Original Research Article

Exploring the quality of dried tilapia *(Oreochromis niloticus)* processed using different drying methods

Abstract

This study aimed to evaluate the effective drying methods for qualified dried tilapia (*Oreochromis niloticus*) products. Three different types of dryers, *viz*., ring tunnel dryer, oven dryer, and smoke dryer, were used for a specific period. Quality indicators such as sensory parameters, water reconstitution behavior, proximate composition, and TVB-N contents were analyzed for each product. The moisture content of SD samples contains more moisture than others (25.33%), while significantly lower moisture contents were observed in RTD. High protein levels (62.81%) and (61.69%) were found in a sample obtained from OD and RTD respectively. The protein content was significantly ($P \leq 0.05$) reduced in SD tilapia (54.35%). The higher lipid contents found in RTD and OD samples were 7.48% and 7.49%, respectively. The highest ash contents were recorded in RTD (14.89%). TVB-N content ranged between 7.03 to 7.45 mg/100 g, and the lowest TVB-N value was observed in dried fish produced by the ring tunnel drying method. RTD products hold more water, and the rate of rehydration was faster when compared to fish dried in a smoking kiln and hot air oven. The sensory parameters of dried samples were assessed, and preferences were given for RTD samples as compared to SD and OD in terms of odor, color, texture, and general appearance except texture of SD samples was better than the RTD and OD. Overall, the results demonstrated that RTD products compete with SD with few exception RTD would be the better choice for tilapia drying.

Keywords: tilapia, drying methods, proximate composition, water reconstitution, TVB-N

Introduction

Bangladesh is an agriculture-based country where the fisheries sector accounts for 3.52 percent of the national GDP and 26.37 percent (which is more than one-fourth) of the agricultural GDP (DoF, 2020). Around 170 million people, which comprises more than 12% of Bangladeshi, rely on fisheries and activities related to aquaculture for living, both full-time and part-time (DoF, 2020). In the case of inland open-water production, Bangladesh ranked third and reported fifth in aquaculture production, making it one of the world's leading fish producers (FAO, 2020). Bangladesh also holds fourth in tilapia production worldwide and third in Asia in FY 2019-20

(DoF, 2020). In Bangladesh, total fish production has expanded roughly six times in the last three decades (45.03 lakh MT in 2019-20, which was 7.54 lakh MT in 1983-84) (DoF, 2020). Moreover, fish production in Bangladesh has attained self-sufficiency, with per capita fish consumption of 62.58 g/day, exceeding the target set previously of 60 g/day (DoF, 2019).

Due to limited handling and transportation infrastructure, a considerable number of fish spoils and is wasted during the post-harvest period as it cannot consume all of the fish obtained nor can transport it to other regions whenever necessary (Rana et al. 2019). Poor handling results in the loss of a high percentage of captured fish in underdeveloped and developing countries (Oladele and Odedeji, 2008). About 32-35% of total catches are lost during pick seasons due to market problems, post-harvest losses, environmental pollution, human health effects, pollution of dam water, and economic losses (Zebib and Tsegay, 2015). Furthermore, there are issues regarding refrigerators scarcity; they become full of unsold products.

Several techniques can be used to preserve fish to retain its quality and extend the product's shelf life. Traditional methods of fish processing and preservation include dehydration (drying, salting, and smoking), cold storage, freezing, canning, and chemical treatment (Tesfay and Teferi, 2017). Drying is the most effective technique among fish preservation techniques (Calicioglu et al., 2002). Drying reduces the moisture content, proliferating bacteria, and mold growth. Bacteria cannot survive, and autolytic activity is considerably reduced if the moisture level of fresh fish is lowered to roughly 25% during drying. Still, the moisture content must be reduced to 15% to prevent mold growth. Various drying methods, such as ring tunnel drying, oven drying, and smoke drying, are used to lower the moisture content more efficiently. These drying methods are significantly more hygienic, and effective, and have less risk of health hazards. Dried fishes are made from various marine and freshwater species (Rana et al., 2020). Tilapia fish are ideal for drying since they are available all year and can be sold at a higher price with added value. Dried fish is one of the significant sources of animal protein and other critical elements for maintaining a fit and sound body (Arannilewa et al., 2005). Moreover, due to its distinct taste and flavor, dried fish is highly recommended by Bangladeshis in the coastal, central, and northeastern parts (Rana et al., 2020). The nutrient contents are always higher in dried fish products than in raw fish (Rasul et al., 2018).

