Int.J.Curr.Microbiol.App.Sci (2017) *6*(12): 3242-3252

International Journal of Current Microbiology and Applied Sciences
ISSN: 2319-7706 **Volume 6 Number 12 (2017) pp. 3242-3252**
Journal homepage: http://www.ijcmas.com

Original Research Article https://doi.org/10.20546/ijcmas.2017.612.377

Quality Changes of Mrigal (*Cirrhinus mrigala*) during Different Stages of Rigor Mortis

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Keywords

Rigor mortis, Quality, Moisture, Analysis.

Article Info

Accepted:
23 October 2017
Available Online:
10 December 2017

A B S T R A C T

Rigor mortis is an important stage post mortem where most of the biochemical and microbial reactions start in fish. In the present study, Mrigal was analysed for its quality at room temperature for every 3hours time interval for 24 hours through the biochemical, microbial and sensory methods. Among the changes in proximate composition of Mrigal, Moisture content increased whereas the protein, lipid and ash contents decreased. In the biochemical analysis, it was observed that TVBN, PV, TBA and FFA values increased during the storage. In the Microbial analysis, it was observed that the Total Plate Count, *Staphylococcus aureus, Escherichia coli, Pseudomonas* spp., *Aeromonas* spp. and sulphur producers showed an increase. In the sensory evaluation of fish, it was observed that the sensory scores decreased with increase in storage time. The quality was also evaluated by using torry meter and it showed a decreasing pattern. On correlating the sensory and instrumental scores it was observed that mrigal was acceptable for 15 hours.

Introduction

The aquaculture production has shown an increase in the recent years. We have witnessed developments in the advanced techniques of transportation, preservation and storage. The consumption of fish has been increasing. However, notwithstanding the technical advances and innovations, many countries, especially less-developed economies, still lack adequate infrastructure and services including hygienic landing centres, electric power supply, potable water, roads, ice, ice plants, cold rooms and refrigerated transport. These factors, associated with tropical temperatures, result in a high proportion of post-harvest losses and quality deterioration, with subsequent risk to the health of consumers. In addition, marketing of fish is also more difficult owing to often limited and congested market infrastructure and facilities (FAO, 2012). Though there are lot of developments, people those who are living in the coastal areas will prefer the fresh/ raw fish than iced or frozen fish.

Fish quality plays an important role in fresh/ raw fish as the consumption of spoiled fish will cause health hazards. Right from the time of harvesting, many changes occur in fish that will ultimately degrade the quality of fish. As the time of exposure to natural environment increases the quality of fish will degrade.

Hence the quality plays an important role. The quality of fish deteriorates because of microbial spoilage and biochemical reactions during handling and storage. Many methods based on sensory evaluation, physical, microbiological properties and chemical indices have been used to assess fish muscle quality during storage. Sensory methods are the most satisfactory ways of assessing the freshness quality of fish in terms of consumer expectation. However, Alasalvar *et al.,* (2001) suggested that sensory evaluation of fish muscle should be carried out concurrently with other methods used to evaluate fish freshness. Change in microbial population is a traditional quality index of fresh fish.

Fresh fish is susceptible to rapid spoilage at the ambient temperature due to autolysis and growth of microbial populations. Deterioration in sensory quality, loss of nutritive value and negative modifications of physical properties are known to occur after death in wild and farmed fish species due to the action of different mechanisms. A significant aspect of fresh fish distribution and consumption is the effective monitoring of time and temperature conditions that affect both safety and overall quality of fish. The loss of quality in fishery products depends on several intrinsic and extrinsic factors such as the species, spawning, feeding habits, temperature of the water, catching methods and storage conditions. Fish, however, is more susceptible to spoilage than certain other animal protein foods, such as meat and eggs. As part of the natural process by which organic matter is broken down and returned to the nitrogen cycle, fish flesh is rapidly invaded, digested and spoiled by the micro-organisms which are abundant on the skin and in the intestines. Enzymes also contribute to the dissolution, and oxidation by atmospheric oxygen is an additional process of deterioration, particularly in the case of natural fats.

Based on this background the present study was conducted to evaluate the changes that occur in mrigal during the stages of rigor mortis.

