

Quality and shelf life status of salted and sun dried fishes of Tuticorin fishing villages in different seasons

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Abstract

The nutritional quality and shelf life of salted and sun dried fishes of Tuticorin coastal villages were assessed seasonally. The quality parameters varied with seasons and it was poor during monsoon season. The spoilage indicators TMA-N and TVB-N of the dried fish sample did not exceed the permissible limit. During monsoon season the dried fish showed visible fungal growth within one month of storage. During the second month of the post monsoon period dried fish showed slight visible fungal growth. In summer season, no visible fungal colonies even after 90 days of storage were recorded. During the storage period dried fishes absorbed moisture from the atmosphere which resulted in the increase of microbial load and in turn led to the increase of TVB-N value. The poor quality of dried fishes were mainly due to unhygienic processing, inadequate salting, unhygienic drying, use of spoiled fish for processing and lack of air tight packing of the dried fishes.

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Introduction

Fish is one of the most important sources of animal protein and has been widely accepted as a good protein source and other elements for the maintenance of healthy body (Ravichandran *et al.*, 2012). It also provides a good source of high quality protein and contains many vitamins and minerals. It is an extremely perishable commodity and quality loss can occur very rapidly after catch (Khan and Khan, 2001; Musa *et al.*, 2010; Dewi *et al.*, 2011). Curing of fish is an ancient method of preservation in India that primarily involves two stages viz, salting and drying (Sanjeev and Surendran, 1996; Anon, 2001). Salted fish products have been shown to be safe for consumption. It decreases the water activity and consists of transporting salt into food structures and is governed by various physical and chemical factors such as diffusion, osmosis and a series of complicated chemical and biochemical processes (Turan *et al.*, 2007). Sun drying of fishes is a simple and the oldest known method of fish preservation. Drying method is considered as the least expensive method of fish preservation (Balachandran, 2001). This traditional method is followed for the preservation of fish especially in rural areas (Chakrabarti and Varma, 1999). Traditional drying is often rudimentary and good hygiene is rarely practiced. During the monsoon, when the humidity is high, drying cannot be achieved by traditional methods. By this time, the fish can absorb the moisture and it serves as a habitat

for microbial population such as bacteria, fungi and viruses and insect attack (Azam, 2002). In India about 17% of the total catch is being used for the production of dry fishes (Jeya Shakila *et al.*, 2003). Salted dried fish was a major source of animal protein available at cheaper price for the economically weaker sections of the society, especially people residing in coastal areas (Prasad *et al.*, 1999). The consumption of dried fishes is about 32% of the total marine landings in India. This ranks second to fresh fish consumption (Thomas and Balachandran, 1989). Fish is harvested from relatively cleaner environments but during subsequent handling, bacteria of spoilage type and of public health significance type come in contact with the fish (Chichester and Graham, 1973). Immediate cooling or salting of the catch is more important in tropical conditions because the ambient temperature is high and it leads to rapid spoilage (Jeya sakila *et al.*, 2003).

The quality of salted and sun dried fishes are adversely affected by the occurrence of microorganisms. Determination of microbiological quality of such processed fishes is very important for guarding consumer's health and hygiene (Lilabati *et al.*, 1999). The presence of the pathogenic loads in dried fishes is acquiring importance in view of the safety and quality of the seafood (Patterson and Ranjitha, 2009). The spoilage indicators and visible fungal attacks caused by microorganisms are known to adversely affect the quality of cured fishes. Growth of fungus causes off flavours, soften the flesh and

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some can produce potentially dangerous mycotoxins under certain circumstances (FAO, 1982). This causes considerable decrease in the consumption of dried fish. Apart from contaminated salted and dried fish, other common sources of contamination are air and dust in and around fish processing place, contaminated coastal water and soil and unhygienic handling (FAO, 1982; Prabhakaran and Gupta, 1990). Many of the bacteria capable of causing disease are considered to be saprophytic in nature but only become pathogenic when fishes are physiologically unbalanced, nutritionally deficient, or as a result of other stressors such as poor water quality, overstocking, which allow opportunistic bacterial infections to human beings (Akinjogunla et al., 2011).

