# Process development for low-salted dried fish production and quality determination

**M.J. Paththuwe Arachchi* and D.S. Ariyarathna**

*National Aquatic Resources Research and Development Agency (NARA), Crow Island, Colombo 15, Sri Lanka.*

## Abstract

Salted dried fish is a common, low-cost protein source among the South-East Asian people. The traditional dried fish processing techniques currently practiced by Sri Lankan fisher community lead to reduced protein value of fish due to excessive usage of salt. The general purpose of this study is to develop a method to produce dried fish using least amount of salt and preserve the protein value and minimize the salt intake through dried fish consumption. For this study Talang queenfish (*Scomberoides commersonianus*) and Goldstripe sardinella (*Sardinella gibbosa*) fish were selected as these two varieties are popular among the consumers. The minimum strength of brine which is able to bring the Water Phase Salt (WPS) value to 20% was determined using series of brine solutions with different strengths. The shelf life, physical parameters and nutritional value of low-salted dried fish was determined using the standard methods. Brine solution with 10% concentration was selected as the minimum strength that results the WPS value higher than 20%. The protein percentage of low-salted dried Talang queenfish was 56.30±1.57 and it was 45.15±2.28 in traditional dried fish. In Goldstripe sardinella fish protein percentage were 48.27±1.18 and 37.17±1.34 respectively in low-salted and traditional methods. Low-salted dried fish can store for more than three months time under the natural environmental conditions. Vacuum packaging is the mostly recommended packaging method for low-salted dried fish. Findings of this research revealed that low-salted method is more suitable over large fish cut in to thin slices than small fish.

**Keywords:** low-salted, dried fish, Water Phase Salt (WPS), protein

**Corresponding Author – Email: madujay18@gmail.com*

## Introduction

Fish is considered as an important source of high-quality proteins and contains many vitamins and minerals which are required for the maintenance of healthy body (Ravichandran, *et al*., 2012). In Sri Lanka, fish and fishery products contribute for 38% of total protein intake by the population (MFARD, 2015). Fish is considered as an extremely perishable commodity and quality deterioration can occur from the time of death (Khan & Khan, 2001). Curing of fish is an ancient method of preservation that primarily involves two stages, salting and drying (Sanjeev and Surendran, 1996). Salted fish products have been shown to be safe for consumption. Salting decreases the water activity, transport salt into food structures and leads to 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 considered as the simplest, cheapest and the oldest known method of fish preservation (Balachandran, 2001). Salted dried fish is a major source of animal protein available at cheaper price which is affordable for economically weaker sections of the country. The major problems associated with Sri Lankan dried fish industry are use of low-grade raw materials (fish) and reduced shelf life due to mould growth occurring as a result of excessive use of salt. When salt content of fish is high under humid conditions cured dried fish reabsorbs water and increases the moisture content. Relative humidity of over 70% leads to mould growth in dried fish (Rao, *et al.*, 1962).

Dried fish producers use excessive amount of salt and reluctant to dry the salted fish adequately in order to minimize the weight loss in drying. Excessive consumption of salt leads to cardiovascular diseases and reduction of even 1 g of salt per day is projected to resulted large declines in annual cardiovascular events and deaths (Bibbins-Domingo, *et al*., 2010). As the salt concentration of a solution is increased, the charges on the surface of the protein interact with the salt, not the water, thereby exposing hydrophobic patches on the protein surface and causing the protein to fall out of solution. Therefore, when salt content increases loss in salt soluble proteins increase. Water Phase Salt (WPS) value is directly related to water activity of a food item (Ross & Dalgaard, 2004). In order to store in room temperature and reduced oxygen conditions salted dried fish must have 20% WPS value (Fish and Fisheries Products Hazards and Controls Guidance, 2001). In the development of low salted dried fish WPS value of the final product was considered as the critical parameter.

The purpose of present investigation was to develop a high quality, protein rich, low salted dried fish product using readily available two Sri Lankan fish species, Talang queenfish (*Scomberoides commersonianus*) and Goldstripe sardinella (*Sardinella gibbosa*).

## Materials and Methods

### Collection and preparation of raw materials for low-salted dried fish

Freshly harvested, 20 kg of Talang queenfish (*Scomberoides commersonianus*) and 20 kg of Goldstripe sardinella (*Sardinella gibbosa*) fish were obtained from Negombo fishery harbour. Talang queenfish were cut in to slices of 1.5 cm thickness with skin. Goldstripe sardinella fish were descaled and eviscerated. Proper cleaning of fish was ensured prior to salting. Fish from each species was divided in to 6 portions as 6 treatments were planned. Concentration series of brine (w/w) (6%, 7%, 8%, 10%, 12%, 15%) was prepared using salt crystals and water. Volume of each brine solution was decided based on the weight of the fish used for each treatment (fish: brine; 1:3).

