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Effect of improved drying methods on biochemical and microbiological quality of dried small head ribbon fish, *Lepturacanthus savala*

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ABSTRACT
In the present study, fish were dried adopting improved methods, namely solar tent drier (STD), raised bamboo platform (RBP) and black polythene sheet (BPS). The biochemical quality of fresh ribbon fish showed 75.66% moisture content, 17.66% crude protein content, 2.08% fat content and 0.76% of ash content. Whereas microbiological quality fresh ribbon fish showed TPC was 2.90 x 10^5 cfu/ g, halophilic bacteria and pathogenic bacteria were absent. Drying time for fish dried by different methods were observed to be 58 h, 82 h and 130 h for STD, RBP and BPS respectively. Initial moisture content of ribbon fish dried in STD 17.85%, RBP 19.35%, BPS dried 19.95% and dried ribbon fish sample collected from market was 30.6% and same was increased at the end of 120 days storage. Higher protein content was found at beginning of storage in the range of 40-44% in all samples except market sample (MS). Crude fat content of ribbon fish, dried by different methods fluctuated in accordance with moisture during storage. While the initial ash content was 15.55% in a dried ribbon fish sample collected from the market, it was slightly higher in ribbon fish dried by various methods and same was decreased at the end of 120 days storage. Gradually increased pattern showed in case of TMA-N, TVB-N and PV in all samples of dried ribbon fish while a variation of salt content was observed due to increased in drying time. Initial total plate count of ribbon fish dried in STD, RBP, BPS and market sample as recorded at $2.96x10^3$, $3.80xl0^3$, $1.12xl0^4$ and $2.30xl0^4$ cfu/g respectively and the same increased to $5x10^3$, $6.30x10^3$. $4.80x10^4$ and $5.80x10^4$ cfu/g, respectively at the end of 120 days storage. Initial total halophilic count of ribbon fish dried in STD, RBP, BPS and market sample were observed to be $2.40x10^2$, $2.44x10^2$, $5.50x10^3$ and $2.20x10^4$ cfu/g respectively. It increased to $4.0x10^2$, $5.10x10^2$, $2.0x10^4$ and $1.4x10^5$ cftu/g, respectively at the end of 120 days storage study. Initially ribbon fish dried in STD and RBP were observed to be free from fungus. However, TFC in STD and raised RBP dried sample was recorded as $4.60x10^1$ and $4.80x10^1$ cfu/g respectively at the end of four months storage. The TFC of ribbon fish dried on BPS and market sample at initiation of storage was found to be $0.9x10^2$ and $l.2x10^3$ cfu/g, respectively, and then TFC in these samples increased to $2.60x10^2$ and $2.70x10^3$ cfu/g respectively after four months storage. Ribbon fish dried in improved methods were absolutely free from total Coliform organism initially and during entire 120 days storage. While total Coliform organisms could be detected in dried ribbon fish samples collected from local market. It was recorded to be initially and increased during storage.

Keywords: Ribbon fish, solar tent drier (STD), raised bamboo platform (RBP), black polythene sheet (BPS), market sample, biochemical and microbiological study.

1. Introduction

Curing and drying are traditional low cost preservation techniques. The processing techniques vary with the type, nature, size and condition of the fish. Improper handling and processing can result in a poor quality product due to spoilage and insect infestation. By controlling raw material quality, processing variables and drying conditions the product quality can be improved significantly. At present, about 1.4 million metric tonnes of fish which accounts for about 8.0% of the total world catch is cured and utilized. The important producers of cured fish are China, Japan, USSR, Indonesia, Philippines, Ghana, Canada and India [13]. In India, at present, 14% of the total fish catch goes for curing, which is highest among the different ways of disposition next to consumption of fresh fish [13]. Bombay duck, pink perch, croakers, mackerel, soles, seer fish, silver bellies, ribbon- fish and anchovies are usually employed for curing in our country.

Though, sun drying is most simple and economical method of fish preservation. Sun drying still has many limitations, such as long period of drying during cloudy climate. In areas of high humidity, it is often difficult to dry the fish to low moisture content. Sun drying of fish often results in low quality as a result of slow drying, insect infestation and contamination from air borne dust etc. Therefore, it is necessary to adopt improved methods of drying to get better quality of dried fish [9].

