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EFFECTS OF DRYING METHODS ON PHYSICO-CHEMICAL, MICROBIOLOGICAL AND SENSORY PROPERTIES OF TORPEDO SCAD (*Megalaspis cordyla*)

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ABSTRACT

Generally, fish are unhygienically sun dried, which causes the considerable reduction of quality and safety of the product. The effects of drying methods on physico-chemical, microbiological, and sensory properties of *Megalaspis cordyla* were investigated. Fish were dried using traditional (without pre-treatment), improved (treated with 5% salt solution), improved-TC (treated with 5% salt solution and rubbed with turmeric and chili powder) and solar tunnel (treated with 5% salt solution) drying methods. Sensory evaluation revealed that solar-dried products showed comparatively better quality than the products produced by other drying methods. Rehydration ability of solar dried products was comparatively higher than other dried products. Moisture content of dried *M. cordyla* was ranged from 16.28% to 21.30%. However, no significant ($p > 0.05$) variation was found in protein, lipid and ash content on dry matter basis. Significantly ($p < 0.05$) the lowest peroxide value, acid value and carbonyl value were observed in solar dried products. In contrast, comparatively higher amount of PUFAs were found in solar dried products followed by improved, improved-TC and traditionally produced dried fish. The aerobic plate count of dried *M. cordyla* varied between 2.04 log CFU/g and 5.71 log CFU/g. Results of this study suggested that the dried fish produced by solar tunnel drying method showed comparatively better quality than other drying methods for the consumer's safety.

Keywords: *Megalaspis cordyla*, drying methods, sensory properties, chemical composition, fatty acid, lipid oxidation

INTRODUCTION

Sun drying is a traditional and important processing method to preserve seafood since ancient times. Different drying methods have different effects on dried fish. During the drying process, seafood is exposed to light, heat, and air, which can affect the nutritional quality of the product. For domestic market, about 20% of the artisanal catch is being dried by traditional sun drying method **(Hasan *et al.*, 2016a)** and Bangladesh earns 425.20 million BDT of foreign currency by exporting 3143.93 metric ton of dried fish in the year of 2017-18 **(DoF, 2018).** However, sensory and nutritional quality of those dried products are not satisfactory for human consumption due to unhygienic processing and handling of fish, inappropriate drying methods and time, insects' infestation, microbial and fungal growth, indiscriminate use of various types of pesticides, improper storage and lipid oxidation of dried fish **(Reza *et al.*, 2005; Chaijan *et al.*, 2006; Hasan *et al.*, 2016b; Rasul *et al*, 2020)**.
Lipids of marine fish are rich in n-3 long chain polyunsaturated fatty acids (**Aidos *et al*, 2002; Passi *et al*, 2002**) are very prone to oxidation that is also favored by sun drying. Lipid oxidation has an important role to change the quality and safety of products. Besides, lipid oxidation products have adverse effects on human body **(Larsson *et al*., 2015; Bellanti *et al*., 2017)**. Now-a-days, people are more concerned about the health and nutritive value of the food product when they buy them for their consumption **(Hossain *et al.*, 2008; Bhuiyan *et al.*, 2008)**. Therefore, fish processors should be aware about processing time, technique and finally the nutritional quality and safety of the dried products. To improve the quality of dried fish, various drying techniques have been established with diverse pre-treatments. During drying of fish, powdered chili pepper and turmeric powder have been reported to be used against insect infestation **(Nowsad, 2005; Rahman *et al.*, 2017)**. In addition, solar tunnel drying method is used to produce quality dried fish, which do not need any power from electrical grid or fossil fuels **(Nowsad, 2003)**. Different kinds of solar tunnel dryer have been designed and examined for fish drying **(Ogbonnaya, 2009).** Thus, a suitable drying method of fish is crucial to improve nutritional value by retarding the microbial growth and lipid oxidation. Furthermore, it is necessary to ensure quality and safe dried fish for the consumers as well as earning more foreign currencies.
Torpedo scad, *Megalaspis cordyla* (locally known as Kauwa fish) is belongs to the family of Carangidae, mostly found in coastal and marine waters in Bangladesh. The taste of this fish is very poor that is why consumers do not prefer to eat it although the price of this fish is comparatively cheaper than other marine fishes. Generally, many people do not like to eat some marine fish species as fresh but they prefer these fish as dried for its characteristic taste and flavor. So far, there is no dried fishery products prepared from this species. Thus, there is an opportunity to produce dried product of this species that might improve the quality and taste of the final products and it might be a value addition of this species. Therefore, this study was aimed to investigate the effects of drying techniques on the physico-chemical, microbiological and sensory characteristics of *M. cordyla*.