Curing is a simple and cheap method of processing requiring least technical expertise. But it has great significance and relevance in the socioeconomic system of small scale fisher folk (Felicia and Patterson, 2003). In Tamil Nadu, cured fishery products have good internal market and also exported to other countries, but during the last few years there has been a decline in the consumption and export of dried fish products mainly because of poor quality (Sugumar et al., 1995; Ashok Kumar, 2008). Tuticorin is well known for salted and dried fish that are exported and local consumption (Felicia and Patterson, 2003). Most of the salt curing process in Tuticorin is being carried out on the shore itself in unhygienic conditions. This will certainly have an impact on the quality of the product (George Joseph et al., 1986; Sugumar, 2002). Generally in remote villages around Tuticorin, fisher folk sell low quality fishes which are unhygienically salted and dried. Even though they get a profit from it, the quality of fishes is not a great concern for them. Hence the objective of the present study is to determine the quality and shelf life of the dried fishes processed in Tuticorin fishing villages.

Materials and Methods

The sun dried fin fishes such as *Stolephorus commersonii*, *Sardinella fimbriata*, *Liza parsia*, *Siganus canaliculatus*, *Sauridatumbil*, *Plectorhinchus schotaf*, *Pomadasy maculatus*, *Otolithes ruber* and *Upeneus taeniopterus* were bought from fishing villages of Tuticorin and brought to the laboratory in clean polythene covers. Fishes were collected and divided in to two separate lots. One was used for quality assessment and another part was used for shelf life study in different seasons.

The dried seafood samples were analyzed for Moisture content (AOAC, 1990), Total plate count

(FDA BAM, 2001), Total fungal count (Surendran et al., 2006), *E. coli* (AOAC, 1998), *Salmonella* (FDA BAM, 2007), *Vibrio* (FDA BAM, 2004) and spoilage indicators TMA-N and TVB-N (Conway, 1947).

Enumeration of bacterial load was done using plate count agar by spread plate technique. Ten g of the sample was mixed with 90 ml saline water. Appropriate dilutions of fish homogenate were spread on plate count agar and incubated at 37°C for 24-48 hours and the colonies were counted for total Plate count and the count was expressed as cfu/g (FDA BAM, 2001).

Fungal count was done (Surendran et al., 2006) by using Rose Bengal Chloramphenicol (RBC) agar. Twenty-five g of the sample was blended with 225 ml of 0.1% peptone water and 0.1 ml of the appropriate dilutions of the sample was spread on the surface of the medium and incubated at room temperature (28±1°C) for 3-5 days and the colonies were counted for total fungal count and the count was expressed as cfu/g.

The MPN Technique was used to determine the level of *E. coli* in dry fish samples. Dry fish homogenate was transferred to lauryl sulphate tryptone broth (LSTB) tubes and incubated at 37°C for 24 hours and observed for growth and gas production. Samples from positive LSTB tubes were transferred to EC broth tubes and incubated at 37°C for 24-48 hours, Samples from positive EC broth was streaked on to Eosine methylene blue agar plate to confirm the *E. coli*.

For the isolation of *Salmonella*, 25 g of sample was homogenized and enriched in 225 ml lactose broth at 37°C for 24 hours. Selective enrichment of *Salmonella* was carried out in tetrathionate (TT) broth and Rappaport vassilidis (RV) medium in thermostatically controlled water bath. Each of these enriched cultures was streaked in XLD Agar. Typical *Salmonella* exhibit pink colonies with or without black centers.

For isolation of *Vibrio*, 25 g of sample was homogenized and enriched in 225 ml of alkaline peptone water (APW) at 36°C for 24 hours. Selective isolation of *Vibrio* was carried out in thiosulphate citrate bile salt sucrose agar (TCBS). Presence of *Vibrio* shows yellow colored colonies.

The spoilage indicators, trimethylamine nitrogen (TMA-N) and total volatile base nitrogen (TVB-N) were determined from trichloroacetic acid extract of the seafood by the micro diffusion method.

Results

Table 1 to 3 represents the results of biochemical

Table 1. Qualitative analysis of the samples during monsoon season (Temp 26°C)