Sun drying can be improved considerably by raising the fish off the ground on wooden frames. This allows air to circulate beneath the fish, thus facilitating drying from both sides. It also breaks the cycle of insect reproduction. Waterman [35] reported that drying fish on racks with mosquito netting, wherein fish is more exposed to air and wind and less prone to contamination and insect infestation.

The use of a solar tent dryer for collecting and concentrating solar radiation to achieve elevated temperature during drying has been recommended as a good alternative to sun drying of fish [10]. Small-headed ribbon fish, *Lepturacanthus savala* (Cuvier) has wide distribution almost all along the coast of India. Considering the abundance of this fish along Konkan coast and its importance as a dried fish product the fish has been selected for drying studies.

For getting better quality-dried fish, it is very essential to use improved methods of fish drying. Moreover, it is also important to maintain required hygiene during the different phases of fish drying. In view of this, the present study is aimed at drying the ribbon fish *Lepturacanthus savala* by improving methods, namely solar tent dryer, raised bamboo platform, black polythene sheet and carrying out the complete process of fish drying under hygienic condition. Packaging the dried fish in trend pack and carrying out the storage studies of these fish for a period of four months to understand the impact of adopting improved methods and maintain hygienic condition during processing.

Along with this, the sample of dried ribbon fish collected from the market was packed in the trend pack and a storage study of same was also carried out to understand differences between biochemical and microbial value in the fish dried by improving methods and the one dried by traditional method.

2. Material and Methods

2.1 Fabrication of solar tent drier

Based on the design given by [10] the solar tent drier was constructed. The original drier had clear plastic on the side facing the sun and black polythene on the opposite side, whereas in case of solar tent drier in the present study the side facing the sun had top half covered with transparent sheet and the bottom half covered with black polythene sheet. The other two sides were covered with black polythene sheet which absorb solar radiations that heat the air within, thus enhancing the natural convective flow of air during drying.

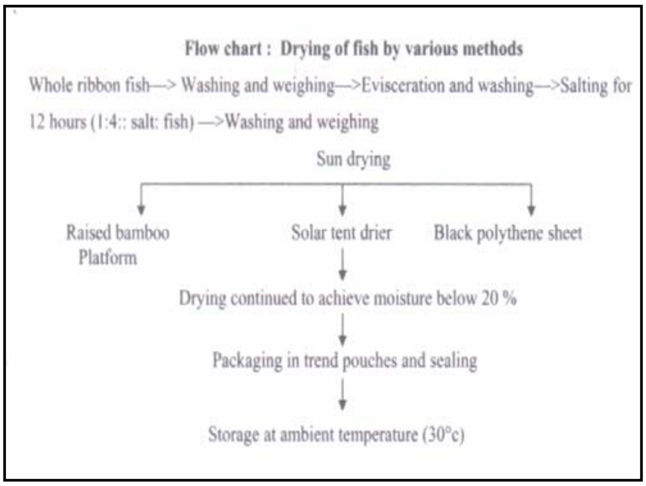
2.2 Fabrication of raised bamboo platform

Raised bamboo platform of dimensions 2.0x1.0 m was fabricated using split bamboo. The bamboo platform was raised above the ground using the plywood stand of 0.5 m for better circulation of air from the both the sides of fish.

2.3 Preparation of fish for drying

The fish was washed, weighed, eviscerated, cleaned thoroughly, salted with 1:4 ratio (salt to fish), kept overnight, washed and divided into 3 lots of ten kg each and dried using three substrates namely solar tent drier, raised bamboo platform and black polythene sheet.

In all above three, the fish were dried for ten hours per day until the moisture content was lowered to below 20%.



2.4 Biochemical analysis

Proximate composition of dried ribbon fish was estimated as per the Association of Official Analytical Chemists [4]. The parameters under study were moisture, estimated by the method of drying in an electric oven, fat by the ether extraction, (Soxhlet Apparatus) and crude protein by the acid digestion method (Micro-Kjeldhal). Ash was determined by using Muffle furnace. Acid insoluble ash was determined after extraction of ash using HCl maintained in oven at 135 °C as per [4]. Salt was determined as per [4]. Trimethyl amine nitrogen (TMA-N) values were estimated by the Conway micro diffusion method [7] and expressed as mg N%/100 g fish muscle. The Total volatile base nitrogen (TVB-N) values were estimated by the Conway micro diffusion method [7] and expressed as mg N%/100 g fish muscle. Peroxide value (PV) of dried ribbon fish was estimated by a titrimetric method of [4].