MATERIALS AND METHODS

Fish samples collection

Fresh Torpedo scad, *M. cordyla* (length 25.76 ± 5.32 cm and weight 413.36 ± 9.81 g) were bought from the local fish market, Gazipur, and were brought with proper icing to the Fish Processing Laboratory of Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Gazipur, Bangladesh.

Drying methods

M. cordyla was dried using four different methods of drying- namely traditional sun drying, sun drying on ring tunnel dryer, sun drying on ring tunnel dryer with turmeric and chili powder, and solar tunnel drying, which are designated as traditional, improved, improved-TC and solar, respectively. Fish were dried under sunlight and air during day time (10:00 am to 4:00 pm for 7 days) until the water content was reduced to approximately 16-20% during the month of February, 2019 (average day temperature 24 ˚C). Dried fish were then packaged in an air tight polythene bag and stored at -20 ˚C until further analyses.

a. Traditional sun drying

Fish were dressed and hanged on a rope. In this method, fish were not cleaned and immersed in a salt solution. The dried fish were kept in a low temperature freezer (-20 ˚C) until use.

b. Sun drying on ring tunnel dryer

For the improved sun drying method, ring tunnel dryer was prepared according to **Nowsad (2005)**. Briefly, ring tunnel dryer was made using iron poles and mosquito nets. Before hanging on the ring, fishes were eviscerated, rinsed with clean water and immersed in a solution containing 5% salt for 10 min.

c. Sun drying on ring tunnel dryer with turmeric and chili powder

For this type of sun drying, ring tunnels were prepared as the previous one. In this method, fishes were eviscerated, rinsed with clean water and immersed in a solution containing 5% salt for 10 min, and rubbed with turmeric (0.1%) and chili (0.1%) powder solution. Then, treated fish were hanged in the ring tunnel dryer but no mosquito net was used.

d. Drying in a solar tunnel dryer

Solar tunnel drying is an atmosphere friendly method of fish drying. Solar tunnel dryer was prepared according to the method of **Nowsad (2005)**. The fishes were eviscerated, rinsed with clean water and immersed in a solution containing 5% salt for 10 min. Then the fish was hanged on a solar tunnel dryer.

Determination of sensory characteristics

Sensory characteristics of dried fishes were evaluated by following **Rasul *et al.* (2018)**. Individual sensory booths were used to perform sensory evaluation. Representative dried fish were served to assess the physical characteristics by a panel of 10 members (ages from 22 to 36 years) from the Department of Fisheries Technology of BSMRAU.

Determination of water reconstitution

Water reconstitution behaviors of dried fishes were measured by following **Majumdar *et al.* (2017)**. Briefly, dried fish sample (8-10 g) was dipped in a water bath with varying temperature (ambient temperature (24 ºC to 29 ºC), 40 °C and 60 °C). The dried fish was soaked into water for 60 min. The soaked sample was removed every 15 min and again weighed. The percentage of moisture uptake in rehydrated fish was estimated using the following equation:

$$\text{Water Reconstitution (\%)} = \frac{\text{Wr} - \text{Wi}}{\text{Wi}} \times 100$$

Where, Wi = Weight of the dried sample; Wr = Final weight of the rehydrated sample

pH measurement

For the determination of pH, sample (10 g) was grinded in a blender with 100 ml of deionized water and homogenate was prepared. pH of the homogenate was directly measured using a pH meter (MeterLab PHM 310, China).

Biochemical analysis

Analysis of proximate composition

The proximate composition (moisture, crude protein, crude lipid and ash) was determined following **AOAC (2002)** method.

Extraction of total lipid

Extraction of total lipid from dried fish samples were done by **Bligh and Dyer (1959)** method using a solvent mixture of chloroform: methanol: distilled water (10:5:3). The extracted lipid was redissolved in chloroform and kept at -20 °C for further use.

Acid value measurement

Acid value (AV) was measured using **AOAC (2002)** method. Total lipid (0.5 g) was diluted with a solution of ethanol and diethyl ether (1:1) and potassium hydroxide (0.01 N) was used for titration. The results were reported as mg KOH/g lipid.

Peroxide value determination

The peroxide value (PV) of total lipid was measured using **AOAC (2002)** method. Briefly, 0.5 g of total lipid was diluted with a solution of glacial acetic acid and chloroform (3:2). Saturated potassium iodide (0.5 mL) was mixed to the solution and stored for 10 min at dark condition. Freshly prepared starch solution (1%) and deionized water (30 mL) was added to it and sodium thiosulfate (0.01 N) was used for titration. The PV value was stated as meq/kg of lipid.

