Effect of Hot Smoking on the Chemical Composition and Quality Criteria of Some Fish Species from Lake Nasser, Egypt

Sayed Ibrahim¹, Nabil Farah², Olfat Habib², Alaa El-Far¹*, Harrison Charo-Karisa²,  
Ahmed Nasr-Allah²

¹Fisheries Division, National Institute of Oceanography and Fisheries (NIOF), Egypt  
²WorldFish Center, Cairo, Egypt

*Corresponding Author: alaa-elfar@hotmail.com

ARTICLE INFO
Article History:  
Received: Dec. 12, 2023  
Accepted: Dec. 26, 2023  
Online: Dec. 30, 2023

Keywords:  
Freshwater fish,  
Smoked fish,  
Quality criteria,  
Lake Nasser

ABSTRACT
The effect of hot smoking conditions was investigated on the chemical composition and quality criteria of six fish species collected from Lake Nasser, Egypt. The results revealed that fresh Oreochromis niloticus, Lates niloticus, Hydrocynus forskalii, Alestes dentex, Mormyrus spp. and Chrysichthys spp. contained 79.39, 78.46, 75.83, 74.95, 69.48 and 70.79% of moisture, 17.72, 19.16, 19.24, 18.57, 16.63 and 15.82% of crude protein, 1.33, 0.84, 3.62, 5.18, 9.52 and 8.90% of lipids, 1.04, 1.16, 1.02, 1.17, 3.85 and 3.76% of ash content, respectively. Additionally, the values of their quality criteria; total volatile basic nitrogen (TVB-N) and thiobarbituric acid reactive substances (TBARS), pH and microbial load were within the international recommended limits. After the hot smoking process, these values underwent marked changes according to fish species investigated and the reduction rates of weight recorded of 40.63, 39.81, 36.65, 35.92, 39.56 and 37.84%, respectively. In addition, values of TVB-N and TBARS increased, while pH values and microbial load decreased in smoked samples. Both E. coli and salmonella spp. were not detected in raw and smoked samples. Sensory evaluation showed that smoked H. forskalii and A. dentex fish were better than others. In general, based on the results obtained, the values of moisture content and microbial load decreased, while crude protein, lipids, ash, TVN and TBARS increased in all smoked fish samples.

INTRODUCTION
Lake Nasser is the most important fishery in Upper Egypt, providing important sources of income and livelihood for fishers, traders and processors in Aswan Governorate (Nasr-Allah et al., 2016). In addition, it has a diverse fishery with 52 fish species belonging to 15 families (van Zwieten et al., 2011). Fish and its products are one of the most important foods due to their high digestibility, nutritional value and minerals, such as phosphorus, calcium, magnesium, etc. Furthermore, fish harvesting, handling,
processing and distributing provide livelihood for people, as well as economic benefits for many countries (Abisoye et al., 2011; Sarower-E-Mahfuj et al., 2012). However, fish are a perishable food material that deteriorates soon after harvest at high ambient temperature (Aberoumand, 2010). Therefore, it should be preserved by using chilling, freezing, salting, drying, smoking, canning and biopreservation methods (Asiedu & Sanni, 2002).

Concerning fish smoking, smoking is one of the oldest methods used to process and preserve fish. Smoked fish is a traditional part of the diet of a large section of the world’s population. However, the gap between the demand and supply of fish is widening due to the increase in population, poor postharvest handling, low facilities of processing and storage, and utilization of unconventional fish species. Additionally, smoking method varies between different countries and within the same country, and it depends on the species of fish used and the type of product desired. Besides, smoking can inhibit the formation of toxins in products, reduce the growth of bacteria, and also change the color and flavor of fish (Swastawati et al., 2000; University of Florida, 2004; Visciano et al., 2008). The quality of smoked fish is affected by processing conditions (Duffes, 1999), raw material (Cardinal et al., 2001), smoking method (Cardinal et al., 2006), smoke agent (Siskos et al., 2007) and storage conditions in addition to salting method (Alcicek & Atar, 2010). Therefore, this work was performed to investigate the effect of hot smoking conditions on the chemical composition and quality criteria of some fish species obtained from Lake Nasser, Egypt.