2.5 Microbiological analysis

Fish samples were analysed for total plate court (TPC), halophilic count (HQ). Total fungal count (TFC), Total coliform (TC) and for pathogenic organisms (*E. coli, Staphylococcus. Streptococcus. Salmonella and. Vibrio*) by the methods recommended by [11].

2.6 Organoleptic analysis

During the storage studies, various sensory characteristics such as colour, taste, odour, texture and overall acceptability were evaluated by a group of ten trained panelists using a ten point hedonic scale. Statistical analysis was done by the method of [33]. The significant results are mentioned as $P<0.01$ or $P<0.05$.

3. Results and Discussion

As fresh fish is not available throughout the year, dried fish is in demand in the period of scarcity. During the season of abundant catches, there is glut in the sell. At such times salting and drying to be sold during lean season preserve the catch. The traditional method is unhygienic and does not follow particular standards [1]. The quality of fish dried by conventional methods is not satisfactory due to yellow discoloration, off-odour, high sand content, insect infestation, belly bursting, disintegration and high microbial load [34].

Uncontrolled growth of microbes in such cured products leads to serious implications and keeping quality and safety of the product. Keeping this in view an attempt is made to carry out comparative studies of fish dried by different methods. The quality of these fish, dried by different methods was compared with quality of market sample.

3.1 Quality of fresh ribbon fish

Fresh ribbon fish used in the present study content 75.66% moisture, 17.66% crude protein, 2.08% crude fat and 0.76% ash (Figure 1). TPC value of 2.90 x 10^4 cfu/g was observed in fresh fish. While working on the proximate composition and microbial analysis of ribbon fish, [25] reported similar values.

3.2 Drying time for fish dried by different methods

In the present study, drying time was found to be different when the fish was dried by different methods, namely solar tent drier, raised bamboo platform and black polythene sheet.

Solar tent drier required less time i.e. 58 hours. Reason behind this was circulation of hot air within solar tent drier, which increased internal drier temperature and reduced drying time. However, raised bamboo platform required 82 hours for drying fish. More drying time when dried on raised bamboo platform was obvious than solar tent drier since the raised bamboo platform was placed in an open place so there was no creation of hot air as it was in a solar tent drier. The fish, dried on black polythene required longest drying time i.e. 130 hours the reason for this prolonged period of drying may be accumulation of water on the black polythene sheet, which was absorbed by the fish again.

Curran C.A *et al*. [9] observed that 3 days were required for fish drying in solar tent dryer. Also they reported that fish dried on sloping rack-required 4 days for reducing moisture up to 20%. The drying of ribbon fish by different methods is given in the chart 1.

3.3 Biochemical changes during storage study

Fresh ribbon fish used in the present study content 75.66% moisture, 17.66% crude protein, 2.08% crude fat and 0.76% ash (Figure 2). While working on the proximate composition of ribbon fish, [25] reported similar values for moisture, crude fat and ash and slightly lower values for crude protein.

The initial moisture content is the most important factor affecting the ultimate quality and storage life of dried fish [3]. Figure 3 revealed that the initial moisture content of dried ribbon fish procured from market was 30.6%, which was significantly higher as compared to ribbon fish dried in STD (17.85%), on RBP (19.35%) and BPS (19.95%). Similarly, high moisture percent ranging from 39.53 to 46.58% for dried ribbon fish from Ratnagiri curing centre was reported by [18]. Basu S *et al*. [6] also reported high moisture levels ranging from 36.1 to 52.0% for dried ribbon fish from Andhra Pradesh fish markets. MPEDA has specified 35% as the maximum moisture level for dried ribbon fish [22]. In the present study, the moisture content of dried ribbon fish procured from the market falls within the acceptable levels specified by MPEDA. The fish dried in STD recorded relatively higher protein content (44.13%) right from the beginning of storage, followed by fish dried on RBP (42.22%) and on BPS (41.35%). While the dried fish procured from the market showed lower protein content (32.48%) as compared to fish dried by the above methods (Figure 4). This difference in protein content may be attributed to the removal of moisture to a greater extent than the ribbon fish procured from local market.

Shrivastava KP [32] observed similar inverse relationship between moisture and protein during storage of dried shrimps packed in polythene bags. During storage at ambient temperature salt-dried fish showed inverse relationship between moisture and protein [20, 21].