Species name	TPC (CFU/g)	TFC (CFU/g)	Moisture (%)	E.coli MPN/100ml	Salmonella 25 g	Vibrio 25 g	TMA-N mgN/100 g	TVB-N mgN/100 g
<i>S.commersonii</i>	5×10 ⁴	1.0×10 ⁴	40.0	20	Absent	Absent	9.8	21.63
<i>S.fimbriata</i>	6×10 ⁵	4.0×10 ⁴	38.5	15	Present	Present	13.6	27.3
<i>L.parsia</i>	6.4×10 ⁵	2.1×10 ⁴	43.1	15	Absent	Absent	15.9	31.0
<i>Scanaliculatus</i>	7.5×10 ⁵	6.0×10 ⁴	48.2	25	Present	Present	16.2	35.2
<i>Saurida tumbil</i>	4×10 ⁴	1.6×10 ⁴	33.6	40	Absent	Absent	11.0	25.33
<i>P.schotaf</i>	8×10 ⁵	7.4×10 ⁴	58.6	45	Present	Present	18.8	38.26
<i>P.maculatus</i>	3.6×10 ³	2.2×10 ³	36.1	35	Absent	Present	10.6	22.91
<i>O.ruber</i>	3×10 ³	1.1×10 ³	34.2	15	Present	Present	11.4	20.28
<i>U.taeniopterus</i>	4.5×10 ³	3.3×10 ³	35.6	35	Present	Absent	9.16	23.90

Table 2. Qualitative analysis for of the samples during post monsoon season (Temp 28°C)

Species name	TPC (CFU/g)	TFC (CFU/g)	Moisture (%)	E.coli MPN/100ml	Salmonella 25 g	Vibrio 25 g	TMA-N mgN/100 g	TVB-N mgN/100 g
<i>S.commersonii</i>	3.6×10 ³	1.1×10 ³	38.14	16	Absent	Absent	6.3	16.41
<i>S.fimbriata</i>	4×10 ⁴	2.0×10 ³	35.5	14	Absent	Absent	8.6	20.16
<i>L.parsia</i>	3.9×10 ⁴	8.3×10 ²	40.0	14	Absent	Absent	9.62	19.2
<i>Scanaliculatus</i>	4.7×10 ⁴	4.3×10 ³	38.0	20	Present	Absent	9.9	20.25
<i>Saurida tumbil</i>	3.0×10 ⁴	9×10 ²	30.2	15	Absent	Present	8.2	18.16
<i>P.schotaf</i>	7.5×10 ⁴	5.4×10 ³	40.4	15	Present	Present	17.1	22.72
<i>P.maculatus</i>	2.5×10 ²	6×10 ²	29.0	7	Present	Absent	8.5	19.20
<i>O.ruber</i>	2.7×10 ³	1.9×10 ³	30.1	11	Absent	Absent	7.7	15.77
<i>U.taeniopterus</i>	3.7×10 ³	2.6×10 ³	31.9	10	Absent	Present	8.3	16.00

Table 3. Qualitative analysis of the samples during summer season (Temp 31°C)

Species name	TPC (CFU/g)	TFC (CFU/g)	Moisture (%)	E.coli MPN/100ml	Salmonella 25 g	Vibrio 25 g	TMA-N mgN/100 g	TVB-N mgN/100 g
<i>S.commersonii</i>	1.5×10 ²	1.0×10 ²	18	15	Absent	Absent	4.66	13.9
<i>S.fimbriata</i>	2.6×10 ³	2.1×10 ²	19	15	Absent	Present	5.12	11.69
<i>L.parsia</i>	2.5×10 ³	1.9×10 ¹	20	20	Absent	Absent	4.00	12.28
<i>Scanaliculatus</i>	8.6×10 ²	3.5×10 ²	23	15	Absent	Present	6.4	11.22
<i>Saurida tumbil</i>	1.7×10 ³	2×10 ²	15	6	Absent	Absent	5.2	13.0
<i>P.schotaf</i>	1.1×10 ⁴	5.0×10 ²	26	19	Absent	Absent	7.77	19.20
<i>P.maculatus</i>	6.9×10 ¹	-	19	15	Absent	Absent	4.4	9.90
<i>O.ruber</i>	1.5×10 ²	2.9×10 ²	15	11	Absent	Absent	5.1	8.30
<i>U.taeniopterus</i>	3.3×10 ²	1.0×10 ²	20	20	Absent	Absent	5.0	13.26

and microbial analysis of salted and sun dried fishes at different seasons such as monsoon, post monsoon and summer seasons. The result of shelf life status of the dried fishes in 3 month storage period in different season is shown in Tables 4, 5 and 6.