**MATERIALS AND METHODS**

**Fish samples**

About 5kg of each six freshwater fish species were purchased from the fishermen in Lake Nasser (Landing site), Egypt. The average (mean ± SE) length and weight of fish species were 26.20± 0.37cm and 372.4± 22.57gm for the Nile tilapia (Oreochromis niloticus), 34.11± 0.52cm and 428.50± 22.62gm for the Nile perch (Lates niloticus), 35.04± 0.28cm and 299.60± 13.84gm for Tiger fish (Hydrocynus forskailii), 33.13± 0.42cm and 284.80gm for Characin (Alestes dentex), 36.38± 0.52cm and 358.40± 19.63gm for bottle nose (Mormyrus spp.), and 25.32± 0.19cm and 252.10± 7.28gm for
claroteid catfish (*Chrysichthys* spp.), respectively. They were transferred in icebox, gutted and carefully washed with tap water. Scales and viscera were manually removed.

**Edible salt**

Edible salt (Sodium chloride) packets were purchased from a local market.

**Sawdust**

Sawdust wood pieces used to produce smoke are acacia wood, it is available to fishing boat makers.

**Packaging materials**

Polyethylene bags were purchased from a local market.

**Salting and drying processes**

Cleaned gutted fish samples were immersed in 15% salt solution for 1h at ambient temperature (29.0° C) in Misr-Aswan Company for Fishing and Fish processing. After salting, samples were carefully washed with tap water to remove the excessive salt and partially dried for 2h under ambient conditions.

**Hot smoking process**

Salted fish species samples were hot smoked in stainless steel smoking chamber (dimensions; 2m height×70cm length×60cm width), 4 shelves, hooks and ironed-fire box (50×50×50cm) connected to smoking chamber by flexible tube. Furthermore, its capacity is approximately 50kg of fish. Hot smoking process could be divided into three stages: preliminary drying and smoking at 40°C for 2h, drying and smoking at 55- 60°C for 2h, and cooking at 85°C for 1h. Subsequently, all smoked fishery products were left at ambient conditions to cool and packed in polyethylene bags.

**Analytical methods**

Chemical composition (moisture, crude protein, lipid, ash, sodium chloride and carbohydrates content) of raw and smoked fish products were determined according to the official method of analysis of the AOAC (2000).

**Quality criteria**

The pH value of fish samples was measured using a digital pH meter, following the method outlined by *Zaika et al.* (1976). Total volatile basic nitrogen (TVB-N) content was determined according to the recommended method outlined by AOAC (2000). Thiobarbituric acid reactive substances (TBARS) value was determined
according to the guidelines of Vyncke (1970). TBARS value was calculated using the following formula: mg Malondialdehyde/kg of sample = 7.8× O.D. at 538nm.

**Microbiological examination**

Total bacterial count was determined according to the guidelines of ICMSF (1998) using nutrient agar medium. Inoculated dishes were incubated at 37°C for 2-3 days. 

*Escherichia coli* count was done using MacConkey agar, and the plates were incubated at 37°C for 24h. Colonies with pinkish red growth having a metallic sheen or reflection confirm the presence of *E. coli*. *Salmonella* count, and samples for detection of *salmonella* were plated out on brilliant green agar. The plates were incubated at 37°C for 24h, and reddish white colonies with a pinkish zone confirmed the presence of *Salmonella* spp.

**Sensory evaluation**

Sensory attributes score for smell, texture, taste, appearance and overall acceptability were evaluated, following the method of Afolabi *et al.* (1984) for each product by 15 panelists of Misr-Aswan Company for Fishing and Fish processing, using a five points hedonic scale with five representing liked extremely and one representing disliked extremely.