Crude fat content of ribbon fish dried by different methods fluctuated in accordance with moisture during storage (Figure 5). From the result, it appeared that the crude fat decreased during storage in ribbon fish dried by different methods. This decrease may be due to moisture gain. Kumar D *et al*. [21] while working on similar lines reported an increase in fat content of salt-dried mackerel due to moisture loss during the storage period.

The initial ash content of the dried ribbon fish procured from the market was lower (15.35%) as compared to the ribbon fish dried in STD (16.67%), on RBP (16.73%) and on BPS (16.70%). This may be due to the difference in the salt content, indicating that the higher proportion of ash is mostly due to appropriate quantity of salt used during processing of ribbon fish for drying in STD, on RBP and on BPS (Figure 6). Khuntia BK [20] while working on keeping quality of dry salted mackerel recorded a high degree of positive correlation (r = 0.9989) between ash and salt content.

The initial acid insoluble ash content of fish dried in STD was 1.17%, on RBP was 1.66%, on BPS was 1.77% and for the dried ribbon fish procured from the market the acid insoluble ash was 4.5% (Figure 7). The lower values of acid insoluble ash for the fish dried in solar tent drier may be due to the complete protection of fish from dust, wind-blown particles and other foreign matter in the solar tent drier. Basu S *et al*. [6] reported lower values of acid insoluble ash in laboratory dried (1.2%) and tunnel dried ribbon fish (1.2%) as compared to the dried ribbon fish procured from the market (2.8%). Bala and Islam (2001) reported that the fish dried in solar tunnel drier was completely protected from rain, insects and dust. Lower values of acid insoluble ash in solar tent dried ribbon fish were recorded, which were followed by ribbon fish dried on RBP and fish dried on BP sheet.

The results shown in Figure 8 revealed that the initial salt content of dried ribbon fish procured from market showed lower percent of salt (12.6%) as compared to ribbon fish dried in STD (15.85%), on RBP (15.5%) and on BPS (15.8%). This may be due to the fact that no specific duration of salting was being followed by the fishermen, inadequate quantity of salt was used. The dried ribbon fish from the Andhra Pradesh fish market was found to have a salt content ranging from 10.1 to 11.8%. The tunnel dried and laboratory dried ribbon fish showed higher per cent of salt ranging from 19.5 to 20.9% and 16.9 to 17.5% respectively as compared to the market samples [6].

In the present study, TMA-N increased gradually in all the products (Figure 9). In the processing of dried fish where microbiological proliferation no longer occurs after dehydration to the shelf stable moisture, accumulation of TMA-N and other amine compounds has been reported to occur during storage [36]. Increase in TMA-N was also observed by [20] during storage of dry salted mackerel. Lower TMA-N values were observed for the fish dried in STD and on RBP as compared to the one dried on BPS and procured from market initially as well as throughout the storage. Such differences may be due to their differences in microbial load and activity of enzymes. Connell JJ [8] has suggested 10-15 mg N% TMA-N as the limit beyond which fish could be considered as spoiled for most uses. On the contrary, in the present study, the dried fish was still acceptable organoleptically even when TMA-N was higher than 10-15 mg N% TMA-N. Khuntia BK *et al.* [20] also reported that even though higher TMA-N values were observed the products were still acceptable organoleptically.

The total volatile bases in fish tissues include ammonia, monomethyl amine, dimethyl amine, and trimethyl amine etc. The increase in these volatile bases leads to deterioration of odour and flavour in fish [19]. In the present study, the TVB-N content of solar tent dried ribbon fish increased from 30.5 to 73.23 mg N%, 46 to 82.2 mg N% for ribbon fish dried on RBP, 89.5 to 247.5 mg N% for ribbon fish dried on BPS and 70.6 to 211.56 mg N% for dried ribbon fish procured from the market (Figure 10). Such trend corroborates with the finding of [2] in dry, wet and mixed salting of *Sardinella eba* and *Clupea harrengus*. However, the rate of TVB-N formation was different.

Fish lipids contain polyunsaturated fatty acids, which are highly susceptible to oxidation during prolonged storage [26]. In the present study, peroxide value increased throughout the storage, but the increase was only within narrow limits (Figure 11). The PV was more in case of fish dried on BPS as compared to the other products. This may be due to prolonged exposure to light and air during initial drying phase resulting in the oxidation of fatty acids. Also the cause of such lipid oxidation may be the pro-oxidant effect of sodium chloride [26].