Total Plate Count (TPC) fluctuated in different seasons. High total plate count of 8×10⁵ (cfu/g) was observed during monsoon season in *P. schotaf* (7.5×10⁵ cfu/g), *S. canaliculatus* (6.4×10⁵ cfu/g), *L. parsia* (6.0×10⁵ cfu/g), *S. fimbriata* and (5×10⁴, 4×10⁴ cfu/g), *S. commersonii* and *S. tumbil*. During the post monsoon season higher plate count was observed in *P. schotaf* (7.5×10⁴ cfu/g) followed by

Table 4. Changes in selected parameters in dried fishes during storage in post monsoon season

Storage days	<i>Stolephorus commersonii</i>											
	0			30			60			90		
1	2	3	1	2	3	1	2	3	1	2	3	
38.14	16.41	Nil	40.0	28.0	Nil	42.33	32.1	+	45.51	43.6	++	
<i>Sardinella fimbriata</i>												
35.6	20.16	Nil	36.4	21.14	Nil	41.0	30.6	+	43.5	38.0	++	
<i>Liza parsia</i>												
40.0	19.2	Nil	41.1	27.0	Nil	43.7	31.2	+	45.4	40.6	+	
<i>Siganus canaliculatus</i>												
38.0	20.25	Nil	39.8	18.66	Nil	42.0	25.21	+	48.0	37.2	++	
<i>Saurida tumbil</i>												
30.2	18.16	Nil	39.0	22.6	Nil	45.0	30.3	+	50.1	39.40	++	
<i>Plectorhinchus schotaf</i>												
40.4	22.72	Nil	30.6	20.70	Nil	35.7	30.42	+	39.0	46.94	++	
<i>Pomadasy maculatus</i>												
29.0	19.20	Nil	27.8	25.78	Nil	31.8	35.60	++	33.1	42.33	++	
<i>Otolithes ruber</i>												
30.0	15.77	Nil	32.8	21.6	Nil	35.5	29.4	++	38.55	36.44	++	
<i>Upeneus taeniopterus</i>												
31.9	16.00	Nil	33.4	20.2	Nil	35.66	25.6	++	38.77	36.9	++	

1. Moisture (%), 2. TVB-N mgN/100 g, 3. Visible fungal colony

Table 5. Changes in selected parameters in dried fishes during storage in monsoon season

Storage days	<i>Stolephorus commersonii</i>											
	0			30			60			90		
1	2	3	1	2	3	1	2	3	1	2	3	
40.0	21.63	Nil	45.2	35.2	+	46.3	40.7	++	51.4	50.8	++	
<i>Sardinella fimbriata</i>												
38.5	27.3	Nil	41.7	29.8	+	46.9	40.2	++	56.2	61.0	++	
<i>Liza parsia</i>												
43.1	31.0	Nil	50.3	34.1	+	55.8	42.6	++	59.6	56.8	++	
<i>Siganus canaliculatus</i>												
48.2	35.2	Nil	51.4	38.66	+	59.8	45.21	++	61.0	57.2	++	
<i>Saurida tumbil</i>												
33.6	25.33	Nil	44.2	33.6	+	45.0	36.7	++	49.9	51.9	++	
<i>Plectorhinchus schotaf</i>												
58.6	38.26	Nil	62.0	41.44	Nil	63.4	47.62	++	69.66	56.4	++	
<i>Pomadasy maculatus</i>												
30.1	22.91	Nil	40.3	36.4	+	48.3	40.3	++	58.4	46.8	++	
<i>Otolithes ruber</i>												
34.2	20.28	Nil	43.2	35.07	+	58.4	46.8	++	63.66	63.74	++	
<i>Upeneus taeniopterus</i>												
35.6	23.90	Nil	40.1	33.30	+	49.1	45.5	++	52.3	49.0	++	

1. Moisture (%), 2. TVB-N mgN/100 g, 3. Visible fungal colony

S. canaliculatus (4.7×10⁴ cfu/g), *S. fimbriata* (4×10⁴ cfu/g) and *L. parsia* (3.9×10⁴ cfu/g). During summer season higher plate count was observed in *P. schotaf* (1.1×10⁴ cfu/g, *S. fimbriata* (2.6×10³), *L. parsia* (2.5×10³), and *S. tumbil*.