**Statistical analysis**

The results obtained were statistical analyzed according to Statistical Package for the Social Sciences (SPSS), Ver. 20.

---

**RESULTS AND DISCUSSION**

**Proximate composition**

Data presented in Table (2) show the proximate composition of raw fish and hot-smoked fish samples. *O. niloticus*, *L. niloticus*, *H. forskalii*, *A. dentex*, *Mormyrus* spp. and *Chrysichthys* spp. contained 79.39, 78.46, 75.83, 74.95, 69.48 and 70.79% of moisture, 17.72, 19.16, 19.24, 18.57, 16.63 and 15.82% of crude protein, 1.33, 0.84, 3.62, 5.18, 9.52 and 8.90 of lipids, 1.04, 1.16, 1.02, 1.17, 3.85 and 3.76% of ash content, respectively. It could be observed that, the *O. niloticus* had the highest moisture content, while the *Mormyrus* spp. had the lowest moisture content; which might be due to lipid content, and this
confirms the inverse relationship between moisture and fat content in fish flesh. Similar trends were reported in the studies of Rahman et al. (1995), Owaga et al. (2010), Adedeji et al. (2014), Koral et al. (2015) and Mostafa et al. (2023).

Table 1. Chemical composition (mean, ww) of raw and smoked fish products

<table>
<thead>
<tr>
<th>Fish species</th>
<th>Item</th>
<th>Chemical composition</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Moisture %</td>
</tr>
<tr>
<td>O. niloticus</td>
<td>Fresh</td>
<td>79.39</td>
</tr>
<tr>
<td></td>
<td>Smoked</td>
<td>37.64</td>
</tr>
<tr>
<td>L. niloticus</td>
<td>Fresh</td>
<td>78.46</td>
</tr>
<tr>
<td></td>
<td>Smoked</td>
<td>37.78</td>
</tr>
<tr>
<td>H. forskalii</td>
<td>Fresh</td>
<td>75.83</td>
</tr>
<tr>
<td></td>
<td>Smoked</td>
<td>39.22</td>
</tr>
<tr>
<td>A. dentex</td>
<td>Fresh</td>
<td>74.95</td>
</tr>
<tr>
<td></td>
<td>Smoked</td>
<td>38.73</td>
</tr>
<tr>
<td>Mormyrus. spp.</td>
<td>Fresh</td>
<td>69.48</td>
</tr>
<tr>
<td></td>
<td>Smoked</td>
<td>32.08</td>
</tr>
<tr>
<td>Chrysichthys spp.</td>
<td>Fresh</td>
<td>70.79</td>
</tr>
<tr>
<td></td>
<td>Smoked</td>
<td>31.11</td>
</tr>
</tbody>
</table>