3.4 Microbiological changes in storage study

The amount of bacteria in foods serves as a general indicator of hygiene. Determination of total bacterial count is widely used to assess the bacterial quality of fish. The limit for TPC is 1 x 10^5 cfu/g in the dried product [15].

In the present study, low initial TPC was found in fish dried in solar tent drier (2.96x10^3 cfu/g) and raised bamboo platform (3.80x10^3 cfu/g). This may be attributed to low moisture content and drying carried out under hygienic conditions. On the contrary, initial TPC value of ribbonfish dried on black polythene was high (1.12x10^3 cfu/g). This high value may owe to more time required for fish drying.

At the beginning of storage, the TPC of market sample was remarkably higher (2.3ox10^4 cfu/g) than fish dried in a solar tent drier and raised bamboo platform, the reason for higher TPC in market sample may be to higher moisture content in the market sample. Joseph KG *et al.* [18] observed that TPC value (3.7338xl0^3 cfu/g) of market samples was higher than the laboratory dried sample.

Basu S *et al.* [6] reported that TPC value of dried ribbon fish collected in market of Andhra Pradesh was higher (4.2xl0^4 cfu/g) than laboratory dried and tunnel dried ribbon fish. Reason behind this was higher TVN and moisture content. Abraham TJ [1] observed that commercial sun dried sardine was high in TPC value being 4.35x10^4 cfu/g than anchovy dried by improving methods, namely boiled and dried oven dried, solar tent dried and sun dried fish.

In the present study during storage TPC value in all the samples increased due to increase in moisture content. A similar trend was observed by Khuntia BK *et al.* [20] during storage of wet salted and dry salted mackerel. Abraham TJ [1] studied microbial stability of cured fishery products by improved curing and packaging methods, they reported that TPC increased during a four months period for boiled and dried, oven dried, solar tent dried, sun dried anchovy and seer fish samples. Ramachandran A *et al.* [25] reported that TPC of semidried ribbon fish increased from 2.5x10^3 to 6.8x10^5 cfu/g during storage.

In agreement with these observations of present study, Silva LYA *et al.* [30] reported that TPC value increased from 0.7x10^1 to 5.99x10^3 cfu/g after four weeks storage in catfish treated with 25 % Nacl and 1% Sorbic acid.

Bacteria generally do not grow in products with water activity of less than 0.85. In relation to salt. halophilic and haloduric bacteria will grow in cured fish with water activity down to 0.75. Halophilic bacteria usually have specific requirement for 10% or more salt in the food medium [12]. Dry salted fish is less susceptible to insect attack, but more susceptible to halophilic bacteria that are introduced from salt Abraham TJ *et al.* [1].

In the present study initial THC value of fish dried in solar tent drier and raised bamboo platform was low (2.40x10^2 cfu/g and 2.44x10^2 cfu/g respectively) as good quality crystalline white salt and appropriate salting ratio were adopted. Prasad MM [23] reported the use of quality salt and salting carried out according to weight of fish reduces the halophilic bacteria.

The THC value of fish dried on black polythene sheets was higher (5.50x103 cfu/g) initially, compared to the other two methods. This may be because of more time required for fish drying on the black polythene sheet.

While, the initial THC value of market sample was high (2.20x10^4 cfu/g) due to poor quality salt and higher moisture content. Khuntia BK *et al.* [20] noticed that the halophilic bacteria could not be detected initially in wet salted and dry salted mackerel prepared in the laboratory. They concluded that the use of preservative and/or storage at a cooler temperature remarkably reduce the halophilic bacteria count. On the other hand. Basu S [6] reported that the THC value of commercially dried ribbon fish was higher (4.lx10^3 cfu/g) than tunnel dried and laboratory dried ribbon fish, which was l.6x10^3 cfu/ g and l.3x10^3 cfu/g respectively. Joseph KG *et al.* [18] reported the average THC for dried ribbon fish of Kerala to be 4.5 x10^3 cfu/g.

Prasad MM [23] reported that THC value of fish samples collected in the Kakinada area was high and ranged from 2.7x10^3 to 6.84x10^5 cfu/g due to higher moisture content.

In the present study, the THC value increased 'in all the samples, throughout the storage study. The same trend was observed by Khuntia BK *et al*. [20]. The THC values increased during storage due to in- crease in moisture. Prasad MM [23] observed similar increment in THC from 1.6 x 10^5 at the beginning of storage to 1.3x10^3 cfu/g at the end of 120 days storage due to increase in moisture content.