Materials and Methods

Mrigal (*Cirrhinus mrigala*) harvested early in the morning from nearby farmer's ponds located at Muthukur were brought to the Fish Processing laboratory, College of Fishery Science, Muthukur and used for the studies. As the farmer's ponds were very near to the processing laboratory the fish were brought in plastic polystyrene insulated containers (without ice) within 10 minutes of harvest. The average length and weight of fish were 38.36 ± 0.22cm and 844.50 ± 25.09 grams, respectively.

Immediately after reaching the lab, the fishes were washed with ice cold potable water and arranged in plastic trays without any cooling media. Fishes were exposed to the lab environment without any covering or protection. The initial sampling was done by taking four fishes, three for estimating different quality parameters like proximate, biochemical and microbiology analysis. One fish was used for sensory assessment and the initial readings were considered as '0' hour readings and the sampling was carried out at 3 hours interval time upto 24 hrs.

Biochemical analysis

Proximate composition of Mrigal was analyzed by the method described in AOAC (2000). TVBN and TMAN was determined by the method of Conway (1962) and expressed as mg/100 g of meat. Peroxide value was determined using method adopted by Jacobs (1958). TBA value was determined as described by Tarladgis *et al.,* (1960) and expressed as mg malonaldehyde per kg of fish sample. Free fatty acid was estimated by

Olley and Lovern (1960) method. Water holding capacity (WHC) of fish muscle was measured by modified centrifugation method described by Delvalle and Gonzales-Inigo (1968) and expressed in percentage (%).

Microbial analysis

The microbiological analysis was carried out following the methods described by APHA (1992). This study included Total Plate Count (TPC), *Staphylococcus aureus*, *Escherichia coli*, *Faecal streptococci*, total *Psychrophiles*, total H_2S producers, *Aeromonas* spp, *Pseudomonas* spp, *Vibrio* spp, *Salmonella* spp. and *Listeria monocytogenes*.

Sensory changes

Fish were observed for changes in their appearance, odour, taste and texture by 8 Panel members. The sensory evaluation for overall acceptability was carried out after cooking the selected fish and it was done by 8 trained panelists using 9 point hedonic scales viz., Like extremely (9), Like very much (8), Like moderately (7), Like slightly (6), Neither like nor dislike (5), Dislike slightly (4), Dislike moderately (3), Dislike very much (2), Dislike extremely (1). Torry meter readings were taken to know the correlation between sensory score and instrumental score.

Statistical analysis

The SPSS 16 (IBM, 2010) Statistical Package for Social Sciences was used for analysis of the experimental results. Sufficient numbers of samples were carried out for each analysis. The results were expressed as mean ± standard deviation (SD). Correlations were established between the various characteristics by using "Post Doc" coefficient of SPSS (IBM, 2010). Sensory scores for overall acceptance of the product were correlated with the storage time, and the shelf life of rohu in ice was calculated using linear regression plot.

Results and Discussion

Changes in proximate composition

The moisture content increased throughout the storage period from 77.81 ± 0.16 % (0^{th} hour) to 84.86 ± 0.26 % (24 hour) whereas the protein, lipid and ash contents showed an decrease from 14.19 ± 0.25 % (0 hour) to 11.86 ± 0.07 % (24 hour), 6.52 ± 0.17 % (0 hour) to 2.39 ± 0.22 % (24 hour) and 1.48 ± 0.03 % (0 hour) to 0.84 ± 0.05% (24 hour) respectively (Table 1). The moisture content and lipid content have inverse relation. The decrease in protein content may be due to the protein denaturation. This was probably due to the reduced activity of fish and fat level in the feed.