Samples of H. forskalii had the highest crude protein, while the Chrysichthys spp. had the lowest content than others. The results of crude protein content are in accordance with those reported by Jim et al. (2017). Concerning variation lipid content, our results coincidewith those of Steffens (2006); the lipid content depending on species, size and nutrition the lipid level of the flesh in freshwater fish can vary considerably. Samples of Mormyrus spp. had the highest ash, while the H. forskalii had the lowest ash content compared to others. These results are harmonized with those of Sigurgisladottir et al. (2000), Kumolu-Johnson et al. (2010), Adedeji et al. (2014), Al-Reza et al. (2015), Amos and Paulina (2017) and Mostafa et al. (2023), who reported that chemical composition of fish varied according to size, sex, season of the year, genetic makeup, feed intake, metabolic efficiency and environment. Additionally, Okeyo et al. (2009) found that proximate composition of the Nile perch (L. niloticus) was 78.5– 79.5% of moisture, 17.7– 19.8% of crude protein, 0.59– 0.63% of lipid, and 0.5– 0.63% of ash content. With regard to the effect of hot smoking on the proximal analysis, smoked O. niloticus, L. niloticus, H. forskalii, A. dentex, Mormyrus spp. and Chrysichthys spp. samples contained 37.64, 37.78, 39.22, 38.73, 32.08, and 31.11% of moisture, 53.88,
55.47, 49.06, 45.87, 37.23, and 37.48% of crude protein, 4.12, 3.31, 9.24, 12.84, 21.34, and 21.19% of lipids, 3.76, 3.65, 2.68, 2.97, 9.62, and 9.31% of ash content, respectively. Smoked *H. forskalii* recorded the highest moisture (39.22%) after hot smoking, while the *Chrysichthys* spp. showed the lowest moisture (31.11%) than others. The moisture content percentage differences between species may be traced back to certain factors, including size, sex, feed intake, genetic makeup, metabolic efficiency, and season of the year. These results are in line with the results reported by Amos and Paulina (2017). On the other hand, samples of *L. niloticus* exhibited the highest protein (55.47%), while *Mormyrus* spp. had the least protein (37.23%). An increase in protein content of smoked samples may be due to product dehydration which concentrated the protein during the heat temperature, thus increasing the nutritive value of the fish. Similar findings have been detected in the studies of Kumolu-Johnson et al. (2010) and Amos and Paulina (2017). *Mormyrus* spp. had the highest fat (21.34%), while the *L. niloticus* displayed the lowest fat (3.31%) compared to others. Fat content increased as a result of heat produced by smoking, resulting in moisture loss, increasing the concentration of nutrient in the remaining mass of fat as related to lipid oxidation, which produced volatile compounds of the fish samples. These findings concur with those reported by Salán et al. (2006); during fish smoking and sun drying fish lose its moisture content, which results in an increase in the concentration of nutrient in the remaining mass of fats. It was noticed that, *Mormyrus* spp. had the highest ash content (9.62%), while the *H. forskalii* had the lowest ash content (2.68%) than others. Furthermore, the ash content increased in all smoked fish samples. This could be attributed to factors such as fish species, season, sex, and food availability, as reported by Bilgin et al. (2008). Additionally, the increase in ash content may be associated with an increase in the dry matter content followed by dehydration during salting and smoking processes.

**Weight loss%**

Table (2) displays the initial average weight of raw fish samples; *O. niloticus, L. niloticus, H. forskalii, A. dentex, Mormyrus* spp. and *Chrysichthys* spp. were 372.44, 428.50, 299.63, 284.81, 358.38 and 252.13g, respectively, and the reduction rates of weight recorded were 40.63, 39.81, 36.65, 35.92, 39.56 and 37.84%, respectively. The
smoked *O. niloticus* samples exhibited the highest loss, while *A. dentex* samples experienced the lowest loss. This loss% is due to the gutting, loss in water content as affected by salting, partially drying and smoking.

### Table 2. Effect of hot smoking on weight loss% of fish samples

<table>
<thead>
<tr>
<th>Fish species</th>
<th>Fish no.</th>
<th>Initial weight (g)</th>
<th>Final weight (g)</th>
<th>Loss %</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Oreochromis niloticus</em></td>
<td>16</td>
<td>372.4±22.57</td>
<td>221.1±13.26</td>
<td>40.63±0.22</td>
</tr>
<tr>
<td><em>Lates niloticus</em></td>
<td>16</td>
<td>428.5±22.62</td>
<td>257.9±12.77</td>
<td>39.81±0.22</td>
</tr>
<tr>
<td><em>Hydrocynus forskalii</em></td>
<td>16</td>
<td>299.6±13.84</td>
<td>189.8±8.32</td>
<td>36.65±0.24</td>
</tr>
<tr>
<td><em>Alestes dentex</em></td>
<td>16</td>
<td>284.8±16.03</td>
<td>182.5±9.84</td>
<td>35.92±0.43</td>
</tr>
<tr>
<td><em>Mormyrus spp.</em></td>
<td>16</td>
<td>358.4±19.63</td>
<td>216.6±11.91</td>
<td>39.56±0.15</td>
</tr>
<tr>
<td><em>Chrysichthys spp.</em></td>
<td>16</td>
<td>252.1±7.28</td>
<td>156.7±4.16</td>
<td>37.84±0.27</td>
</tr>
</tbody>
</table>

These results are in line with those of Sigurgisladottir *et al.* (2000), Magawata and Musa (2015) and Amos and Paulina (2017), who reported that the yield and quality of the final product are based on species, weight, smoking time, temperature, heat source, evaporation of water content of fish. However, our results showed values of moisture contents significantly lower than the recommended value (65%) for smoked fish, as reported by Cardinal *et al.* (2001).