The quality parameters such as TMA-N and TVB-N values vary in dry fishes in different seasons and the results are presented in Table 1, 2 and 3. TMA-N value during monsoon season ranged between 9.8 – 18.8 mg/100 g and the highest and lowest value were recorded in *P. schotaf* (18.8 mg/100 g) and *S. commersonii* (9.8 mg/100 g). During post monsoon season the value ranged from 6.3 – 17.1 mg/100 g and high and the same two species had higher and lower values. In summer the value for TMA-N ranged from

Table 6. Changes in selected parameters in dried fishes during storage in summer season

<i>Stolephorus commersonii</i>												
Storage days	0			30			60			90		
1	2	3	1	2	3	1	2	3	1	2	3	
18.0	13.9	Nil	12.3	12.6	Nil	13.9	18.9	Nil	15.8	31.9	Nil	
<i>Sardinella fimbriata</i>												
19.0	11.69	Nil	18.4	17.86	Nil	18.4	22.46	Nil	10.2	34.3	Nil	
<i>Liza parsia</i>												
20.0	12.28	Nil	18.0	15.11	Nil	16.12	14.26	Nil	11.2	14.00	Nil	
<i>Siganus canaliculatus</i>												
23.0	11.22	Nil	20.2	18.16	Nil	18.0	21.46	Nil	9.2	30.09	+	
<i>Saurida tumbil</i>												
15.1	13.0	Nil	14.2	17.22	Nil	13.6	26.8	Nil	11.0	29.15	Nil	
<i>Plectorhinchus schotaf</i>												
26.0	19.20	Nil	20.3	15.15	Nil	18.0	20.37	Nil	20.0	33.30	+	
<i>Pomadasys maculatus</i>												
19.0	9.90	Nil	17.0	9.00	Nil	10.8	11.22	Nil	10.0	22.0	Nil	
<i>Otolithes ruber</i>												
15.0	8.30	Nil	13.6	14.8	Nil	12.4	18.2	Nil	10.0	20.06	Nil	
<i>Upeneus taeniopterus</i>												
20.0	13.26	Nil	16.2	17.66	Nil	13.8	23.7	Nil	12.10	35.0	Nil	

1. Moisture (%), 2. TVB-N mgN/100 g, 3. Visible fungal colony

4.00-7.7 mg/100 g. The highest and lowest values were observed in *P. schotaf* and *L. parsia*. In the case of TVB-N values of dried fishes in monsoon, post monsoon and summer seasons ranged from 20.28 – 38.26 mg/100 g, 15.77 – 22.72 mg/100 g, and 9.90 – 19.20 mg/100 g respectively.

Seasonal variation of moisture content in different types of salted and dried fish samples were presented in Table 1, 2 and 3. Higher moisture content was observed in monsoon seasons. The MPN values for *E. coli* were lower in summer season (MPN 6 - 20/100 ml) and it was slightly higher in post monsoon seasons (MPN 7- 20/100 ml) and higher in monsoon (MPN 15-45/100 ml). Fungal count was higher in monsoon season followed by post monsoon and summer seasons. The pathogenic bacteria such as *Salmonella* was not detected in the samples collected during summer season while *Vibrio* was positive only in *S. fimbriata* and *S. canaliculatus*. In post monsoon season *Salmonella* contamination were detected in *S. canaliculatus*, *P. schotaf* and *P. maculatus*. *Vibrio* species was found in *S. tumbil*, *P. schotaf* and *U. taeniopterus*. In monsoon *S. fimbriata*, *P. schotaf*, *O. ruber* and *U. taeniopterus* tested positive for *Salmonella* and *Vibrio* was present in 5 samples such as *S. fimbriata*, *S. canaliculatus*, *P. schotaf*, *P. maculatus* and *O. ruber*.

Tables 4, 5 & 6 shows seasonal variation of moisture content, TVB-N content and time taken for visible fungal growth during the storage of dry fishes. It was observed that there was difference in the nine types of samples and it also varied with the season. During storage in the monsoon season visible fungal colonies appeared quickly in all types of samples.

Discussion

Total plate count (TPC)