Biochemical changes

The value of p^H decreased initially and then increased during subsequent storage period from an initial value of 6.89 ± 0.09 to 6.14 ± 0.07 at the end of 12^{th} hour and again increased to 6.49 ± 0.02 at the end of 24^{th} hour of storage at room temperature (Table 2). The p^H initially decreased, probably because of glycogen degradation into lactic acid, then increased as a result of accumulation of volatile compounds. The relatively low p^H values encountered till 12 hours of storage reflects the good nutritional state of fish. These results are in similar observations made by Ababouch *et al.,* (1996) which is probably because of glycogen degradation into lactic acid, then increased as bacterial proliferation resumed. Similar results were obtained by Köse and Erdem (2004) in anchovies. With increase in storage time, the total volatile base nitrogen content also increased. Initially the fresh fish was having a TVBN content of 0.47 ± 0.16 mg/100g of meat. The value increased

to 54.68 ± 0.28 mg/100g of meat at the end of 24 hours storage period and formed a linear relationship with storage time (Table 2). From the results of TVBN it was evident that TVBN content mrigal has attained the maximum limit of acceptance on 18th hour. Connell (1975) stated that TVB-N content in fresh fish has high negative correlationship with storage time indicating that TVB-N is a good indicator of spoilage.

During the present study, TVB-N content in mrigal increased during the storage at ambient temperature. In the present study, TVB-N formed a strong correlation with sensory scores ($P < 0.01$). Similar results were obtained by Ababouch *et al.,* (1996), Köse and Erdem (2004) in anchovies, Ola and Oladipo (2004) and Adoga *et al.,* (2010). Rapid increase in TVB-N during storage, particularly towards the end of storage period has been attributed to increasing bacterial population resulting in bacterial spoilage (Hossain *et al.,* 2005). TVB-N normally low during the edible storage period, increasing levels were found in fish near rejection levels. TVB-N and TMA-N might be considered as a good indicator of freshness at ambient temperatures since; the results formed a strong correlation with total plate count, sensory and instrumental readings.

The peroxide value formed a linear relationship with storage time. The peroxide value at the initial hour of sampling was found to be 4.00 ± 0.35 meq O_2/kg of fat (0 hour) and it increased to 19.00 ± 0.35 meq O_2/kg of fat at the end of 24 hours of storage at room temperature (Table 2). The peroxide value increased significantly during storage of fish at ambient temperature. Increase in TVB-N with the lapse of storage, particularly, towards the end of storage period may be attributed to bacterial spoilage after the bacterial population has grown (Hossain *et al.,* 2005). Similar results are obtained by Adoga *et al.,* (2010) in Tilapia (*Oreochromis niloticus*).

Thiobarbutric acid value, which is considered as secondary lipid oxidation product increased with increase in storage time. The value increased from 0.39 ± 0.08 mg of malonaldehyde/kg to 7.43 ± 0.09 mg of malonaldehyde/kg of sample (Table 2).

The TBA value is widely used as an indicator of degree of lipid oxidation. Although the TBA values in this study at ambient temperature were found to be quite low, they formed a strong correlation with sensory ($P < 0.01$) and instrumental scores ($P < 0.01$). Similar values are shown by Köse and Erdem (2004) in anchovies. Similar observations were made by Sravani (2011) in rohu.

The free fatty acid content increased and followed the same trend as PV and TBA. It increased from 0.0033 ± 0.00 (% of oleic acid) at '0' hour to 0.2548 ± 0.00 (% of oleic acid) after 24 hours of storage at room temperature (Table 2). FFA, resulting from lipid hydrolysis accumulates during frozen storage and accelerates quality deterioration (Saeed and Howell, 2002). Similar results were obtained by Srikar *et al.,* (1993) and Sarma *et al.,* (1998) where the lower increase in FFA may be attributed to the slower rate of lipid oxidation. Similar observations have been recorded for other species. Similar observation was made by Aubourg *et al.,* (2004) in horse mackerel *Trachurus trachurus* and Stodolnik *et al.,* (2005) in *Scomber scombrus*. Munoz *et al.,* (2006) showed an increase in the content of FFA of lipids extracted from frozen carp fillets frozen stored up to 75 days.

