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Determination of fish quality in Alexandria small-scale fisheries: A value chain analysis

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ABSTRACT

The Egyptian Mediterranean fisheries sector is a critical contributor to the country's economy, with fish exports accounting to approximately 40% of the total agricultural exports. This sector also plays a vital role in providing employment opportunities, particularly for those living along the Mediterranean coast. However, the sector has been facing various challenges that threaten its sustainability, including overfishing, illegal fishing practices, and environmental degradation. A value chain analysis can help to identify the various stages of the fisheries sector and their interdependencies. In this study, four value chain stages (vessels, wholesalers, retailers, and hypermarkets) were conducted in Alexandria, Egypt, for particular 30 fish species (*Mullus barbatus, Sardinella aurita,* and *Diplodussargus*). To conduct the value chain study in the sampling areas of small-scale fisheries, the following parameters were assessed: total volatile nitrogen (TVN), thiobarbituric acid (TBA), and pH, The results of the TBA tests and TVN analysis revealed notable disparities between the stages. These tests were frequently used to estimate the quality and freshness of fish, and their findings showed that samples with higher concentrations of these substances had more failures. Conclusively, the current study recommended stricter regulations on harvest size restrictions, monitoring programs, certification procedures, postharvest facilities, seasonal closures, social enterprises, finance facilities, and habitat protection as suggested by applying value chain analysis in small-scale fisheries management.

1. INTRODUCTION

Fish is one of the most essential foods, being highly digestible and palatable. It is also recognized to have a greater rate of food conversion than animals that are similar to meat (Folador, J. et al., 2006). In addition, fish oil supplies many essential vitamins, including A, D, and B groups, in addition to calcium, phosphorus, and iodine, it also serves as a good calorie source (Feldhusen, 2000). Lipid (fat or oil), ash (minerals), protein, and water make up the four main components of the edible portion of fish meat.

The process of dissecting fish muscle into its four fundamental components is known as "proximate analysis". Obtaining trustworthy information regarding the proximate composition of the majority of fish species is challenging (Venugopal and Shahidi, 1996; Bandarra et al., 2009). Thus, fish quality for human consumption is evaluated using total volatile nitrogen (TVN), thiobarbituric acid (TBA), and pH testing. Fish pH measurement is crucial because pH fluctuations, particularly abrupt ones, can have detrimental effects on human health or even be fatal to fish (Kelleher, 2004).

Total volatile nitrogen (TVN) serves as a quality parameter for fish meal raw materials. TVN primary components, trimethylamine (TMA) and ammonia (NH3), increase in the presence of fish spoilage. However, when estimating the freshness of fish during the early stages of storage, the analysis of trimethylamine alone is not considered trustworthy, as it only reflects advanced spoilage levels (Baixas-Nogueras et al., 2002).

The research of value chains in the fisheries sector is a systematic approach to analyzing the main components of the production process, particularly in small-scale fisheries, where ways of improving quality and product design are identified. Moreover, data and information needed for management options and measures are provided (Rosales et al., 2017; Sally et al., 2023).

The proposed study aimed to understand and analyze the value chains of fish and fishery products in the Egyptian Mediterranean, with a focus on the small-scale sector, to ascertain the nutritional worth of Mediterranean fish through value chain analysis, which can help identify the different stages of fisheries.

2. MATERIAL AND METHODS

2.1. Collection of samples:

Ninety random specimens of fresh fish, *Mullus barbatus, Sardinella aurita, and Diplodussargus* (30 of each stage), were gathered from distinct stages. The length of specimens ranged from 10 to 20 cm (*Mullus barbatus, Sardinella aurita, and Diplodussargus*). Each specimen was carefully placed in a distinct plastic bag and carefully stored in an ice box before being transported to the laboratory for thorough examination. Tissue samples of each fish specimen were

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extracted using stainless steel instruments on impeccably clean glass working surfaces, following the guidelines set forth by Food and Agriculture Organization (FAO, 1980).

2.2. Sample coding, stages, and species of the chain analysis:

Stages for value chain analysis were coded as the following: Vessels (A); Wholesalers (B); Retailers (C) and Hypermarkets (D). However, the codes for the species under study were *Sardinella aurita* (1); *Mullus barbatus* (2), and *Diplodus sargus* (3).