During monsoon season, the highest total plate count (TPC) was observed by post monsoon season and summer season. Higher total plate count of 10^6 /g or above is considered to be of poor quality for fish. The acceptable limit of bacterial count for dried fish is 1×10^5 at 37°C (Surendran *et al.*, 2006). In this study *P. schotaf*, *S. canaliculatus*, *L. parsia*, *S. fimbriata* had high TPC in monsoon which exceeds the permissible limit. Similar work was carried out in dried fishes of Tuticorin fish market and reported high bacteria count in *S. fimbriata* (Ashok Kumar, 2008; Sinduja *et al.*, 2011). In Cochin market the bacterial count in dried fishes was less than 10^7 g⁻¹ (Sanjeev, 1997). Saritha *et al.* (2012) reported high bacterial count in dried fishes of Cuddalore dry fish market. Nigerian market the total bacterial count of dried beef and dried fish sample was 10^5 and 10^9 (Adesiyani *et al.*, 1992). In this study the dried fishes procured from fisher folk had bacterial count above the permissible limit and it was high in monsoon season due to high moisture content of the environment. The least bacterial load was observed in summer due to high temperature, low moisture and adequate drying. Our study agreed with Rao *et al.*, (1962) who reported the loss of moisture in meat sample during summer which retards the bacterial growth. Lilabathi *et al.* (1999) reported the direct relationship between the microbial count and moisture content of the dried fish sample. During monsoon period high bacterial count was observed due to high humidity in atmospheric temperature (Sinduja *et al.*, 2011). Heterotropic bacterial load of about 10^6 - 10^7 CFU/g was reported in fish in retail trade at Cochin (Nambiar and Iyer 1990) and a load of up to 10^8 from fishes marketed in Karachi (Shamshad *et al.*, 1992). Patterson and Ranjitha (2009) enumerated TPC from commercially and experimentally dried fishes showed that total plate count seemed to be high in the commercially dried fishes than the experimentally dried fishes.

TMA-N and TVB-N values indicate the freshness of the fish (Beatty and Gibbons, 1936). These spoilage indicators levels in fish muscles have been used as indices of spoilage having good correlation with bacterial growth. The values of biogenic amines vary with the different seasons.

The production of TMA-N was dependent on the bacterial activity as well as from endogenous enzyme (Mohd. Yusuf Ali *et al.*, 2010). Connell (1980) recommended the value of 10-15 mg/100 g of TMA-N for human consumption. In the present

study dried fishes collected during monsoon and post monsoon season had the TMA-N value above the acceptable limit for some fishes.

TVB-N is accepted universally as an indicator of quality that uses ammonia. The highest TVB-N values were observed in dry fishes during monsoon season and it ranged from 20.28 to 38.26 mg/100 g. The acceptability level of TVB-N in dried fish is 35 - 40 mg/100 g as the upper limit and above that level fishery products are considered unfit for human consumption (Kimura and Kiamakura, 1934). In post monsoon season TVB-N values ranged from 15.77 - 22.72 mg/100 g and 9.90 - 19.20 mg/100 g in summer. All the nine dried fish samples collected from monsoon season shows high TVB-N value. TVB-N measurement indicates the extent of the breakdown of protein due to bacterial and enzymatic action leading to amine production. Enzyme from the spoilage microorganism can metabolize the amino acids of the fish muscle producing ammonia, trimethylamine, dimethylamine (total volatile base nitrogen) which is used to estimate spoilage. While Castell and Triggs (1955) have expressed that there is a wide variation in critical values suggested for individual species. Horse and Sekine (1956) found a sudden increase in TMA-N to be concurrent with onset of bacterial putrefaction. In our result TMA-N increased with the increase of bacterial count. These results agreed with the results of (Saritha *et al.*, 2012; Sinduja *et al.*, 2011). Huss (1988) suggested that formation of TMA-N in fish muscle is due to the increase of spoilage bacteria levels. TVB-N level in fish has also been used to indicate the growth of microorganisms leading to spoilage (Lakshmanan, 2002). Iyer *et al.* (1986) reported that TVB-N level of fish in retail market was as high as 98 mg/100 g. TVB-N level of dried fishes in Tuticorin market was 30 -18.4, 18.95 - 14.81, 9.31 - 14.14 mg/100 g in monsoon, post monsoon and summer season respectively (Sinduja *et al.*, 2011). TVB-N level of *S. fimbriata* stored at 20°C for 24 hours was 23.9 mg/100 g and it increased to 53.6 mg during 4 days of storage (Yamanaka *et al.*, 1986). Estrada (1985) explained that the TVB-N increased during storage at ambient temperature. Connells (1975) reported visible fungal colonies in fish sample even before TVB-N value reached the maximum permissible limits. Horie and Sekeine (1956) also found a sudden increase in TMA-N (>10 mg %) to be concurrent with onset of bacterial putrefaction although bacterial growth begins immediately after the resolution of rigor.