Table.1 Proximate composition of mrigal during ambient temperature storage study

Storage period (hours)	Moisture* (%)	Protein* (%)	Fat* (%)	Ash* (%)
0	77.81 ± 0.16^{a}	14.19 ± 0.25^{f}	6.52 ± 0.17^{g}	1.48 ± 0.03^{e}
3	78.49 ± 0.41^{b}	14.01 ± 0.26^{fg}	6.14 ± 0.12^{g}	1.36 ± 0.03^{d}
6	79.15 ± 0.42^{c}	13.85 ± 0.22^{efg}	5.64 ± 0.32^{f}	1.35 ± 0.08^{d}
9	80.1 ± 0.31^{d}	13.66 ± 0.29^{d}	4.89 ± 0.12^{e}	1.33 ± 0.07^{d}
12	81.1 ± 0.09^{e}	13.42 ± 0.29^{d}	4.02 ± 0.19^{d}	1.28 ± 0.07^{cd}
15	82.16 ± 0.2^{f}	12.99 ± 0.22^{c}	3.61 ± 0.10^{c}	1.17 ± 0.02^{c}
18	83.15 ± 0.13^{g}	12.56 ± 0.07^{b}	3.16 ± 0.03^{b}	1.05 ± 0.04^{b}
21	84.21 ± 0.51^{h}	12.16 ± 0.02^{a}	2.89 ± 0.07^{b}	0.98 ± 0.01^{b}
24	84.86 ± 0.26^{i}	11.86 ± 0.07^{a}	2.39 ± 0.22^{a}	0.79 ± 0.05^{a}

Each value is represented as arithmetic mean ± SD of n =3

Table.2 Biochemical changes in mrigal stored at ambient temperature

Storage period (hours)	p^{H}*	TVBN * (mg/100g of meat)	PV* (meq O_2/kg of fat)	TBA value* (mg of MA/kg of sample)	FFA * (% of oleic acid)
0	6.89 ± 0.09^{g}	0.47 ± 0.16^{a}	4.00 ± 0.35^{a}	0.39 ± 0.08^{a}	0.0033 ± 0.00^{ab}
3	6.76 ± 0.03^{f}	6.81 ± 0.16^{b}	5.80 ± 0.35^{b}	1.07 ± 0.09^{b}	0.0154 ± 0.00^{a}
6	6.58 ± 0.06^{e}	15.87 ± 0.16^{c}	7.40 ± 0. 35^{c}	1.35 ± 0.05^{c}	0.0260 ± 0.00^{ab}
9	6.29 ± 0.03^{bc}	19.32 ± 0.28^{d}	9.80 ± 0. 35^{d}	1.87 ± 0.08^{d}	0.0419 ± 0.00^{ab}
12	6.14 ± 0.07^{a}	25.84 ± 0. 28^{e}	11.20 ± 0. 35^{e}	3.25 ± 0.09^{e}	0.0613 ± 0.00^{c}
15	6.22 ± 0.05^{b}	30.56 ± 0. 28^{f}	12.40 ± 0. 35^{f}	5.15 ± 0.14^{f}	0.0979 ± 0.00^{abc}
18	6.29 ± 0.03^{bc}	36.68 ± 0. 28^{g}	14.80 ± 0. 35^{g}	6.21 ± 0.09^{g}	0.1596 ± 0.00^{abc}
21	6.34 ± 0.04^{c}	42.92 ± 0. 28^{h}	17.00 ± 0. 35^{h}	6.62 ± 0.12^{h}	0.2128 ± 0.00^{bc}
24	6.49 ± 0.02^{d}	54.68 ± 0. 28^{i}	19.00 ± 0. 35^{i}	7.44 ± 0.09^{i}	0.2548 ± 0.03^{c}

* Each value is represented as arithmetic mean ± SD of n =3.

^{abcd} Means followed by the same superscript with in a coloum are not significantly different (p > 0.01)

Table.3 Total plate count, *Staphylococcus aureus* and *Escherichia coli* counts of mrigal stored at room temperature.