2.3. Determination of pH:

Around 10 g of the substance was mixed with 10 milliliters of neutralized distilled water in a blender. The resulting homogenate was continuously agitated for 10 minutes at room temperature. The pH value was measured using a Bye model 6020 pH meter from the USA. To calibrate the pH meter, two buffer solutions with known pH values (alkaline pH 7.01 and acidic pH 4.01) were employed. Subsequently, the pH electrode was rinsed with neutralized water and carefully submerged into the homogenate after adjusting the temperature correction system (Pearson, 2006).

2.4. Determination of TVN:

In a clean and dry beaker, the sample (10 g) was mixed thoroughly with distilled water (30 ml) via a blender for 2 minutes. To achieve a pH of 5.2, 0.02M HCl was added in the form of two drops. The resulting homogenate was heated to 70°C, then cooled to room temperature, and subsequently filtered. The outer ring of the Conway unit was precisely filled with 2 ml of the sample extract and 1 ml of saturated potassium carbonate (KCO3). The Conway unit was rotated gently and covered, after which it was incubated at 36°C for 2 hours. The hydrochloric acid (HCl) in the inner ring of the Conway unit was titrated against 0.01M sodium hydroxide (NaOH) by methyl red as an indicator (T1 ml). The calculation for TVN per 100 grams was determined by the formula TVN/100g = 26.88 x (2-T1), where T1 stands for the volume of NaOH consumed during titration (FAO, 1980).

2.5. Determination of TBA:

Determination of the liver lipid peroxidation of liver was determined according to Botsoglou *et al*. 1994.

2.6. Statistical analysis:

Analysis of variance of treatments difference was performed according to Steel and Torrie (Steel R.G. 1980). Statistical analysis was done by ANOVA available within the MSTAT-C software package (2.0 1998). The ANOVA test was used for comparing means of the studied variables and for comparing the studied parameters between different samples. Correlations between studied variables were performed. All data are presented as mean ± SE. A value of $p < 0.05$ was considered statistically significant.

3. RESULTS

3.1. pH, TVN, and TBA of collected *Sardinella aurita* samples

Table (1) unveiled the levels in the explored *Sardinella aurita* specimens from four stages (vessels, wholesalers, retailers, and hypermarkets). The average onboard pH values were 6.17, 6.30, 6.40, and 6.35 for wholesalers; 6.45, 6.5, and 6.40 for retailers; and 6.40, 6.50, and 6.45 for hypermarkets.

The TVN Values fluctuated from 24.5 mg% on average for 24 to 25 mg%, 25.5 mg% on average for wholesalers, 25.2 to 25.6 mg% on average for retailers, and 25.2 to 26 mg% on average for hypermarkets.

The TBA values for divergent sources: vessels (2-2.40 mg%, average 2.21 mg%), wholesale (2.40-2.50 mg%, average 2.44 mg%), retailer (25.2-25.8 mg%, average 2.45 mg%), and hypermarket (2.5-26 mg%, average 2.5 mg%).

Table 1 TVN, TBA, and pH-values for *Sardinella aurita.*

Stages	*TVN* (mg/100 g)	*TBA* (mg MDA /kg)	*pH*
A1	*24.5±0.50*	*2.21±0.87*	*6.17±0.16*
B1	*25.23±0.25*	*2.44±1.09*	*6.35±0.05*
C1	*25.5±0.3*	*2.45±1.07*	*6.4±0.02*
D1	*25.6±0.41*	*2.5±1.06*	*6.45±0.05*

*Values are mean values ± S.D.

3.2. pH, TVN, and TBA of collected *Mullus barbatus* samples

The pH, TVN, and TBA levels in the investigated samples from four stages (vessels, wholesalers, retailers, and hypermarkets) are illustrated in table (2).

The price pH range onboard varied from 6.5 to 6.60, with an average of 6.6. For the wholesaler, it ranged from 6.60 to 6.70, with an average of 6.68. Nonetheless, for the retailer, it differed from 6.70 to 6.78, with an average of 6.69. Lastly, for the hypermarket, it diverged from 6.70 to 6.80, with an average of 6.76.

