 (1%) increased from 4.58 to 34.12 mg/100 g, Tu2 (1.5%) increased from 4.56 to 32.58 mg/100 g and Tu3 (2%) increased from 4.55 on initial day to 31.77 mg/100 g at the end of 18th day (Fig. 5, Table 5). Similar results were found by Arulkumar *et al.* (2017)^[2] for cuttlefish (*Sepia brevimana*) treated with turmeric extract during chilled storage. On the initial day, the TVB-N content was 11.0 mg/100 g, which was increased to 41.33

mg/100 g for control and 33.7 mg/100 g for treated samples. Analogous results were observed by Pezeshk *et al.* (2011)^[13] for vacuum-packaged rainbow trout treated with turmeric, shallot extracts, and their combination. At the beginning of the storage period, the TVB-N value of samples was 12.60 mg/100 g, which was gradually increased up to 24.66 mg/100 g for turmeric extract, 25.20 for shallot extract and 25.00 for the combination of turmeric and shallot extract and control was increased up to 38 mg/100 g at 15 days of storage period. The reduced levels of TVB-N in Tu1, Tu2, and Tu3 as compared to Tu0 may be due to the preservative effect of turmeric extract, which helps to inhibit bacterial growth and thus reduces the volatile base formation during storage.

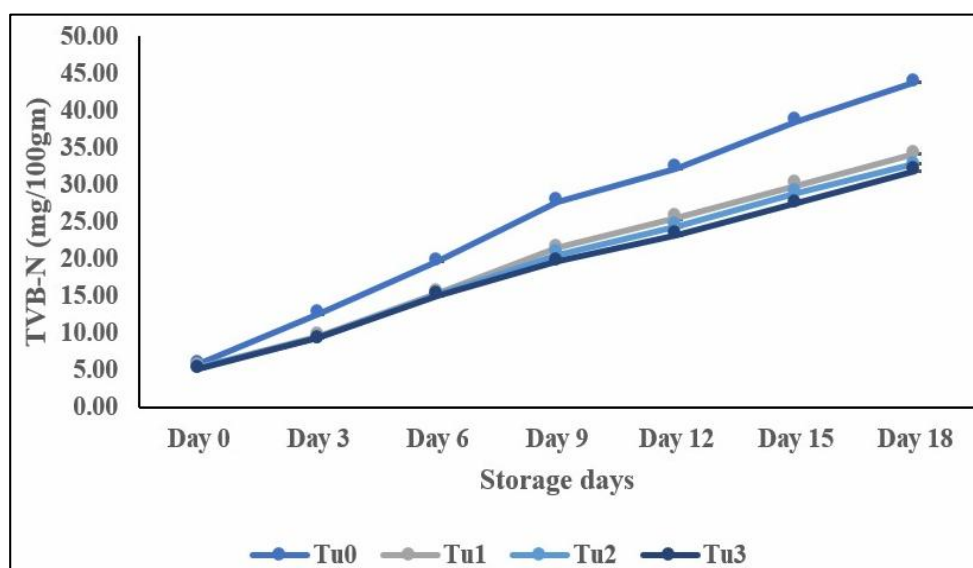


Fig 5: Changes in TVB-N value of Nile tilapia fish steaks treated with different % of turmeric extract during chilled storage. Values represent Mean $\pm$ SD of three determinants.

Microbiological analysis

Changes in the Total plate count during chilled storage

In the present experiment, the total plate count of all samples was increased gradually with an increase in storage time. The total plate count of sample Tu0 (0%) increased from 2.59 to 7.58 log cfu/g, Tu1 (1%) increased from 1.89 to 6.56 log cfu/g, Tu2 (1.5%) increased from 1.81 to 5.97 log cfu/g and Tu3 (2%) increased from 1.77 to 5.67 log cfu/g for the 18th day of the storage period (Fig. 6, Table 6). The reduction in TPC values for Tu1, Tu2 and Tu3 showed during chilled storage for 18 days, as compared to Tu0, may be attributed to the antibacterial effect of turmeric extract. Similar values were observed by Arulkumar *et al.* (2017)^[2]

for cuttlefish (*Sepia brevimana*) treated with turmeric extract during chilled storage. The initial values for the bacterial load on samples were 1.77 and 1.88 log cfu/g for the control and treated group, respectively. It was further increased up to 8.19 and 7.14 log cfu/g on day 18. Pezeshk *et al.* (2011)^[13] observed matching results for vacuum-packaged rainbow trout treated with turmeric, shallot extracts, and their combination. At the beginning, the bacterial load was 2.14, which was increased gradually. The control reached a bacterial load of 7.44 log cfu/g, but the treated samples had a bacterial load of less than 6 log cfu/g on day 20.

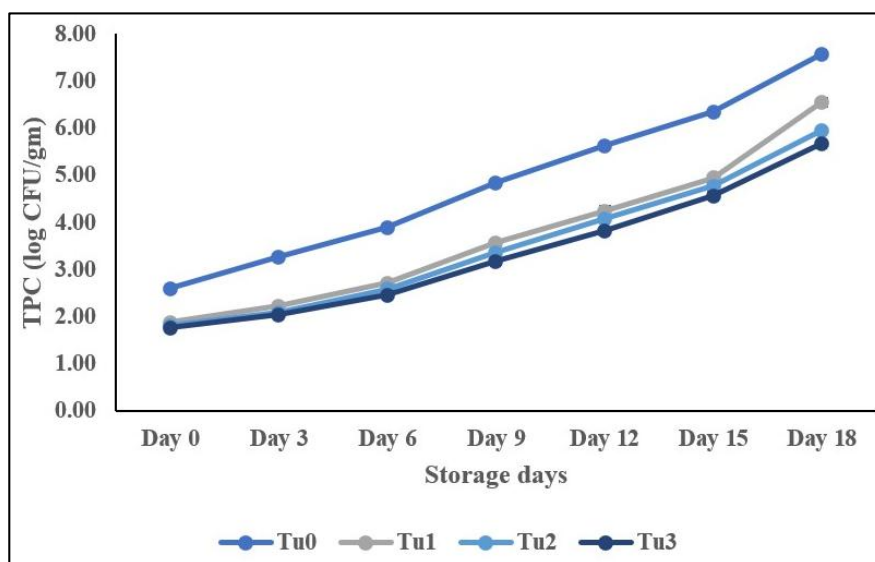


Fig 6: Changes in TPC value of Nile tilapia fish steaks treated with different % of turmeric extract during chilled storage. Values represent Mean $\pm$ SD of three determinants.

Conclusion

The findings indicate that aqueous extract of turmeric is an effective natural preservative for Nile tilapia steaks. Application at different concentrations successfully impeded microbial proliferation and minimized lipid and protein deterioration, maintaining acceptable quality throughout a 15-day chilled storage period. Despite the efficacy of various concentrations, the 1.5 % turmeric extract treatment was found to be organoleptically superior, achieving the highest overall acceptability after 15 days of chilled storage. Based on the findings, it is concluded that a 20-minute treatment with a 1.5 % turmeric extract solution is optimal for enhancing the shelf life of Nile tilapia fish steaks under chilled storage conditions (4 ± 1 °C).

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