Carbonyl value estimation

Carbonyl value (CV) of total lipid was measured following the method of **Endo *et al.* (2003)** with slight modification. A standard curve was prepared using n-octylaldehyde and carbonyl compounds were expressed as µM/g of lipid.

Analysis of fatty acid composition

Total lipids were transformed to fatty acid methyl esters (FAME) by the method of **Prevot and Mordret (1976)**. Briefly, lipids were diluted in *n*-hexane (1 ml), and 2N-NaOH methanolic solution (0.2 ml) was added to it. The mixture was heated for 20 seconds at 50 ºC and then 2N-HCl methanolic solution (0.2 ml) was added. The upper layer, FAME was taken and analyzed on a Gas Chromatograph (GC 353, GL Science Inc., Tokyo, Japan) with a 0.5 µm PEG-20M liquid phase-coated G-300 column (40 m × 1.2 mm i.d.) and quantified by FID detector. The injector, detector and column temperature were 240, 250 and 170 ºC, respectively. The fatty acids were identified by comparison with the retention times of known standards (GL Sciences Inc., Tokyo, Japan).

Aerobic plate count (APC)

APC of bacteria in dried *M. cordyla* fish was estimated using spread plate count technique. Briefly, 10 g dried fish sample was blended with 90 ml of physiological saline (0.85% NaCl) for preparing consecutive decimal dilution. Each dilution of fish homogenate cultured in sterile plate count ager following spread plate method and incubated at 37°C for 24 hours. Bacterial colonies (30-300 colonies) were then counted as cfu/g and converted it as log CFU/g **(Barraw and Feltheam, 1993)**.

Statistical analysis

All the data were reported as mean ± standard deviation (SD). Data were analyzed using ANOVA followed by Duncan's multiple range test using Statistix 10 (Analytical Software, Tallahassee, FL, USA). A significant difference was considered at the level of $p < 0.05$.

RESULTS AND DISCUSSION

Sensory characteristics of dried *M. cordyla*

The sensory characteristics of dried fishery products depends on the freshness of the raw materials. Influence of drying techniques on sensory properties of dried *M. cordyla* is presented in Table 1. Traditionally produced dried fish showed the highest scores ($p < 0.05$) of color, odor and texture when compared with other drying methods. It has been reported that the dried fish having higher sensory scores indicate poor quality **(Rasul *et al.*, 2018)**. In this study, superior quality of dried *M. cordyla* was found in solar dried product followed by improved, improved-TC and traditional dried product. However, there was no insect infestation noticed among all the dried products. Similar findings were also observed in solar dried *Puntius sophore* and *Mystus gulio* than sun-dried products in India **(Nath *et al.*, 2013)**.

Table 1 Effect of drying methods on sensory properties of *M. cordyla*[1]

Treatment	Color	Odor	Texture	Insect Infestation
Traditional	5.30 ± 0.16^{a}	6.30 ± 0.16^{a}	2.25 ± 0.11^{a}	1.00 ± 0.00^{a}
Improved	3.22 ± 0.13^{c}	1.74 ± 0.11^{c}	1.47 ± 0.10^{c}	1.00 ± 0.00^{a}
Improved-TC	4.06 ± 0.11^{b}	2.26 ± 0.18^{b}	1.68 ± 0.12^{b}	1.00 ± 0.00^{a}
Solar	1.20 ± 0.10^{d}	1.32 ± 0.13^{d}	1.24 ± 0.11^{d}	1.00 ± 0.00^{a}

[1]Each value is expressed as a mean (1–10 scoring) ± SD (n = 10). Means with different superscripts within a column are significantly different ($p < 0.05$)