### Some quality criteria

Total volatile basic nitrogen (TVB-N) is one of the most widely used measurements of seafood quality and is thought to be an important parameter for determining the freshness of fish products (Huss, 1995). The effect of hot smoking on some quality criteria of fish species are shown in Table (3).
Table 3. Mean of some chemical parameters and pH value of raw and smoked fish flesh

<table>
<thead>
<tr>
<th>Fish species</th>
<th>TVB-N (mg/100g)</th>
<th>TBARS (mg MDA/kg)</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Raw</td>
<td>Smoked</td>
<td>Raw</td>
</tr>
<tr>
<td><em>Oreochromis niloticus</em></td>
<td>14.83</td>
<td>18.39</td>
<td>0.39</td>
</tr>
<tr>
<td><em>Lates niloticus</em></td>
<td>13.74</td>
<td>19.11</td>
<td>0.32</td>
</tr>
<tr>
<td><em>Hydrocynus forskalii</em></td>
<td>15.12</td>
<td>19.68</td>
<td>0.52</td>
</tr>
<tr>
<td><em>Alestes dentex</em></td>
<td>14.45</td>
<td>17.66</td>
<td>0.48</td>
</tr>
<tr>
<td><em>Mormyrus spp.</em></td>
<td>14.92</td>
<td>19.35</td>
<td>0.51</td>
</tr>
<tr>
<td><em>Chrysichthys spp.</em></td>
<td>14.30</td>
<td>19.14</td>
<td>0.43</td>
</tr>
</tbody>
</table>

Values of TVN in raw *O. niloticus*, *L. niloticus*, *H. forskalii*, *A. dentex*, *Mormyrus* spp. and *Chrysichthys* spp. samples were 14.83, 13.74, 15.12, 14.45, 14.92 and 14.30mg/100g, respectively, and increased in smoked fish samples to 18.39, 19.11, 19.68, 17.66, 19.35 and 19.14mg/100g, respectively. According to EEC (1995), the TVB-N values of fresh fish are much lower than the acceptable upper limits of 25–35mg/100g for some fish species. An increase in TVB-N after hot smoking is related to bacterial spoilage (Connell, 1995) and the endogenous proteases and microbial contamination are the main sources causing the increase in TVB-N value during the preservation and processing of fish and fish products. Furthermore, these results are in agreement with the findings of Zhang et al. (2013). The increment in TVN content in smoked fish products compared to raw fish is in agreement with the findings of Mostafa et al. (2023). The TBA index is widely used as an indicator of the degree of lipid oxidation. Based on data presented in Table (3), TBA values of raw *O. niloticus*, *L. niloticus*, *H. forskalii*, *A. dentex*, *Mormyrus* spp., and *Chrysichthys* spp. samples were 0.39, 0.32, 0.52, 0.48, 0.51, and 0.43mg MDA/kg and increased in smoked samples to 0.82, 0.77, 0.89, 0.82, 0.96 and 0.91mg MDA/kg sample, respectively. An increase in TBA value in smoked samples may be attributed to the partial dehydration of fish and oxidation of unsaturated fatty acids as a result of smoking at relatively high temperatures. These results are in accordance with Bilgin et al. (2008) and Mostafa et al. (2023). Additionally, Table (3) shows the pH values of raw *O. niloticus*, *L. niloticus*, *H. forskalii*, *A. dentex*, *Mormyrus* spp. and *Chrysichthys* spp. samples were 6.73, 6.84, 6.71, 6.83, 6.75, and 6.88, and they decreased slightly to 6.41,
6.45, 6.39, 6.52, 6.47, and 6.58 in smoked fish samples, respectively. The decrease in pH values after smoking is due to the degradation of proteins and amino acid. Furthermore, a relationship exists between pH values and acidity, possibly attributed to lactic acid oxidation and the presence of phenolic compounds of smoke. These results agree with those of da Silva et al. (2008) and Mostafa et al. (2023).