The coliforms are aerobic and facultative anaerobic gram negative, non- sporing rods. The primary habitat of coliforms is in the large intestine of animals and human beings. The presence of coliforms indicated that fish is handled under unhygienic condition. Good manufacturing practices can reduce the occurrence of coliforms. In the present study, the fish dried by various methods were free from total coliforms throughout the study period. These may be due to the hygienic practices followed during processing and drying of fishes. However, coliform organisms were present in the market sample increased considerably during storage. The occurrences of Coliform organism in a market sample may be attributed to poor handling and processing, repeated use of brine, insufficient salt, unhygienic drying conditions and insufficient time.

Basu S [6] reported that 80% of the market samples showed the presence of Coliform ranging from 20-80/g. Whereas laboratory dried and tunnel dried samples were free from coliform organisms. On the contrary, Joseph KG [18] reported that the laboratory dried and commercially dried ribbonfish were free from Coliform organisms.
While working on identical line Abraham TJ [1] reported similar trends of increase in total Coliform during storage in the sun dried sardine. Silva LYA [30] also noticed similar increasing trend of Coliform organism in dried catfish without treatment.

E. coli is a gram negative, rod shaped, non-spore forming bacteria. The primary habitat of *E. coil* is the intestine of man. The presence of *E. coli* in fish indicated that fish was handled under unhygienic condition. The limit for *E. coli* for dried fish is 20/g [15]. In the present study, the fish dried by various methods, namely solar tent drier, raised bamboo platform and black polythene was totally free from *E. coil*. This may be attributed to use of clean potable water for washing of fish and maintaining a totally hygienic conditions during drying operation. The samples collected from local market showed the presence of *E. coli* due to use of near shore water for washing and unhygienic drying conditions.

Basu S *et al.* [6] reported that ribbon fish dried in tunnel drier and a laboratory were totally free from these pathogenic organisms. He attributed the total absence of these pathogens to hygienic preparation and improved methods of fish drying.

Sachithananthan K [27] observed that market sample of dry fish in Sri Lanka showed the presence of *E. coli* because the beaches in Sri Lanka were subjected to defaecation by people living nearby. In the present study, *E. coli* slightly increased during storage from 0.7x10' to 1.9x10'/g in market sample. Hog ME [14] reported the presence of *E. coli* in dry fishes of Bangladesh. Prasad MM [23] isolated *E. coil* from some of the dry fish samples in the market of Kakinada. Sugumar GT [31] observed higher count of indicator organisms in worker's hand, soil, water and curing tanks.

The *Staphylococci* are asporogenous, nonmotile, gram-positive cocci. The main reservoir of Staphylococcus is man; his hands, face, sweat, boils, ulcers, nasal cavity, throat, ear gum and postnasal drips of man. The contamination with *Staphylococci* can be prevented by adequate control over the health and hygiene of fish handlers. The permissible limit for most of the fishery products and dried fish is maximum at 100/g [11].

The fish dried by various methods were absolutely free from *Staphylococci* during entire period of storage in the present study. The reasons behind this as perfect cleaning, adequate salting and maintaining hygienic conditions during drying and storage. However, market samples showed the presence of *Staphylococci.* The occurrence of *Staphylococci* in market samples may be attributed to the imperfect cleaning and unhygienic condition during processing and drying. In agreement with this, [6] reported that dried fish prepared in tunnel drier and laboratory drier are absolutely free from *Staphylococci* when fish dried tinder hygienic condition. On the other hand, [18] reported that coagulase *Staphylococci* were detected in the dried fish samples collected in the village of Kozhikode district of Kerala. Contradicting with this [28] reported that *S. aureus* could not isolate after 3 days drying.

In the present study, during storage *Staphylococci* slightly increased from 2.74x10^1 to 6.5/g. Similar increasing trend was observed by [25] during storage of semidried shark, ribbon fish and dhoma. The *Staphylococci* may have increased to handling of fish from time to time.

Salmonella generally inhabits in the gut of the large number of vertebrate and cause enteric fever, gastro-enteritis and septicemia in human with or without carrier state. The occurrence of Salmonella in dried fish may be attributed to use of infected water or fresh fish itself contain Salmonella. [15] recommended that the dried fish should be totally free from Salmonella. In the present study, fish dried by various methods were free from Salmonella. This may be attributed to adoption of good manufacturing practices during higher count of indicator organisms in the worker's hand, soil, water and curing tanks.