All the nine salted and sun dried sea foods collected from fishing villages during summer season contained low moisture level ranges from 15

- 23%. High moisture content (48.2% and 58.6%) was observed during monsoon season. The dry salting method produced considerable loss of water due to heavy uptake of salt (Martínez-Alvarez and Gomez-Guillén, 2006). Moisture content of fish play an important role in spoilage, lowering of moisture retards the spoilage (Stansby, 1963). The variation in moisture content was observed in all the seasons, only monsoon season showed high moisture with high bacterial count. Seasonal variation in moisture content of dried fish could be the result of variable drying time, environmental changes and level and type of salt used for curing (Anihouvi *et al.*, 2006). However the moisture content seems to be an exact indicator of the susceptibility of the product to undergo microbial spoilage (Troller Christian, 1978). In the present study the moisture content suddenly increased during the monsoon season and considerably reduced during summer season. Our results agree with the results of (Chakrabarti and Varma 1997; Sinduja *et al.*, 2011). Sanjeev (1997) stated that the total bacterial count of dried fishes obtained from Cochin was not less than 10^7 g⁻¹ while the moisture content ranged from 65 - 80%. Our results reveals in monsoon season moisture was 58.6% and the microbial load was 8×10^5 CFU/g. Rao *et al.* (1962) reported that visible fungal colonies appeared quickly on the fish samples in monsoon season due to high moisture content in fish samples and high relative humidity in the atmosphere. In the present study also high fungal count was noted with high moisture content during monsoon.

Pathogenic indicator bacteria such as *E. coli* may not be in large numbers in water or food which cannot be detected by plating methods. In such cases MPN methods are used where large volume of samples can be used for inoculation. MPN method is used to detect the *E. coli* in water or food (Surendran *et al.*, 2006).

In our present investigation the MPN value of the fish sample for *E. coli* varied with the seasons. *E. coli* is a commensal bacterium which colonizes in the intestinal tract of humans. However some are pathogenic causing diarrhea and are termed as enteropathogenic *E. coli*. The MPN values for *E. coli* recorded during summer were between MPN 6 - 20/100 ml. In post monsoon season the values varied between 7- 20/100 ml and in monsoon it varied between 15-45/100 ml. Washing the catches in polluted coastal water definitely adds the faecal indicator bacteria. Faecal contamination near the landing center is also responsible for this (Sugumar, 2002). Drying in an unhygienic way also adds faecal bacteria to the fishes (Anand *et al.*, 2002). Seasonal variation of faecal indicator bacteria in fish and

coastal water has already been reported to be high along Tuticorin fish landing centers (Sugumar 2002; Ashok kumar, 2008; Sinduja *et al.*, 2011). However the faecal pollution at Bhavanager coast was reported to be of human origin based on the faecal index (Vaidya *et al.*, 2001). Sewage is a good source of faecal microorganism and it is considered as a good indicator for faecal pollution in the environment. In our present study there was significant variation of MPN values in all 3 seasons. High MPN values were observed in monsoon season. It may be due to the use of polluted water, unhygienic handling and processing, inadequate drying. *E. coli* count showed more variation between samples collected at the same time and at different seasons which ranged from 9/100 ml to over 1400/100 ml (Sugumar, 2002) 4/100 ml to over 20/100 ml (Sinduja *et al.*, 2011). Level of *E. coli* was high in fresh and dehydrated fish from Cochin fisheries harbour and retail markets of Mumbai. Iyer *et al.* (1986) and Lilabati *et al.* (1999) reported faecal indicators that were not detected in the smoked fishery products. Azam *et al.*, 2003 studied the *E. coli* count in the monsoon season as well in summer season and they found to be more number of *E. coli* in the monsoon season because of moisture.

The dry fish samples were free from visible fungal colonies during post-monsoon and summer seasons while visible fungal colonies were noted on the fishes during monsoon season. In monsoon season, visible fungal colonies appeared quickly due to the moisture content of the fish samples and high relative humidity of the atmosphere. Fungal counts were high in sun dried sea foods during monsoon seasons, slightly decreased in post-monsoon season and fungal counts were low in summer season. The dry fish samples were free from visible fungal colonies initially, but enrichment in RBC broth and plating on RBC agar recovered almost all the fungal flora. The quality of dry fishes was adversely affected by occurrence of fungi (FDA, 1982). In our study seasonal variation in the fungal population was observed in all the dry fish samples. Visible fungal colonies appeared in the dry fish samples and it varied with the season. In monsoon season visible fungal colonies appeared quickly due to the moisture content of the fish samples. Our results agreed with the results of Rao *et al.*, 1962 who reported that in monsoon season visible fungal colonies appeared quickly due to the moisture content of the fish samples and high relative humidity of the atmosphere. Ashok Kumar (2008) had reported fungal contamination in dried fish samples collected from market. Contaminated salt and spoiled fish used for salting, dust in and around fish processing areas contaminated coastal water and improper drying are

the reason for this. Sinduja *et al.* (2011) studied the quality of marketed dry fishes in different seasons and observed higher fungal growth during monsoon season. Dry fishes of Cuddalore market too had high fungal count (Saritha *et al.*, 2012). Patterson and Ranjitha (2009) enumerated TFC from commercially and experimentally dried fishes showed that Total fungal count seemed to be high in the commercially dried fishes than the experimentally dried fishes.