The TVN levels in the fish samples collected onboard ranged from 0 to 0.5 mg% with an average of 0.3 mg%. The wholesaler's samples exhibited a range of 0.5 to 1 mg% with an average of 0.8 mg%. The retailer's samples showed a range of 1 to 2 mg% with an average of 1.5 mg%. Finally, the hypermarket's samples had a range of 1.8 to 2.1 mg% with an average of 2 mg%.

The TBA values in four stages of varying samples: vessel samples reached 0-0.45 mg% with an average of 0.2 mg%, wholesale amounted to 0.45-0.58 mg% with an average of 0.5 mg%, retailer samples diverged from 0.49 to 0.55 mg% with an average of 0.5 mg%, and hypermarkets differed from 0.55 to 0.80 with an average of 0.6 mg%.

Table 2 TVN, TBA, and pH values for *Mullus barbatus.*

Stages	*TVN* (mg/100 g)	*TBA* (mg MDA /kg)	*pH*
A2	0.26± *0.2*	0.2±*0.2*	6.6±*0.05*
B2	0.76±*0.2*	0.5±*0.06*	6.7±*0.05*
C2	1.5±*0.5*	0.5±*0.03*	6.6±*0.09*
D2	*1.9±0.1*	0.6±*0.13*	6.8±*0.05*

*Values are mean values ± S.D.

3.3. pH, TVN, and TBA of collected *Diplodus sargus* samples

Table (3) elucidated the pH, TVN and TBA values of the explored *Diplodus sargus* samples from four stages (vessels, wholesalers, retailers, and hypermarkets). Onboard specimens' pH varied from 6.4 to 6.55 with an average of 6.5, wholesalers reached 6.5-6.60 with an average of 6.6, retailers amounted to 6.65-6.70 with an average of 6.7, and hypermarkets diverged from *6.70 to 6.80 with an average of 6.8.*

The TVN levels in the investigated fish differed from 27 to 28 with an average of 28 mg%, wholesalers reached 28-28.5 mg% with an average of 28.2 mg%, retailers amounted to 28-28.9 mg% with an average of 28.5 mg%, and hypermarkets fluctuated from 28.9 to 29.3 mg% with an average of 29.

The TBA values in multiple phases of samples were taken from the vessels at 0.75 to 0.80 with an average of 0.85, the retailers at 0.78 to 0.85 mg% with an average of 0.81 mg%, and the wholesalers at 0.8 to 0.90 mg% with an average of 0.78 mg%.

Table 3 TVN, TBA, and pH values for *Diplodus sargus*.

Stages	*TVN* (mg/100 g)	*TBA* (mg MDA/kg)	*pH*
A3	*28±0.5*	*0.56±0.05*	*6.5±0.05*
B3	*28.2±0.25*	*0.78±0.05*	*6.6±0.05*
C3	*28.5±0.45*	*0.81±0.03*	*6.7±0.02*
D3	*29±0.20*	*0.85±0.02*	*6.8±0.05*

*Values are mean values ± S.D.

3.4. Correlation matrix in fish

The correlation coefficients between TVN, TBA, and pH for each type of fish in four stages for every port is shown in table (4). In the correlation matrix for *Sardinella aurita*, the correlation coefficient between TVN and TBA was 0.98, highlighting a highly significant positive correlation. In the same manner, the correlation coefficient between TVN and pH reached 0.99, denoting a significant effective correlation. The correlation coefficient between TBA and pH was 0.98, also signifying a positive correlation.

In *Mullus barbatus*, the correlation coefficient between TVN and TBA was 0.98, indicating a strong effective correlation. The correlation coefficient between TVN and pH was -0.85, reflecting a nonsignificant correlation. The correlation coefficient between TBA and pH was -0.80, also highlighting a nonsignificant correlation.

In *Diplodus sargus*, the correlation coefficient between TVN and TBA was 0.6, indicating a strong interrelation. The correlation coefficient between TVN and pH was -0.33, emphasizing a nonsignificant correlation. The correlation coefficient between TBA and pH is -0.75, also denoting a nonsignificant correlation.

Table 4 Correlation matrix for all stages in Sardinella aurita, Mullus barbatus and Diplodus sargus

	Sardinella aurita		*Mullus barbatus*		*Diplodus sargus*	
	TVN	TBA	TVN	TBA	TVN	TBA
TBA	0.981195**	-	0.995452**	-	0.639979*	-
pH	0.996258**	0.986127**	-0.85023	-0.8061	-0.33198	-0.7592

* and ** Correlation is significant at P< 0.05 and 0.01, respectively.