Water reconstitution of dried *M. cordyla*

The water reabsorption of dried *M. cordyla* using various drying process is depicted in Figure 1. The highest water holding capacity was found in solar dried product (57.47%) after 60 min at 60 °C, whereas 40 °C and room temperature showed 55.21% and 53.10% water uptake, respectively. Similarly, the water holding capacity of traditional, improved and improved-TC dried product was found 40.65%, 48.67%, 42.92% after 60 min at ambient temperature, 42.18%, 50.62%, 45.13% at 40 °C and 45.32%, 52.60%, 47.51% at 60 °C, respectively. The water-holding ability of dried fishery product also increased with the increasing of temperature and dipping time **(Majumdar *et al.*, 2018)**. Overall, rehydration rate of solar tunnel dried fishery products was higher than the other dried products. **Akintunde (2008)** found that the cell assemblage of fish muscle enlarged when the water temperature was increased that quickens the speed of water rehydration ability. It has been reported that rehydration capacity positively correlated with the texture of the dried fishery products **(Reza *et al.*, 2005)**. Moreover, water activity impacts the quality of the dried fish and lower water activity value enhances the water uptake capacity. **Sikorski *et al.* (1995)** reported that the water uptake has been completed within 3-15 minutes when the fish dried properly. Furthermore, rehydration ability of the dried fishery products varies with the variation of species besides time and temperature **(Nurullah, 2006; Akintunde, 2008)**.

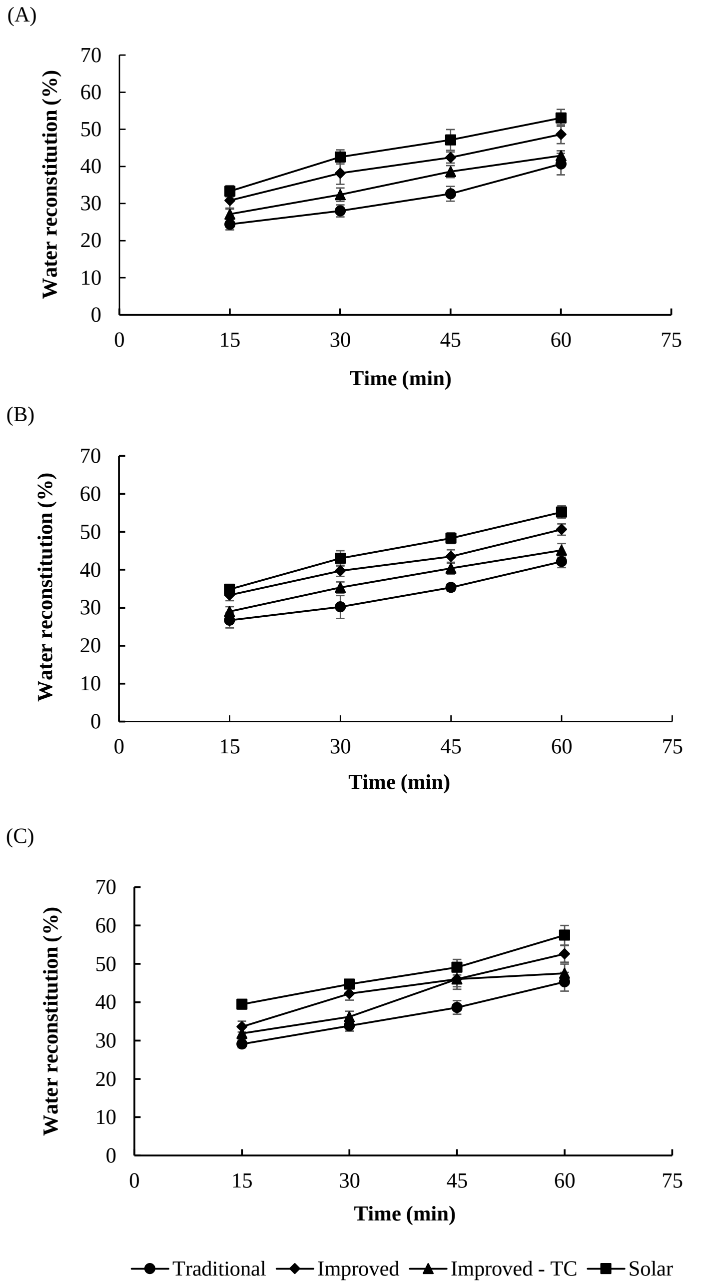

Figure 1 Water reconstitution of dried *M. cordyla* at (A) room temperature (24-29 ºC), (B) 40 ºC and (C) 60 ºC

pH value of dried *M. cordyla*

The pH values of dried *M. cordyla* ranged between 6.65 and 6.96 (Figure 2). Significant ($p < 0.05$) variation was observed in pH values among the dried fish products. The traditional dried fish showed the highest pH value (6.96) and the lowest value (6.65) in solar dried product. It has been reported that during the drying period the pH value was decreased from 6.79 to 6.42 in dried herring fillet **(Shah *et al.*, 2009a)**. In the case of soft dried herring fillets, the pH value was also reduced from 6.50 to 6.35 **(Nakagawa *et al.*, 2007)**. Moreover, traditional air-drying at a comparatively higher temperature is unfavorable to fish muscle and results in changes in pH **(Zyas, 1997)**.