However, an attempt was taken to dry the tilapia fish by applying various drying methods as ring tunnel drying, oven drying, and smoke drying, and then quality parameters were evaluated.

Materials and Methods

Sample Collection and Preservation

For the experiment, fifteen tilapia *(Oreochromis niloticus)* fish, about 350g of each on average, were collected from the Agargaon market at Sher-e-Bangla Nagar, Dhaka-1207, Bangladesh. Samples were stored at low temperatures (4^oC) for further use.

Sample preparation

Fishes were properly washed using potable water; whole fish was weighed on a balance, dressed (by finning, gutting, and spinning), and weighed. The fish were rewashed immediately after dressing to remove the blood, gut particles, slime, and other undesirable substances.

Brining and air drying

Prepared fish were immersed into a plastic bucket containing 5% salt solution for 5 minutes. After bringing, fishes were put on a plastic pan to dry for 10 minutes at room temperature. Air drying was required to cure the fish with a salt solution.

Drying-1: Using Ring Tunnel Dryer (RTD)

The fish were placed inside the sieves of the ring tunnel dryer after air drying. The fish fillets were dispersed into the sieves to ensure proper sunlight penetration on each fillet. After filling the sieves of the tunnel placed into the rooftop of Sheikh Kamal Bhaban of Sher-e-Bangla Agricultural University to run the process. After stocking fish in the trays, a transparent polythene sheet was used to cover the ring tunnel. Polythene was used to carefully cover each side of the ring tunnel, whereas a slight portion was kept open at the top to remove air. The fillets were flipped over to make sure each side of the fillets got proper sunlight. Manually, a spoon was used to flip the fillets, and at the same time, coated polythene was removed. Finally, gum tape was used to properly wrap up the polythene coating.

Drying-2: Using Smoking Kiln (SD)

After air drying, a detachable wire mesh tray was used to place the fish inside the smoking kiln. Fillets were spread on the wire mesh and hung from the sides as well. Continuous and uniform hot smoke was produced by burning wood chips or sawdust on an iron bowl in the lower chamber of the smoking kiln as it could do so. A sensitive thermometer was used to record the smoke temperature inside the smoking kiln during the smoking procedure. The smoking chamber's outlet was manually adjusted to keep the temperature between 50 and 55oC. The temperature of the smoke was measured every 10 minutes of interval to ensure the temperature inside the kiln was uniform. In the middle of the smoking process, fish were flipped upside down with a metal that was free of any type of corrosion to keep the sample both smooth and consistent in terms of appearance and texture. This is done with care to produce unbroken fish. The product was determined to have an appealing brilliant yellowish color and an acceptable texture, indicating that it had been adequately cooked with a smoky flavor. During the smoking process, the colors, texture, and firmness of the fish were evaluated and treated with care. Products were allowed to cool for 15-20 minutes at room temperature after being smoked.

Drying-3: Using Hot Air Oven (OD)

Before drying oven was cleaned thoroughly, and the racks were properly oiled to avoid stucking of samples on racks during drying. The samples were spread on aluminum foil and folded over to ensure that the samples would get heat homogeneously. Then the oven was set at 55oC for 12 hours. The temperature was constantly checked and managed. To accomplish consistent drying and avoid charring, fish were checked hourly and flipped occasionally.

Proximate Composition Analysis

The moisture, crude protein, lipid, and ash content of dried tilapia obtained from three different drying methods were determined by AOAC (2000) methods with few modifications. TVB-N content was determined according to the method reported by Rana et al., (2020).