4. DISCUSSION

Synthetical markers, including pH, TVN, and TBA, are commonly utilized as criteria for evaluating fish quality (ElMarrakchi et al., 1990). In this research, three types of marine fish: *Sardinella aurita, Mullus barbatus, and Diplodussargus* were examined chemically to evaluate the fish quality in three main stages: vessels, wholesalers, retailers, and hypermarkets.

Regarding the pH values, the current results concurred with those claimed by Sakthivel (2005) but were higher than those obtained by Mahmoud (1990), El-Sayed (1991), and Khurana et al. (2002). Bacteria to survive in fish, it is thought to be a restricted component (Wipple and Rohvec,1994). Fish quality management guidelines can be derived from pH values, but they are not appropriate as indices for determining freshness (Ruiz Capillas and Moral, 2001). There were no appreciable variations between the species. According to the Egyptian Organization for Standardization (EOS, 2005), the pH of fish should not exceed 6.5, which was the crucial limit. As a result, 94.44% of the samples were approved, 5.56% rejected, and 100% accepted.

The acceptability of *Sardinella aurita* was found to be satisfactory during the onboard stage, as well as at the retailer and hypermarket stages. On the other hand, *Mullus barbatus* and *Diplodus-sargus* were found to have satisfactory acceptability throughout all stages of the study. On the other hand, the results of TVN values were in line with earlier studies (El-Marrakchi *et al.*, 1990; Etienne *et al*., 2005), but lower than those argued by Malle *et al.* (1983).

TVN levels were influenced by distinct factors, such as the fishing method, post-mortem treatment, storage temperature (Olafsdottir et al., 1997), and species-specific differences (Nazemroaya et al., 2011). Although TVN was not considered a reliable indicator of fish freshness, it has been employed to determine the spoilage of fish muscle (Mazorra-Manzano et al., 2000). Moreover, it did not provide insights into the specific mode of spoilage (Etienne et al., 2005). Nevertheless, it remains one of the most commonly used parameters to evaluate fish quality (El-Marrakchi et al., 1990).

For TVN levels, values below 20 mg% displayed good quality fish, while fish with TVN levels around 30 mg% were considered doubtful in terms of acceptability. Fish containing 40 mg% of TVN was deemed unfit for human consumption (Pearson, 1984). Oka et al. (1989) discovered that initial signs of spoilage became apparent at TVN levels of 28-29 mg%.

Regarding *Diplodus sargus* and *Sardinella aurita*, their acceptability percentage was higher compared to *Mullus barbatus*, which expressed lower acceptability percentages throughout all stages. TBA is an important quality indicator for greasy fish (Lynch and Farsi, 1993). Fish with a larger fat content had the greatest TBA levels (Capunya et al., 2004). The TBA factor is in charge of the rich flavor, color, and odor as well as the texture's degradation (Olafsdottir et al., 1997).

These findings provide insights into the biological characteristics of the three types of fish. *Sardinella aurita* shows higher TVN and TBA values, indicating potentially more increased levels of protein breakdown and oxidative rancidity. Mullus barbatus exhibits lower TVN and TBA values, suggesting better preservation of protein quality and lower lipid oxidation. Diplodus sargus falls between the other two types in terms of TVN and TBA values.

5. CONCLUSIONS

This study concluded that specific chemical tests are efficient for the evaluation of fish quality. In this respect, TVN and TBA appeared to be reliable indicators for determining proteolytic activity. *Mullus barbatus* is the fish sampled with the lowest pH, TVN, and TPA, and this indicates a more extended period of availability. Caution should be exercised when handling *Sardinella aurita* and *Deplodus sargus* due to elevated levels of pH, TVN, and TPA, which are indicative of rapid spoilage.

Based on the results of this study, we suggest the following:

1. Chemical assessment of fish quality is recommended as it is a rapid, accurate method and provides a good indication of fish quality.
2. pH is a poor indicator of fish quality because it varies significantly between fish species.
3. TVN and TBA are suitable indices of freshness assessment for proteolytic activity.

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