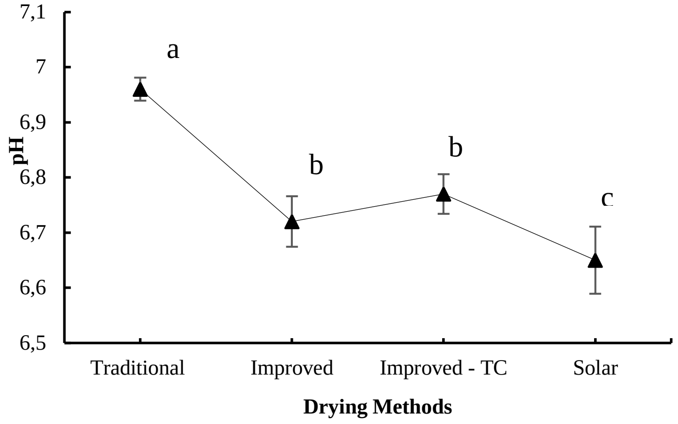

Figure 2 pH value of *M. cordyla* in different drying methods. Each value is expressed as a mean ± SD (n = 3). Means with different superscripts are significantly different ($p < 0.05$).

Proximate composition of dried *M. cordyla* (on fresh matter basis)

Effects of various drying process on proximate composition of *M. cordyla* are depicted in Table 2. The moisture content varied from 16.28% to 21.30%. The amount of crude protein ranged from 61.67% to 65.17% and the highest value ($p < 0.05$) was found in solar dried product and the lowest value was observed in traditionally dried product. The crude lipid and ash content were ranged from 6.14% to 6.98% and 7.80% to 10.19%, respectively. Comparatively higher amount of lipid was found in solar dried products that indicate lower oxidation occurred in this method. However, there was no significant ($p > 0.05$) difference observed in crude protein, crude lipid and ash on dry matter. The amount of protein in solar and sun-dried *Hyperopisus bebe* were 59.8% and 62%, respectively **(Ojutiku *et al.*, 2009)**. The findings of this study coincide with the results of **Immaculate *et al.* (2012)** and **Hasan *et al.* (2016a)**.

Table 2 The proximate composition of dried *M. cordyla*[1]

Treatment	Moisture	Protein	Lipid	Ash
Traditional	21.30 ± 0.59^{a}	61.67± 0.96^{c}	6.14 ± 0.14^{c}	7.80 ± 0.20^{d}
Improved	18.41 ± 0.81^{b}	63.53 ± 0.88^{b}	6.59 ± 0.28^{ab}	9.27 ± 0.10^{b}
Improved - TC	20.84 ±1.28^{a}	62.20± 0.72^{bc}	6.25 ± 0.27^{bc}	8.49 ±0.19^{c}
Solar	16.28± 0.50^{c}	65.17 ± 0.86^{a}	6.98 ± 0.21^{a}	10.19 ±0.14^{a}

[1]Each value is expressed as mean ± SD (n = 3). Means with different superscripts (a-c = fresh matter; e = dry matter) within a column are significantly different ($p < 0.05$)

Lipid oxidation of dried *M. cordyla*

The PV of dried *M. cordyla* was varied from 12.86 to 15.40 meq/kg of lipid in various drying techniques (Figure 3). The lowest peroxide value ($p < 0.05$) was found in solar tunnel dried *M. cordyla* and the value was 12.86 meq/kg of lipid. In contrast, the highest peroxide value was ($p < 0.05$) found in traditional dried product (15.40 meq/kg of lipid) followed by improved-TC (15.07 meq/kg of lipid) and improved (14.19 meq/kg of lipid) drying method. All these values were in acceptable limit (the value less than or equal to meq/kg of oil) for human consumption **(Connell, 1995)**. **Shah *et al.* (2009)** revealed that the peroxide value (5.52 meq/kg to11.86 meq/kg) of herring (*Clupea pallasii*) lipids raised with the increasing of drying time. Moreover, lipids were degraded during storage of dried fishes, which effect on fish flavor owing to the presence of PUFAs **(Alasalvar *et al.*, 2005**; **Majumdar *et al.*, 2018)**.