Presence of *Salmonella* and *Vibrio* species contamination in dried fishes was observed by enriching the samples and plating them on selective plates. Samples were considered positive when typical colonies appeared on selective plates. *Salmonella* sp. was not detected in the sample collected during summer season. In post monsoon season *Salmonella* contamination was detected in few samples and *Vibrio* was observed in most of the samples. Contamination of fish and fishery products with *Salmonella* and *Vibrio* has been reported by many researchers in different parts of India (Bandeekar *et al.*, 1995; Iyer and Shrivastava 1989a; Nambiar and Iyer 1991; Ponda, 2002; Kumar *et al.*, 2003; Sinduja *et al.*, 2011; Saritha *et al.*, 2012). Incidence of pathogens in the sample of fish market may be attributed to external contamination (Iyer and shrivastava, 1989b) and poor handling at ambient temperature (Al Jedah *et al.*, 1998). In some of the cases, the food borne illness such as scombroid poisoning is observed in dry fishes mainly due to the chemical agent and histamine and it is also called as histamine poisoning; *E. coli* is responsible for the production of histamine in the dried fishes (Logesh *et al.*, 2012). In rare cases, *Salmonella* and *Staphylococcus* species produce histamine residue (Huang *et al.*, 2010). So safety measures should be taken to reduce the contaminations and insect infestations.

It was observed that there was difference among the samples and season. During storage in monsoon season visible fungal colonies appeared quickly in large number on all types of samples. Rao *et al.* (1962) reported that fungal growth was a major cause of spoilage with the increase of moisture content. The microbial stability of dried fish products during processing and storage depend on their moisture content (Scott, 1957; Troller and Christian, 1978; Waterman, 1976). When the moisture is high during the drying of fishes, it favors the growth of microbes and there is a chance of infestation with flies. There was a considerable loss of moisture in all the dry fish samples during the storage period in summer season. This decrease in moisture was still well above the limit required to stop the fungal growth. Visible fungal colony appeared late on fishes like *S. canaliculatus*,

P. schotaf and *U. taeniopterus* probably because of the compositional differences among the four dried fishes. The salted fish reabsorbs moisture during the storage period and causes damage to the fish. As the fish contains nutrients necessary to support the growth of microorganisms, water content in the fish increased the growth of mould. These are called as “dun”, and cause objectionable flavour and texture (Ochei and Kolhatkar, 2000). TVB-N values of fishes stored for 3 months during summer did not exceed the permissible limit even though fungal growths were seen in some fishes. During monsoon and post monsoon period visible fungal colonies was noticed much earlier in some samples before the TVB-N values reached the maximum permissible limits for dried fish.

Conclusion

Quality studies have been done for the salted and sun dried fishes of fishing villages of Tuticorin. Dried fish samples from the fishing villages of Tuticorin were heavily contaminated with bacteria, fungi and insects due to high moisture level and it was found unfit for edible purposes. These findings reveal the fact that though the fishes subjected for drying were properly salted but the unwanted exposure to moisture due to poor storage facilities might revealed in dilution of salt concentration triggered secondary infestation and contamination with bacteria and fungi. Maximum number of bacteria and fungi recorded in monsoon season confirms that moisture leads to contamination of dried fishes. Further enumeration of pathogens in fish proved that the fish intended for drying were putrefied and not intended for human consumption. Since the quality of the cured fishes is poor, even the salt that was used to preserve the fish was considered ineffective. Hence control measures such as use of good quality raw material, good quality salt, hygienic handling practices, potable water, recommended process, good quality packaging material, hygienic processing place may be considered to improve the quality of the dried fishes. Finally low moisture level of the product and proper storage conditions will help to improve the quality. For conventional drying, hygienic fish drying racks should be used or else the fishes can be dried using solar dryer to reduce the microbial and insect infestations. Landing sites should be maintained clean and the domestic sewage and agricultural runoff which flow into the sea could be treated before discharge to avoid hazards to marine biotopes.

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