Determination of Water Reconstitution Capacity

The water reconstitution capacity of different dried tilapia was determined according to the method reported by Rana et al. (2018). Eight grams of each sample were kept soaked in water at 28^{o}C, 40^{o}C, and 60^{o}C temperatures, and casual stirring was performed for up to 60 minutes. Draining of water was done using a coarse nylon net. A colander was used to transfer all the fish, blotting paper was used to wipe out the outlying water, and the fish was weighed. The percent gain or uptake of moisture by the fish flesh was marked as percent water reconstitution or rehydration (%) and estimated using the following equation:

$$\text{Water reconstitution (\%)} = \frac{W_r - W_i}{W_i} \times 100$$

Where W_i= Initial weight of the dry fish and Wr = Weight of the dry fish after water absorption.

Sensory Analysis

Representative samples (03) were randomly presented to panel members (28 members) from the university community. The sensory characteristics such as color, odor, texture, and appearance were evaluated using a hedonic scale of 9-point (9-like extremely to 1- dislike extremely), as reported by Saeid et al. (2020).

Statistical Analysis

All data were analyzed statistically using statistical software R (Windows version 2.13.1). Duncan Multiple Range Test (DMRT) were performed for specific difference among the samples at a 5% level of significance.

Results and Discussion

A proximate composition such as protein, lipid, ash, and moisture content of dried tilapia are shown in table 1 obtained from different dryers. Rana and Chakraborty (2016) reported the moisture content as one of the indicators of the rate at which deterioration occurs and consequently resulting in the early decomposition of products. The moisture content of ring tunnel-dried, oven-dried, and smoke-dried products was reported as 12.43±1.88%, 13.50±0.90%, and 25.33±1.30%, respectively. The moisture content of the product dried in the smoke dryer was showed significantly higher, almost double as compared to other drying methods. In contrast, the lowest moisture content was recorded in oven-dried products. These results closely agreed with the work of Islam et al., 2006 who found the moisture content as 11.8% to 15.0% for Bombay duck (*Harpodon nehereus*), Silver Jewfish (*Johnius argentatus*), and Ribbon fish (*Trichiurus haumela*) except the smoked dried product. The results of the current study were also supported by Hasan et al., 2006 who observed moisture content of three small dried fishes known as small indigenous species (SIS) was 13.71% to 26.42%. Azam et al. (2003) studied the biochemical assessment of fourteen selected dried fish and observed that moisture content ranged from 18.23-23.61%. Moisture content in smoke-dried products of the current study is observed to be higher than the rest two treatment, which might be due to the effect of the different drying methods (Rasul et al., 2018).

The protein content of RTD, OD, and SD tilapia was recorded as 61.69±0.70%, 62.81±0.82%, and 54.35±1.50%, respectively, which is similar to the outcomes reported by Rana et al., 2019 for Salt-smoke-dried (SSD) of tengra and batashi as 62.75% and 65.0%, respectively. The almost similar type of protein content for dried fishes was also noted by Rana and Chakraborty, 2016 for salt-smoke-dried (SSD) tengra as 63.40%, while 57.32%% to 68.49% were investigated for Bombay duck (*Harpodon nehereus*), Silver Jewfish (*Johnius argentatus*) and Ribbon fish (*Trichiurus haumela*) (Islam et al., 2006) and 63.64% to 64.10% was noticed for tilapia (*Oreochromis niloticus*) (Chukwu, 2009). Protein content was significantly reduced in smoke-dried tilapia, whereas the highest protein content was observed in ring tunnel-dried tilapia and oven-dried tilapia; there was no significant difference found (Table 1).

Table 1: Proximate composition of dried tilapia obtained from different drying methods

Drying methods	Moisture (%)	Protein (%)	Lipid (%)	Ash (%)
Ring Tunnel drying	13.50±0.90^{b}	61.69±0.70^{a}	7.48±0.95^{a}	14.89±1.72^{a}
Oven drying	12.43±1.88^{b}	62.81±0.82^{a}	7.49±0.77^{a}	14.52±1.08^{a}
Smoke drying	25.33±1.30^{a}	54.36±1.50^{b}	6.02±0.57^{a}	11.82±2.08^{a}

$^{a\text{-}b}$Mean value±SD, different superscripts letter in each column are significantly different among drying methods