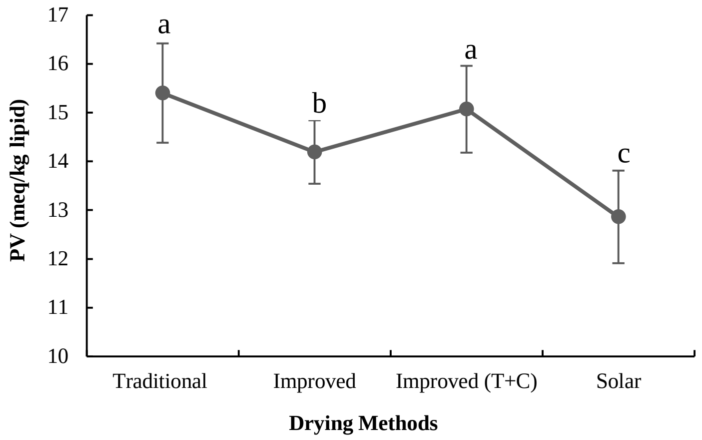

Figure 3 Peroxide value of *M. cordyla* in various drying methods. Each value is expressed as a mean ± SD (n = 3). Means with different superscripts within a line are significantly different ($p < 0.05$)

In addition to peroxide value, acid value was determined to measure the level of lipid hydrolysis in dried fishes. Acid value of traditional, improved, improved-TC and solar tunnel dried *M. cordyla* were 14.82, 12.25, 12.48 and 11.46 mg KOH/g of lipid, respectively (Figure 4). It is known that the higher acid value indicates poor quality of a food product. **Majumdar *et al.* (2017)** observed that the acid value of sun-dried *Wallago attu*, *Channa striatus* and *Glossogobius giuris* was ranged from 16.23 meq/kg to 18.64 meq/kg lipid, which was agreed to the present findings. **Rasul *et al.* (2019)** also observed similar results of peroxide value and acid value in dried *Trichogaster fasciata*. Free fatty acids were usually formed when lipolysis take place in fish muscle lipid **(Pacheco-Aguilar *et al.*, 2000)**. Moreover, oxidation of unsaturated fatty acids develops off-odors and off-flavors, which could deteriorate the nutritional quality and safety of the food product **(Mbunda, 2013)**. The lipid oxidation primary products in fish reduce its protein digestibility **(Boler *et al.*, 2012)**. Formation of secondary oxidation products can cause aging, membrane injury, cardiovascular diseases, atherosclerosis and tumor growth **(Cho, 2005)**.

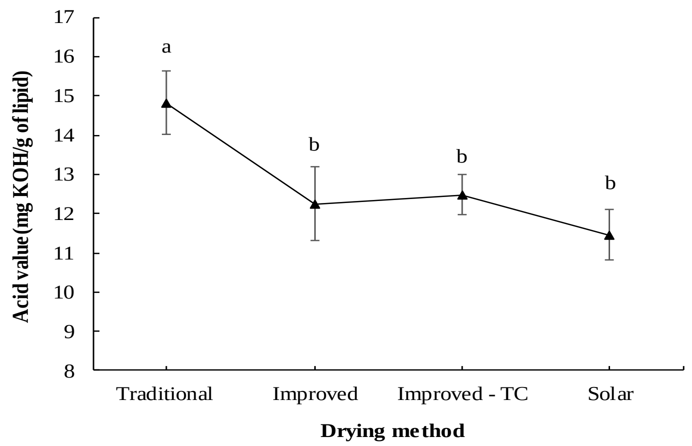

Figure 4 Acid value of *M. cordyla* in various drying methods. Each value is expressed as a mean ± SD (n = 3). Means with different superscripts within a line are significantly ($p < 0.05$) different

CV of dried *M. cordyla* produced by various drying methods is depicted in Figure 5. The CV was varied between 6.21 and 8.22 µM/g of lipid. The highest CV was found in traditional dried product and the lowest value was observed in solar dried product. This result suggested that the lowest oxidation occurred in solar dried fish. However, improved and improved-TC dried product did not show any significant difference. **Shah *et al.* (2009)** reported that the CV of dried herring ranged from 4.66 to 7.27 µM/g of lipid that was agreed to our results.