**Microbial load**

Results presented in Table (4) show the total plate count (TPC), E. coli and Salmonella spp. of raw and smoked O. niloticus, L. niloticus, H. forskalii, A. dentex, Mormyrus spp. and Chrysichthys spp. samples. The TPC recorded values of 4.4, 4.6, 3.9, 3.7, 4.8, and 4.9×10^3 cfu/ g, respectively. The TPC of Chrysichthys spp. sample was recorded the highest, while it was the lowest for A. dentex sample compared to other species. However, these results are within the International Commission on Microbiological Specification for food (ICMSF, 1998); the maximum recommended bacteria count for good quality product is 5.0×10^5 cfu/ g. Furthermore, NFSA (2021) reported that the average of TPC in fresh fish is 10^5-10^6 cfu/ g sample. The total bacterial count of some fish species varied from 10^5–10^8 cfu/ g (Shinkafi & Ukwaja, 2010; Ajayi, 2012; Adedeji et al., 2014; Adeyeye et al., 2015). Our data of TPC follow atrend similar to the results obtained by Mostafa et al. (2023). Variation in TPC of raw fish samples may be due to water conditions and temperature, the method of catch, poor handling, using dirty canoes, equipment, fish boxes and basket, washing fish in dirty water, and placing fish on dirty surfaces (Chytiri et al., 2004; Diei-Ouadi & Mgawe, 2011).

In addition, Table (3) shows that E. coli and Salmonella spp. were absent in all raw fish samples. These results agree with the finding of Chattopadhyay (2000); E. coli including other coliforms and bacteria as Staphylococcus spp. and sometimes enterococci are commonly used as indices of hazardous conditions during processing of fish. E. coli and Salmonella spp. are fecal borne pathogens, and they could occur as a result of contamination from the handlers. Fish harvested from contaminated water can harbor Salmonella spp. (Alexander & Austin, 1986). On the other side, smoked O. niloticus, L. niloticus, H. forskalii, A. dentex, Mormyrus spp. and Chrysichthys spp. samples contained 2.1, 2.6, 2.3, 2.1, 2.9, and 2.7×10^2 cfu/ g, respectively. The TPC (2.9×10^2 cfu/ g) in
smoked *Mormyrus* spp. was recorded the highest, while it was the lowest (2.1×10²cfu/ g) in smoked *A. dentex* and *O. niloticus* than other species.

**Table 4.** Microbiological analysis (cfu/ g) of raw fish and smoked samples

<table>
<thead>
<tr>
<th>Species</th>
<th>TPC</th>
<th>E. coli</th>
<th>Salmonella spp.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Raw</td>
<td>Smoked</td>
<td>Raw</td>
</tr>
<tr>
<td><em>O. niloticus</em></td>
<td>4.4 × 10⁴</td>
<td>2.1 × 10²</td>
<td>Absent</td>
</tr>
<tr>
<td><em>L. niloticus</em></td>
<td>4.6 × 10⁴</td>
<td>2.6 × 10²</td>
<td>Absent</td>
</tr>
<tr>
<td><em>H. forskalii</em></td>
<td>3.9 × 10³</td>
<td>2.3 × 10²</td>
<td>Absent</td>
</tr>
<tr>
<td><em>A. dentex</em></td>
<td>3.7 × 10³</td>
<td>2.1 × 10²</td>
<td>Absent</td>
</tr>
<tr>
<td><em>Mormyrus</em> spp.</td>
<td>4.8 × 10³</td>
<td>2.9 × 10²</td>
<td>Absent</td>
</tr>
<tr>
<td><em>Chrysichthys</em> spp.</td>
<td>4.9 × 10³</td>
<td>2.7 × 10³</td>
<td>Absent</td>
</tr>
</tbody>
</table>