Lipids are one of the major nutrients which determine the nutritional quality of fish. The observed lipid contents were recorded as 7.48±0.95%, 7.49±0.77%, and 6.02±0.57% for ring tunnel-dried, oven-dried and smoke-dried products, respectively. The lipid content in the ring tunnel and oven-dried products were almost identical and were comparatively higher than in the smoke dryer. This finding is similar to those reported by Islam et al. (2006), where the lipid content was reported as 6.08% to 8.62% for Bombay duck (*Harpodon nehereus*), Silver Jewfish (*Johnius argentatus*) and Ribbon fish (*Trichiurus haumela*). According to Rana et al. (2020), the lipid content varied from 4.20% to 13.03% in different indigenous dried fishes. It may be due to the variation of species.

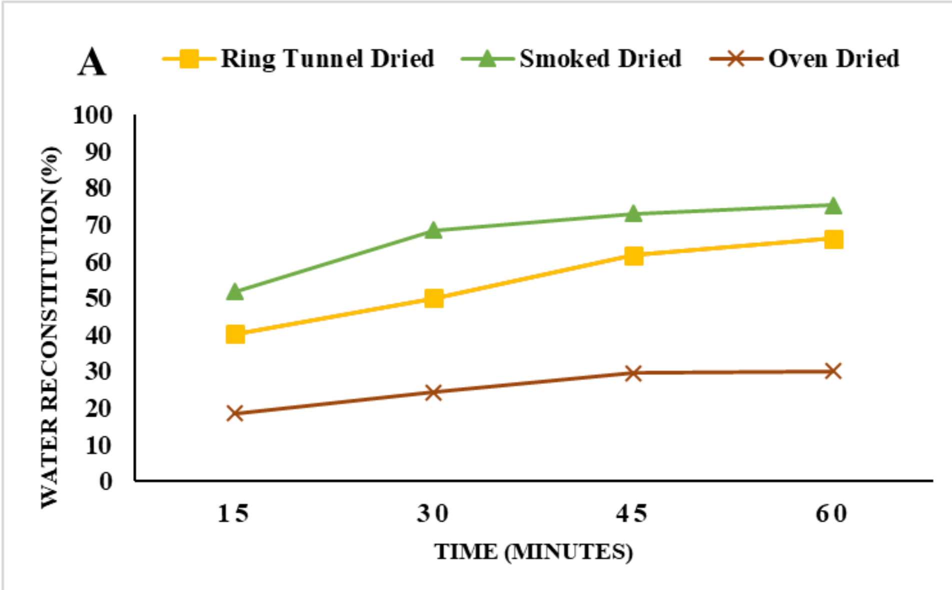
The observed ash content of ring tunnel-dried, oven-dried, and smoke-dried products was recorded as 14.89±1.72%, 14.52±1.07%, and 11.82±2.08%, respectively. Ring tunnel-dried and oven-dried tilapia had a higher level of ash in comparison to those dried in the smoke dryer, but there was no significant difference found. The Ash content of this study was found to be almost similar to the results reported by Islam et al. (2006), where the ash content was reported as 12.25% to 14.88% for Bombay duck (*Harpodon nehereus*), Silver Jewfish (*Johnius argentatus*) and Ribbon fish (*Trichiurus haumela*). Flowra *et al.* (2012) reported a 9 to 30% variation in ash content among the studied dried fishes depending on dry matter and moisture contents.

The water reconstitution characteristics of different dried products from various dryers are shown in Figure 1. At room temperature, the ranges for water reconstitution capacity of dried fishes obtained from different drying methods application were 18.46 to 75.28% while fishes soaked for the entire time duration. The SD samples found the highest reconstitution capacity (75.28%) at the end of the time period, and the lowest found in OD samples was 18.46%. These results are comparable with the work of Hassan et al. (2006) reported that the dried SIS from a solar tunnel dryer had a rehydration capacity of 19.81% after 15 minutes of soaking at 30^{o}C, but 60 minutes later, the rehydration capacity for Mola was 56.66% which was lower than our observation. The low rehydration of dried samples might happen due to the slow water penetration process, mostly to the centre of large pieces of tough and rubbery tissue by diffusion through the protein of the fibre itself (Rana et al., 2018)

While soaking temperature at 40^{o}C, the smoked dried product found the highest reconstitution capacity was 85.37%. The RTD sample also found closed results of 82.61%, where the lowest capacity of water reconstitution (26.52%) was noticed at 60 minutes of soaking. The 40% rehydration capacity was found in dried SIS products at a soaking temperature of 40^{o}C after 60 minutes of soaking (Hasan et al., 2006). This results were lower than our investigation.