The presence of *Streptococci* in any food product clearly indicates faecal contamination and declining in hygiene and sanitation [16]. In the present study fish dried by various methods, namely solar tent drier, raised bamboo platform, black polythene sheet and traditionally dried were totally free from *Streptococci* during entire storage period. On the contrary, Streptococci were detected in some dried fish sample collected in village of Kokzhikode as reported by Joseph KG *et al.* [18]. Similarity was observed by Ramachandran A [25]. They noticed that Streptococci were detected in semi-dried ribbon fish of the market and increased from $0.7xl0^3$ to $7.1.lxl0^3$/g during storage.

3.5 Organoleptic changes in storage study

The results of organoleptic evaluation during storage of ribbon fish dried by different methods viz., STD, RBP, BPS and MS shows that there was a decline in overall quality characteristics, namely appearance, colour, taste, odour, texture and overall acceptability during storage period of 120 days. For the fish dried in STD the initial scores for appearance, colour, taste, odour, texture and overall acceptability were 9, 9.2, 8.8, 9, 9.5 and 9.2 respectively. At the end of 60 days storage the scores for appearance, colour, taste, odour, texture and overall acceptability declined to 8, 8.2, 7.8, 8, 8.5 and 8 respectively and the dried ribbon fish was rated as ‘good’ by the panelists. Further reduction in quality attributes was recorded at the end of storage period of 120 days the scores being 7, 7.1, 6.9, 7, 8 and 7 for appearance, colour, taste, odour, texture and overall acceptability respectively.

The ribbon fish dried on RBP was having the appearance of freshly dried fish, the texture was firm, colour was characteristics of dried ribbon fish, odour was absent and the initial scores for appearance, colour, taste, odour, texture and overall acceptability were 8.5, 8.5, 8.4, 8.6, 8.5 and 8.5 respectively and the product was rated as ‘good’ based on the overall acceptability. After 120 days of storage the scores for appearance, colour, taste, odour, texture and overall acceptability showed a decline and the scores were 6.5, 6.6, 6.5, 6.5, 7 and 6.5 respectively.

The ribbon fish dried on BPS was appearing stale, with firm texture, slight dry fishy odour, slight yellow-brown discolouration and the scores were 7.5, 7.5, 8, 8, 8 and 7.5 for appearance, colour, taste, odour, texture and overall acceptability respectively and the dried ribbon fish was rated as ‘moderately good’ based on the overall acceptability. The ribbon fish dried on BPS was unacceptable after 90 days, the score being 4.5 and panelist rated the dried ribbon fish as ‘slightly poor’. Therefore, ribbon fish dried on BPS was not continued for further organoleptic test. For the dried ribbon fish from MS the initial scores for appearance, colour, taste, odour, texture and overall acceptability were 7.3, 7.5, 7.4, 7.6, 8.1 and 7 respectively, and the dried ribbon fish was rated as ‘moderately good’ based on the overall acceptability. At the end of storage period of 120 days the appearance was dull, colour yellow brown, texture was less firm, odour considerably off and the panelist rated the dried ribbon fish from MS as ‘slightly poor’ after a storage period of 120 days based on the overall acceptability.

In the present investigation all the sensory attribute values decreased steadily throughout the storage period. Decrease in the sensory attribute values during storage of solar tent dried silver belly was reported by [24]. The reactions for appearance is not known, it can be assumed that excessive microbial and enzymatic proteolysis of the tissue causing tissue disintegration [20].

4. Conclusion

The local practice of drying ribbon fish, although widely practiced, poses problems such as high moisture content, inadequate salting, contamination with sand, dust and overall poor quality. These problems can be avoided by proper pre-processing of fish, adoption of good manufacturing practices and use of improved methods such as the STD, which results in faster drying of ribbon fish to lower moisture content. The fish dried in STD was completely protected from dust, wind-blown particles and other foreign matter which resulted in lower acid insoluble ash per cent. The biochemical and microbiological changes during storage were very less in the solar tent dried ribbon fish as compared to the other methods studied. The solar tent dried ribbon fish was of better organoleptic quality followed by raising the bamboo platform throughout the storage period of 120 days. Thus STD and RBP can be proposed as suitable improved methods of drying small head ribbon fish.

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