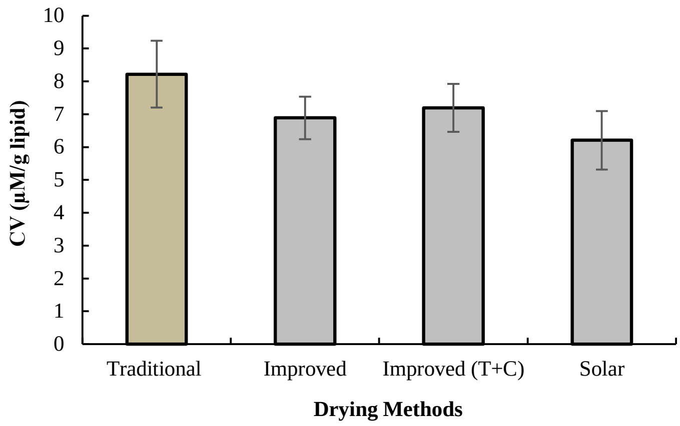

Figure 5 Carbonyl value (CV) of *M. cordyla* in various drying methods. Each value is expressed as a mean ± SD (n = 3)

Fatty acid profile of total lipid in dried *M. cordyla* are presented in Table 3. The dominant fatty acids of lipids were cetoleic acids (22:1n-11), palmitic acid (16:0), stearic acid **(**18:0), oleic acid (18:1n-9) and docosahexaenoic acid (DHA, 22:6n-3). Monounsaturated Fatty Acids (MUFAs) were the major category that varied between 47.33% and 53.83% of total lipid. The PUFAs varied from 26.74-30.45% in which DHA and EPA were prominent. Significantly the highest PUFAs was found in solar dried product and the lowest was found in traditional dried products, which suggested that more lipid oxidation occurred in traditional dried products. **Shah *et al.* (2009)** also observed that PUFAs was reduced due to lipid oxidation during drying of herring fillet. The significant variations of PUFAs in solar dried and experimental dried silverside fish (*Atherina lagunae*) were also influenced by various drying methods **(Selmi *et al.*, 2010)**. Moreover, rough handling, unhygienic processing and storage of fish and fishery products can prompt oxidation of lipid as well as affect the PUFAs that are very sensitive to oxidative rancidity. It has been reported that generation of off-flavor and off-odor in fish muscle might be due to the oxidation of PUFAs, which influence overall sensory properties of fish **(Ramanathan and Das, 1992; Maqsood *et al.*, 2012)**. The findings of this study coincide with the results of **Aro *et al.* (2000)**, who reported that PUFAs of lipids are influenced by season and processing of Baltic herring.

Table 3 Changes in fatty acid composition (mg/g dry matter) of total lipids in *M. cordyla* in various drying methods

Fatty acid	Drying methods			
	Traditional	**Improved**	**Improved-TC**	**Solar**
14:0	1.67 ± 0.16^{c}*	2.10 ± 0.33^{b}	2.06 ± 0.07^{b}	3.09 ± 0.02^{a}
16:0	9.59 ± 0.13^{b}	9.28 ± 1.42^{ab}	9.77 ± 0.05^{b}	10.32 ± 0.04^{a}
18:0	6.42 ± 0.10^{c}	6.70 ± 0.49^{ab}	6.74 ± 0.04^{b}	7.04 ± 0.02^{a}
20:0	0.19 ± 0.01^{c}	0.32 ± 0.05^{a}	0.26 ± 0.04^{b}	0.27 ± 0.01^{b}
Σ saturated	17.87 ± 0.33^{bc}	18.40 ± 2.29^{b}	18.83 ± 0.08^{b}	20.72 ± 0.02^{a}
14:1n-9	0.52 ± 0.01^{a}	0.40 ± 0.12^{a}	0.18 ± 0.02^{b}	0.16 ± 0.01^{b}
16:1n-9	2.41 ± 0.17^{c}	1.85 ± 0.47^{c}	2.78 ± 0.11^{b}	4.23 ± 0.03^{a}
18:1n-9	5.11 ± 0.09^{b}	5.89 ± 0.83^{b}	6.99 ± 0.11^{a}	7.04 ± 0.03^{a}
20:1n-9	1.47 ± 0.19^{c}	3.44 ± 0.24^{a}	2.90 ± 0.04^{b}	3.32 ± 0.03^{a}
22:1n-11	44.32 ± 1.33^{a}	39.80 ± 5.31^{ab}	37.92 ± 1.31^{b}	32.58 ± 0.33^{c}
Σ monounsaturated	53.83 ± 1.36^{a}	51.38 ± 4.15^{ab}	50.77 ± 1.16^{b}	47.33 ± 0.34^{b}
14:2	0.19 ± 0.02^{c}	0.14 ± 0.11^{c}	0.59 ± 0.01^{a}	0.50 ± 0.01^{b}
16:2	2.16 ± 0.06^{c}	1.63 ± 0.33^{d}	2.53 ± 0.05^{b}	2.92 ± 0.03^{a}
16:3	0.74 ± 0.03^{a}	0.42 ± 0.07^{b}	0.41 ± 0.02^{b}	0.45 ± 0.02^{b}
18:2n-6	0.52 ± 0.03^{c}	0.82 ± 0.24^{ab}	0.71 ± 0.04^{b}	1.00 ± 0.01^{a}
18:3n-6	0.19 ± 0.01^{c}	0.32 ± 0.13^{b}	0.48 ± 0.09^{ab}	0.61 ± 0.10^{a}
18:4n-3	0.23 ± 0.01^{c}	0.29 ± 0.05^{bc}	0.32 ± 0.02^{b}	0.66 ± 0.06^{a}
20:3n-6	0.96 ± 0.06^{a}	0.49 ± 0.13^{d}	0.88 ± 0.01^{b}	0.73 ± 0.02^{c}
20:4n-6	1.26 ± 0.14^{b}	2.21 ± 0.19^{a}	1.29 ± 0.05^{b}	1.31 ± 0.02^{b}
20:5n-3	2.29 ± 1.44^{ab}	1.40 ± 0.30^{b}	1.74 ± 0.05^{bc}	2.26 ± 0.06^{a}
22:2	4.37 ± 0.85^{ab}	6.19 ± 1.27^{a}	3.30 ± 0.10^{bc}	3.29 ± 0.02^{c}
22:3	0.88 ± 0.05^{a}	0.92 ± 0.20^{a}	0.92 ± 0.03^{a}	0.95 ± 0.02^{a}
22:4n-6	3.61 ± 0.84^{ab}	4.32 ± 0.34^{a}	4.14 ± 0.29^{a}	3.31 ± 0.12^{b}
22:6n-3	9.34 ± 0.31^{b}	9.43 ± 1.76^{b}	11.44 ± 0.18^{b}	12.46 ± 0.15^{a}
Σ polyunsaturated	26.74 ± 1.67^{bc}	28.58 ± 1.83^{ab}	28.48 ± 0.86^{b}	30.45 ± 0.36^{a}
Others	1.56 ± 0.16^{ab}	1.64 ± 0.27^{ab}	1.92 ± 0.29^{a}	1.50 ± 0.03^{b}