Furthermore, at temperature 60^{o}C, the RTD product retained highest water rehydration capacity was 73.28% and the SD sample also found closed outcomes as 68.14% while OD product found two times lower rehydration percentage as 36.14% after 60 minutes soaking time. This results is comparable with work of Hasan et al., (2006) who observed that dried SIS products produced using traditional dryer exhibit 54.26% to 75.24% rehydration capacity while soaking for 60minutes at 80^{o}C. Nurullah et al. (2006) observed that the small indigenous species (SIS) had 65.26 to 70.51% rehydration capacity at 80°C of soaking temperature after maximum soaking time. These results also supported our investigations for RTD and SD samples.

It has clearly observed that, with an increment of time, reconstitution capacity was raised for all samples. After the end of the time duration, the reconstitution capacity of the RTD and SD sample had noticed to be highest when the soaking temperature stood at 40^{o}C. The rehydration percentage diminished at 60^{o}C for RTD and SD, except for OD samples increased.


A
Ring Tunnel Dried
Smoked Dried
Oven Dried
WATER RECONSTITUTION (%)
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90
80
70
60
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30
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10
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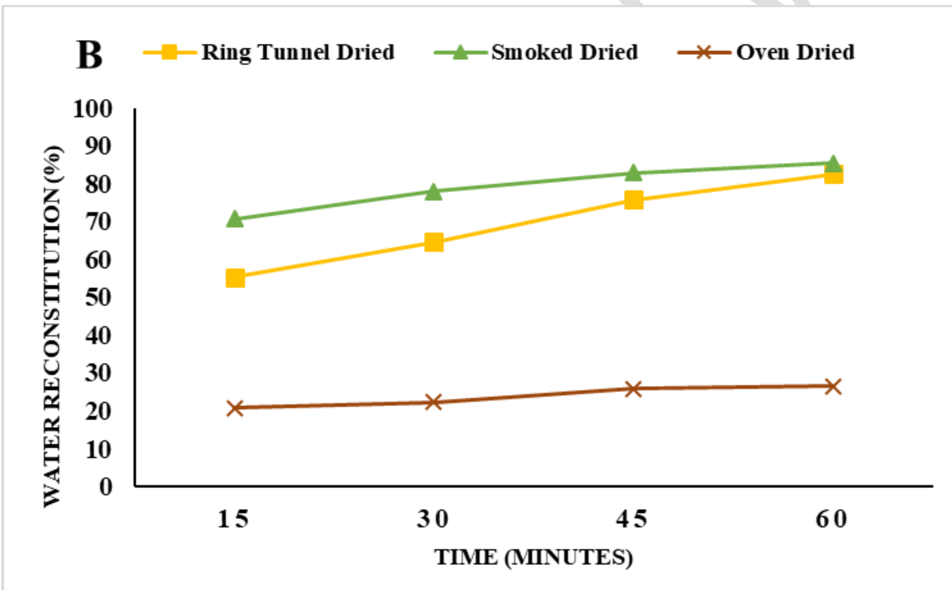
15
30
45
60
TIME (MINUTES)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Ring Tunnel Dried
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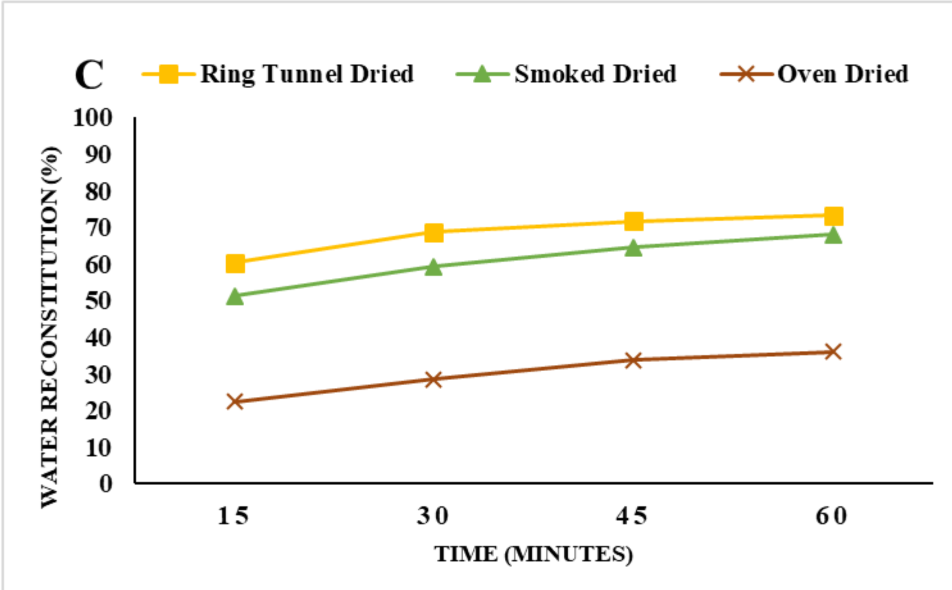