These results are lower than the results obtained by Adelaja *et al.* (2013), Akinwumi and Adegbeheingbe (2015) and Oranusi *et al.* (2018); TPC ranged 4.9×10⁴ – 4.0×10⁶ in smoked fish, they are within the limits according to the International Commission on Microbiological Specification for Food (ICMSF, 1998; NFSA, 2021), and the maximum recommended bacteria count for good quality product is 5.0×10⁵cfu/ g. *E. coli* and *Salmonella* spp. were absent in smoked fish samples too. This may be caused due to quality of fresh fish, salting period, partial drying and high temperature during hot smoking. The absence of *E. coli* and *Salmonella* spp. in smoked samples may be attributed to the effects of salting, dehydration, and heating during hot smoking. The results agree with the outcomes of da Silva (2002), who reported low water activity, absence of moulds, low microbial loads, and better shelf-stability when smoked fish were treated with salt. Furthermore, Salihu-Lasisi *et al.* (2013) recommended that the processed fish should be exposed to a drying temperature that will provide insufficient moisture content for the growth of micro-organisms. The absence of both *E. coli* and *Salmonella* spp. in all raw and smoked fish products in this work agrees with the guidelines of the NFSA (2021).
Sensory attributes

In this experiment, a comparison between six fish species from Lake Nasser was carried out using hot smoking method. To evaluate the good quality for the final product, sensory attributed were evaluated using a hedonic score of 5 points, considering a taste panel test that was also conducted. Indicators taken into account for fixing the quality of the finished product were taste, texture, smell, and appearance, besides the general acceptability. Fig. (1) shows the scores of sensory attributes given by panelists of hot smoked products processed from the Nile tilapia (O. niloticus), the Nile perch (L. niloticus), tiger fish (H. forskali), characin (A. dentex), bottle nose (Mormyrus spp.) and claroteid catfish (Chrysichthys spp.). It was observed that, the taste scores were 4.57, 4.00, 4.21, 4.70, 3.84, and 3.88, respectively. Texture scores were 4.14, 4.00, 4.14, 4.40, 4.20, and 4.00, smell scores were 3.29, 3.38, 3.79, 4.00, 3.62, and 3.38, moreover the total average degrees were 3.95, 3.67, 4.05, 4.32, 3.86, and 3.72, respectively. Based on those results, it could be concluded that, smoked tiger fish and characin were the best among other species. In this study, the TVB-N content is within the acceptable quality and it can be used to support of sensory scores, as reported in the study of Koral et al. (2015).

Fig. 1. Sensory attributes of hot smoked fish samples

CONCLUSION

In conclusion, the process of hot smoking caused a decrease in values of moisture content and microbial load. However, crude protein, lipids, ash, TVN, and TBA increased
compared with raw fish samples. Furthermore, no pathogen microbes indicated that raw and smoked fish samples are of a high quality, safety, and fitting for human consumption.

ACKNOWLEDGEMENT

This publication was undertaken in the framework of Youth Employment in Aswan Governorate project, funded by the Swiss Agency for Development and Cooperation (SDC). The current research is a contribution to the CGIAR Research Program on Fish Agri-Food Systems (FISH).

REFERENCES


Cardinal, M.; Cornea, J.; Se’rot, T. and Baron, R. (2006). Effects of the smoking process on odour characteristics of smoked herring (Clupea harengus) and relationships with phenolic compound content. Food Chemistry, 96, 137-146.


mediterraneus, Steindachner, 1868) at frozen storage (-20±2°C). Turkish J. Fisheries and Aquatic Sciences, 15: 495-504.