Storage period (hours)	TPC * (cfu/gram of meat)		*S. aureus* * (cfu/gram of meat)		*E.coli* * (cfu/gram of meat)	
	24hrs$^{\#}$	48hrs$^{\#}$	24hrs$^{\#}$	48hrs$^{\#}$	24hrs$^{\#}$	48hrs$^{\#}$
0	4.88x10^{2} (2.69)	5.22 x10^{2} (2.71)	0.18 x10^{2} (1.25)	0.22 x10^{2} (1.34)	0.78 x10^{2} (1.89)	0.83 x10^{2} (1.92)
3	8.50x10^{2} (2.92)	8.90 x10^{2} (2.94)	1.40 x10^{2} (2.14)	1.51 x10^{2} (2.17)	1.00 x10^{2} (2.00)	1.05 x10^{2} (2.02)
6	2.46x10^{3} (3.39)	2.47 x10^{3} (3.39)	7.60 x10^{2} (2.88)	7.74 x10^{2} (2.89)	2.16 x10^{2} (2.33)	2.21 x10^{2} (2.34)
9	3.34 x 10^{3} (3.52)	3.36 x 10^{3} (3.52)	4.04 x10^{3} (3.60)	4.06 x10^{3} (3.61)	1.06 x10^{3} (3.02)	1.06 x10^{3} (3.03)
12	2.54 x10^{5} (5.40)	2.6 x10^{5} (5.41)	1.70 x10^{4} (4.23)	1.80 x10^{4} (4.25)	4.40 x 10^{3} (3.64)	4.45 x 10^{3} (3.65)
15	3.12x10^{6} (5.49)	3.20x10^{6} (5.51)	3.10 x10^{4} (4.49)	3.20 x10^{4} (4.51)	6.40 x 10^{3} (3.81)	6.42 x 10^{3} (3.81)
18	9.6x10^{6} (5.98)	9.90x10^{6} (5.99)	1.20 x10^{4} (4.07)	1.25 x10^{4} (4.1)	8.00 x10^{3} (3.90)	1.08 x10^{3} (3.91)
21	1.32 x10^{7} (6.12)	1.38 x10^{7} (6.13)	8.00 x10^{3} (3.90)	8.10 x10^{3} (3.91)	7.20 x10^{4} (4.85)	3.92 x10^{4} (4.86)
24	2.52 x10^{7} (6.40)	2.61 x10^{7} (6.41)	6.5 x10^{3} (3.81)	6.7 x10^{3} (3.83)	1.8 x10^{5} (5.25)	1.84 x10^{5} (5.26)

* Each value is represented as arithmetic mean of 2 estimates.

$^{\#}$ Period of incubation

Figures in parenthesis indicate Log. bacterial counts

cfu = colony forming units

Table.4 Psychrophiles, *Pseudomonas*, sulphur producers and *Aeromonas* counts of mrigal stored at room temperature

Storage period (hours)	*Psychrophiles** (cfu/gram of meat)		*Pseudomonas* spp.* (cfu/gram of meat)		H_2S producing bacteria * (cfu/gram of meat)		*Aeromonas* spp. * (cfu/ gram of meat)	
	24 hrs#	48 hrs#	24hrs#	48hrs#	24hrs#	48hrs#	24hrs#	48hrs#
0	3.56×10^2 (2.55)	3.62×10^2 (2.56)	0.78×10^2 (1.89)	0.83×10^2 (1.92)	0.74×10^2 (1.86)	0.82×10^2 (1.91)	0.56×10^2 (1.74)	0.63×10^2 (1.79)
3	2.76×10^2 (2.44)	2.83×10^2 (2.45)	1.00×10^2 (2.00)	1.05×10^2 (2.02)	2.70×10^2 (2.43)	2.75×10^2 (2.44)	4.34×10^2 (2.63)	4.48×10^2 (2.65)
6	1.88×10^2 (2.27)	1.94×10^2 (2.28)	2.16×10^2 (2.33)	2.21×10^2 (2.34)	3.8×10^2 (2.57)	3.88×10^2 (2.58)	1.2×10^3 (3.07)	1.26×10^3 (3.10)
9	1.60×10^2 (2.20)	1.68×10^2 (2.22)	1.06×10^3 (3.02)	1.06×10^3 (3.03)	3.48×10^3 (3.54)	3.49×10^3 (3.54)	8.6×10^3 (3.93)	8.63×10^3 (3.94)
12	1.34×10^2 (2.13)	1.42×10^2 (2.15)	4.40×10^3 (3.64)	4.45×10^3 (3.65)	4.40×10^3 (3.64)	4.41×10^3 (3.64)	1.68×10^4 (4.22)	1.69×10^4 (4.23)
15	Est < 1	Est < 1	6.40×10^3 (3.81)	6.42×10^3 (3.81)	2.70×10^4 (4.43)	2.74×10^4 (4.44)	1.10×10^5 (5.04)	1.15×10^5 (5.06)
18	Est < 1	Est < 1	8.00×10^3 (3.90)	1.08×10^3 (3.91)	1.08×10^5 (5.03)	1.08×10^5 (5.04)	3.28×10^5 (5.51)	3.30×10^5 (5.52)
21	Est < 1	Est < 1	7.20×10^4 (4.85)	3.92×10^4 (4.86)	3.92×10^5 (5.59)	3.92×10^5 (5.59)	6.42×10^5 (5.80)	6.51×10^5 (5.81)
24	Est < 1	Est < 1	1.8×10^5 (5.25)	1.84×10^5 (5.26)	6.20×10^5 (5.79)	6.23×10^5 (5.79)	3.56×10^6 (6.55)	3.60×10^6 (6.56)