*Different characters in the same row denote significantly different ($p < 0.05$)

Microbial load of dried *M. cordyla*

Quantitative microbiological analysis is a good indicator to determine the dried fish quality. The APC was varied from 2.04 to 5.71 log CFU/g in the dried fish produced by different drying methods (Figure 6). Traditional dried product showed the highest ($p < 0.05$) APC and the lowest APC was observed in solar dried product. The standard APC for fresh fish is 7 log CFU/g **(Ojagh *et al.*, 2010)**. **Mansur *et al.* (2013)** found that the APC of sun-dried fish was varied from 1.84 to 5.3 log CFU/g. Moreover, it has been reported that the APC of some solar dried marine fish products were ranged between 3.27 and 4.49 log CFU/g **(Reza *et al.*, 2009)**.

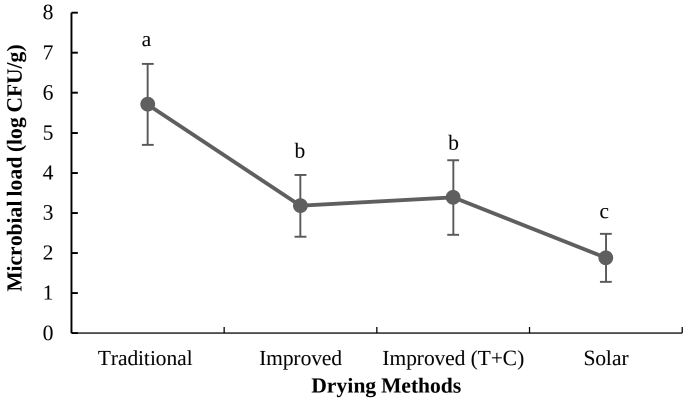

Figure 6 Microbial load of dried *M. cordyla*. Each value is expressed as a mean ± SD (n = 3). Means with different superscripts within a line are significantly (p < 0.05) different

CONCLUSION

The biochemical quality of dried torpedo scad was varied with the variation of drying process. Sensory characteristics, water reconstitution, pH, proximate composition, lipid quality and bacterial count were highly acceptable for the solar dried fish and poor quality was found in traditional dried product. The acceptability of the dried product's quality was solar> Improved > Improved-TC > traditional. Therefore, it can be concluded that solar drying method produced comparatively better quality dried fish than other drying methods.

Conflicts of interest: The authors declare that they have no conflict of interest.

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