Figure 1: Water reconstitution of Dried Tilapia at (A) Room temperature, (B) 40^{o}C, and (C) 60^{o}C by using different dryers.

The TVB-N values of dried tilapia obtained from different drying methods were in the ranges of 7.03 to 7.45 (mg/100g) of muscle (Figure 2). A smoking kiln dryer was found to produce dried fish with the highest TVB-N value, while ring tunnel dryer products produced the lowest TVB-N value. These results showed very lower TVB-N values than those reported by Islam et al. (2012), who found the TVB-N values of dried mola species were dried by solar or rotary dryer ranged between 10.64 to 20.36 mg/100g. Paul et al. (2018) reported that the TVB-N values for traditionally dried marine fishes possess within the range of 28.46 to 42.88mg/100g. Idakwo et al. 2016 reported that the suggested amount of TVB-N for various dried and salted fish products was 100-200 mg per 100 g of muscle. Moreover, the TVB-N value of dried tilapia fillets was found to be between 44.27 and 64.39 mg/100 g of muscle (Gamal et al. 2011). This is explicitly normal to anticipate low TVB-N values in quality dried products since the exceed in value can be considered the dried fish product to be spoiled (Paul et al., 2018). Thus, the lower TVB-N value represents the better quality of the product. It’s clear that ring tunnel-dried tilapia had better quality than others, reflected as the lowest TVB-N value although among the samples there was no significant difference ($P \leq 0.05$) found.