* Each value is represented as arithmetic mean of 2 estimates.
# Period of incubation
Figures in parenthesis indicate Log bacterial counts
cfu = colony forming units
Est – Estimated count

Table.5 Changes in overall sensory scores (OSS) and torrymeter readings of mrigal stored at room temperature

Storage period (hours)	OSS*	Torry meter reading*
0	8.68 ± 0.09^{i}	13.80 ± 0.40^{c}
3	7.76 ± 0.24^{h}	12.43 ± 0.06^{c}
6	7.10 ± 0.36^{g}	12.27 ± 0.25^{c}
9	6.58 ± 0.25^{f}	11.87 ± 0.23^{c}
12	6.03 ± 0.18^{e}	11.63 ± 0.74^{b}
15	5.78 ± 0.20^{d}	10.63 ± 0.67^{b}
18	4.84 ± 0.26^{c}	10.37 ± 0.90^{b}
21	3.73 ± 0.25^{b}	9.80 ± 0.10^{b}
24	3.08 ± 0.14^{a}	9.47 ± 0.49^{a}

* Each value is represented as arithmetic mean ± SD,
n =8 for sensory scores and n =4 for torry meter readings.
^{abcdef} Means followed by the same superscript with in a column are not significantly

Fig.1 Changes in Water Holding Capacity (WHC) content in Mrigal at Ambient Temperature Storage

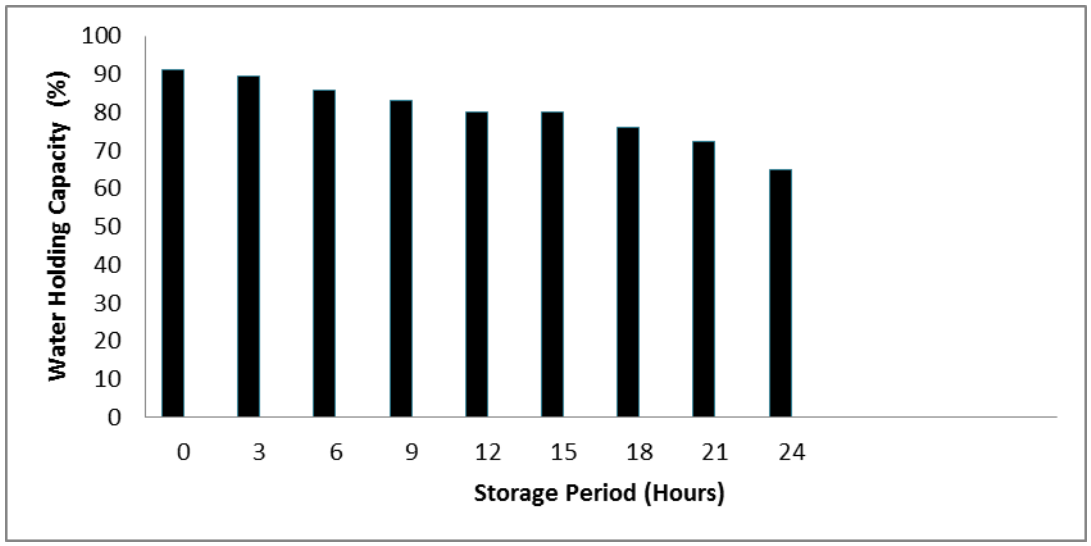
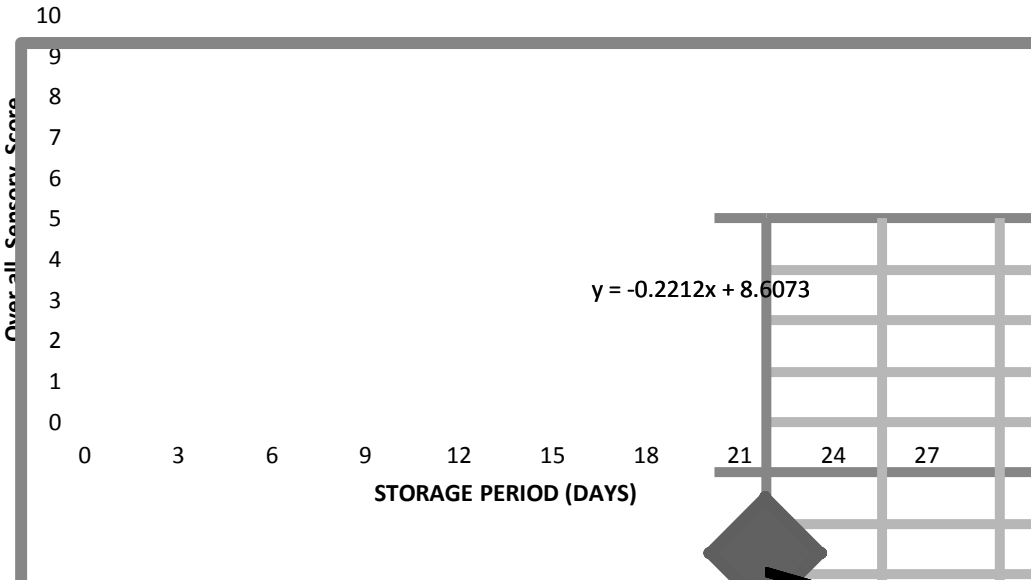


Fig.2 Regression equation of storage period on OSS of Mrigal fish during storage at ambient temperature. Plot of linear regression with time



Aranda *et al.*, (2006) also found that free fatty acids increased linearly with the length of time of storage at -18°C in frozen jack mackerel stored for 120 days. Similar results were observed by Keyvan (2008) in *Rutilus frisi kutum* fish and Makri *et al.*, (2009) in gilthead seabream (*Sparus aurta*). The result of the present study implies that lipolytic enzymes were active in the muscle of frozen fish throughout the storage period. Similar observations were made by Sravani (2011) in rohu.

The water holding capacity decreased from an initial value of 91.20 ± 0.88 % to 65.05±3.52 % at the end of storage for 24 hours (Figure

1). Water holding capacity of mrigal decreased with an increase in storage period. Increase in water loss is due to denaturation of proteins and to release appreciable quantities of water from the flesh (Bligh and Duclos–Rendell, 1986). Decrease in water retention capacity after 2 hr postmortem was reported by Kijowski *et al.,* (1982). Similar observations were made by Sravani (2011) in rohu.

Microbiological estimations

The total plate counts increased with increase in storage time. Initially, the total plate count was found to be 4.88 x10^2 cfu/gram of meat. It increased to 2.52 x 10^7 cfu/gram of meat at the end of 24 hours storage at room temperature (Table 3). From the results it is evident that the TPC of mrigal on 18^{th} hour was nearer to the limit of acceptable indicating that the product was unsuitable for consumption. The *Staphylococcus aureus* count increased from an initial value of 0.18 x 10^2 cfu/gram of meat (0 hour) to 6.5x 10^3 cfu/gram of meat at the end of storage for 24 hours (Table 3). The *E. coli* counts have shown an increasing trend throughout the storage period. The *E. coli* counts have increased from an initial value of 0.78 x 10^2 (0 hour) to 1.8 x 10^5 at the end of 24 hours of room temperature study (Table 3). *Faecal streprococci* was absent throughout the study. The increase in TPC was due to the utilization of NPN matter during storage (Jhaveri and Constantinidens, 1982; Reddy *et al.,* 1997). The shorter shelf-life found in the tropical fish species is mostly explained in terms of the microflora found on tropical fish. The flora found on tropical species are mostly mesophilic in nature and are adapted to live at higher temperatures and responsible for quick spoilage of fish (Disney, 1976; Shewan and Ehrenberg, 1977 and Liston, 1982) and these constitute the bulk of flora on temperate fish species.