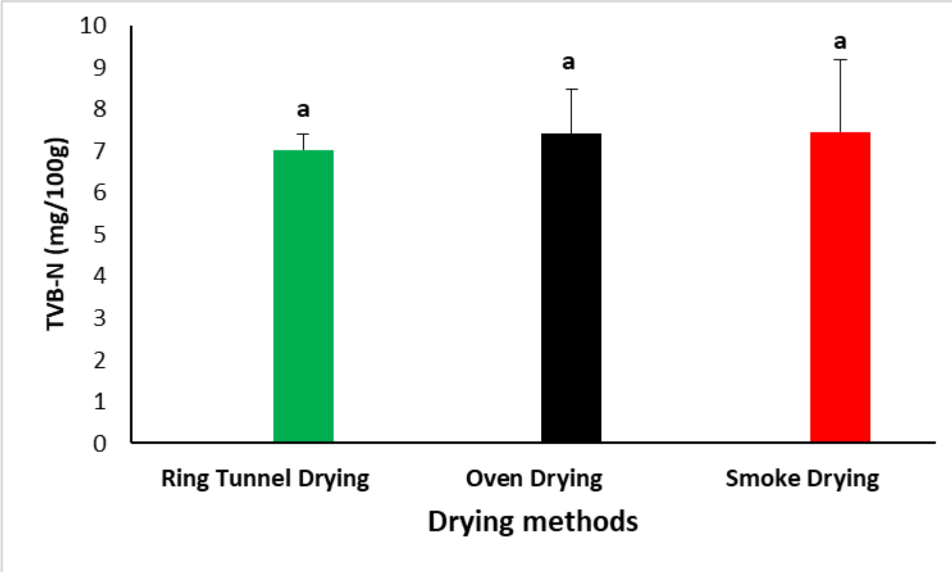

Figure 2: TVB-N values of dried tilapia obtained from different drying

The sensory characteristics of dried tilapia obtained from different drying methods are shown in figure 3. Consumer acceptance was evaluated in terms of appearance, color, odor, and texture. The hedonic score for the odor of RTD tilapia was observed as 7.33, which was significantly higher than the products of OD and SD tilapia, which had hedonic scores for the odor of 6.58 and 6.75, respectively. In the same way, the scores for color, texture, and general appearance of RTD tilapia were reported better as compared to OD and SD tilapia, except for the texture value, where the value of SD was noted well compared to those of RTD. It can be seen that the best quality product based on sensorial attributes was obtained from the RTD system. It might be due to the shorter dehydration time required in the ring tunnel, as it had the ability to trap heat and then facilitate the drying process. Conversely, lower hedonic scores were obtained for smoked and oven-dried products. The result suggested that tilapia dried in ring tunnel dryers had better consumer acceptance than those dried in oven dryers and smoking kiln dryers.

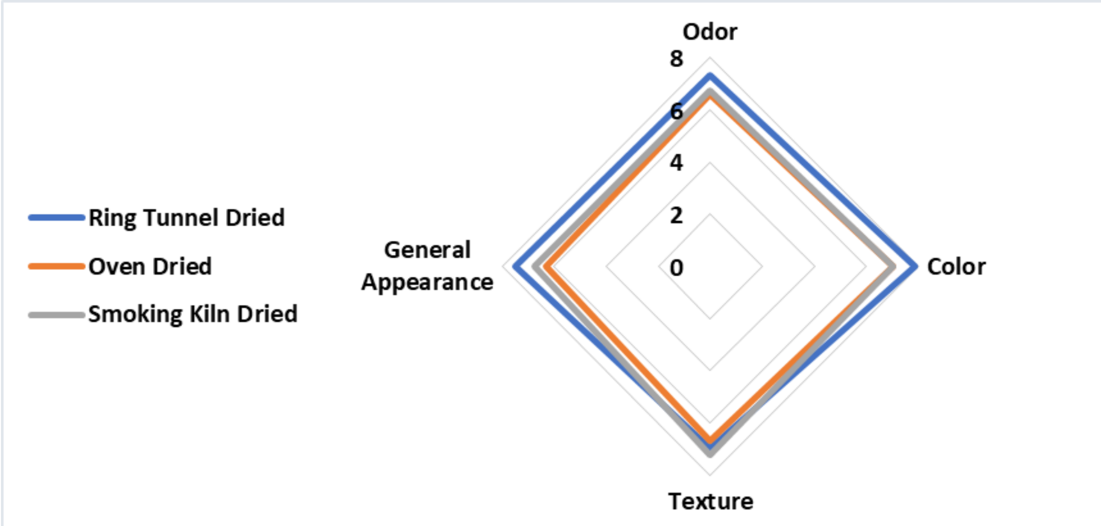

Figure 3: Sensory characteristics of dried tilapia from different dryers

Conclusion

The study revealed that the basic nutritional information of a euryhaline fish tilapia also provides a possible application of efficient drying technique for fish preservation, especially in developing countries where the storage and distribution facility is very poor. The biochemical analysis proved that the overall quality of the RTD product was better compared to others. RTD products showed a better hygienic aspect by shortening the drying period of fish. Among all the dryers, the overall performance of the ring tunnel dryer was better in terms of product quality, drying time, temperature, and hygiene aspects.

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