The main organisms responsible for *Psychrophiles* are *Pseudomonas* and Sulphur producers. Of which *Pseudomonas* spp was absent in the initial 0 hour and then it has increased from 3^{rd} hour with reading 0.18 x 10^2 cfu/g of meat to 2.50 x 10^5 cfu/g of meat in the 24^{th} hour showing an increasing trend throughout the study (Table 4). Sulphur producers also have shown an increasing trend during the storage at room temperature. The sulphur producers has increased from an initial load of 0.74x 10^2 cfu/g of meat to 6.20 x 10^5 cfu/g of meat at the end of 24 hours of room temperature storage (Table 4). The psychrophilic count have decreased from 3.56 x 10^2 cfu/g of meat at 0 hour to 1.34 x 10^2 cfu/g of meat on 12^{th} hour of study and then psychrophiles were absent till the end of study (Table 4). *Aeromonas* spp. increased with the increase in the storage period. *Aeromonas* was estimated to be 0.56 x 10^2 cfu/g of meat at 0 hour of storage, and then it increased to 3.56 x 10^6 at the end of 24^{th} day (Table 4). Nickelson *et al.,* (1980) observed a similar trend in the black drum, sand trout and tilapia. The same can be speculated in the present study also. In case of *psychrophiles,* the count increased continuously. On the contrary, the sulphur producing bacterial counts were not detectable during storage.

Sensory analysis

Sensory analysis was conducted for mrigal stored at room temperature for 24 hours. The sensory scores decreased with increase in storage period. Initially the fresh fish scored 8.68 ± 0.09 at '0' hour and later decreased to 3.08 ± 0.14 at the end of 24 hours storage at room temperature (Table 5). From the sensory scores it was observed that mrigal has reached below the limit of rejection (5) on 18^{th} hour indicating that mrigal was unsuitable for consumption. The decrease of sensory scores was highly correlated with storage time ($P < 0.01$). Similar observations were made by

Ababouch *et al.,* (1996), Ola and Oladipo (2004), Duran and Talas (2009), Meenakshi *et al.,* (2010) and Adoga *et al.,* (2010). Loss in texture during storage has been related to gaping and loss of water (Barassi *et al.,* 1981).

Instrumental method

The torry meter reading decreased significantly from 13.80 ± 0.40 (Fresh) to 9.47 ± 0.49 at the end of 24 hours storage at room temperature (Table 5). The decrease in torrymeter readings are strongly correlated ($P < 0.01$) with storage time and sensory score making it a reliable tool for analyzing the quality of fish stored at room temperature. Based on the correlations between overall sensory scores and storage period, the fish was acceptable for 15hours (Figure 2). From the results of TVBN, total plate count and sensory scores it was observed that the quality of mrigal kept at room temperature was within the acceptable limit till 15 hours. On correlating the overall acceptable sensory scores with storage time, it was observed that mrigal was acceptable for 15 hours at room temperature. Based on the above results it was be concluded that mrigal fish can be stored till 15 hours without any preservation from the time of harvest and later mrigal is unsuitable for consumption.

Acknowledgment

The authors would like to thank the Vice Chancellor of Sri Venkateswara Veterinary University (SVVU), Tirupati, Dean of Fishery Science, SVVU, Tirupati and Associate Dean, College of Fishery science, SVVU, Muthukur for providing facility and support.

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How to cite this article:

Praveen Kumar, G., G.V.S. Reddy, K. Dhanapal, P. Hari Babu and Sandhya Rani, T. 2017. Quality Changes of Mrigal (*Cirrhinus mrigala*) during Different Stages of Rigor Mortis. *Int.J.Curr.Microbiol.App.Sci.* 6(12): 3242-3252. doi: https://doi.org/10.20546/ijcmas.2017.612.377