### Salting process

The fish were merged in the brine solution for 45 minutes in room temperature. In brining ensuring the proper intact of brine and fish is important to penetrate salt in to the flesh of the fish as the salt concentration of brine is less in treatments. After salting, fish was kept for 10 minutes in a plastic mesh basket to drain out the water.

### Control; traditional method

Dried fish was prepared according to the traditional method used in dried fish industry in Sri Lanka as the control. Descaled and eviscerated Goldstripe sardinella fish was dipped in a saturated brine solution (300 g of salt per 1 L of water) for 12 h (over-night). For dried Talang queenfish, dry salting/salt crystals (300 g of salt for 1 kg of fish) was applied to splitted and cleaned fish and kept for 12 h (overnight). After salting Goldstripe sardinella fish were taken out from the brine solution and kept on meshed trays for drying. After salting, salt crystals attached to the surface of Talang queenfish were removed and kept in meshed trays for drying.

### Drying process

Drying of salted fish was done using a solar drier. Drying process was carried out for 3-4 days until the water activity ($a_w$) of fish become 0.75 (SLS 643:2007) or less.

### Determination of WPS value and water activity of dried fish

WPS value of dried fish produced from each treatment was determined using the following formula.

$$\mathrm{WPS} = \frac{\%\mathrm{Salt\ X\ 100}}{\%\mathrm{Moisture} + \%\mathrm{Salt}}$$

Moisture content was calculated as the loss in weight; after drying at 105˚C for 5 h and water activity was measured using the water activity meter (Novasina, Aw sprint). Salt percentage was determined according to the (AOAC, 2000).

**Sensory evaluation**

An in-house panel consisting of 30 members evaluated the color, texture, flavor, and overall acceptability of the cooked dried fish samples. The panelists evaluated the samples independently. The panelists received coded samples of boiled low salted and traditional dried fish prepared using Talang queenfish and Goldstripe sardinella fish. The data obtained from sensory evaluation were then subjected to analysis of variance.

**Determination of proximate composition**

The protein content of low salted dried fish and traditional dried fish of same variety were determined using Kjeldahl method (AOAC, 2005) with the aid of a digestion system (DU 20, VELP Scientifica) and an automated distillation unit (UDK 149, VELP Scientifica) and calculated using total Nitrogen (N) × 6.25. The fat content was analyzed using Bligh and Dyer method (AOAC, 2005). The moisture content was analyzed by drying in a hot air oven (Gallenkamp, UK) at 105°C for 5 hours (AOAC, 2005). The ash content of dried fish samples was analyzed by muffling the samples at 550 °C (AOAC, 1995) using muffle furnace (Eurotherm). All chemicals used were of analytical grade and supplied by Sigma Co. (St'Louise, USA). All determinations were done in triplicates and the mean values were reported.

**Shelf life determination of low-salted dried fish**

After production of dried fish, initial samples were subjected to microbial analysis, sensory evaluation, TVB-N determination and physical parameters analysis such as pH and water activity.

In storage trial dried fish of each treatment and control were divided in to three portions, one portion kept in an opened container (Conventional way of storage of dried fish in Sri Lanka), one portion was packed inside polythene bags and the other portion was vacuum packed. Monthly visual observation for moulds growth and discolorations, texture and aroma, TVB-N, water activity and moisture content of dried fish samples were determined. Storage trial was carried out for four months time under different packaging systems.

**Microbiological analysis**

Aerobic Plate Count (APC), Yeast and mould count, presence of Coliforms, *E. coli*, *Salmonella* and *Staphylococcus aureus* of dried fish samples were determined.

**Determination of Aerobic Plate Count (APC) (SLS 516-1 Sec,1:2013)**

Aerobic plate count was conducted by consecutive decimal dilution technique using pour plate method. Sample for the APC was accurately weighed (10 g) and 90 mL of diluent was added (maximum recovery diluent) to a sterilized stomacher bag and blended. Consecutive ten-fold dilution series were prepared in sterilized test tubes. From all the dilutions, plates were prepared using sterilized plate count agar medium. Plates were made in duplicate and incubated at 37˚C for 48 h. Colonies developed on the plates having 30 to 300 colonies were selected for APC and the colonies were counted using a colony counter (Galaxy 230, Rocker) in subdued light. APC was calculated using the following formula.

$$N = \frac{\sum C}{(n_1 + 0.1n_2)d}$$

Where,

$\sum C$ *is the sum of colonies counted on all the dishes retained*

$n_1$ *is the number of dishes retained in the first dilution*

$n_2$ *is the number of dishes retained in the second dilution*

*d is the dilution factor corresponding to the first dilution*

**Enumeration of yeast & mould counts (SLS 516: Part 2: 1991)**

Enumeration of yeast and mould counts was also done by consecutive decimal dilution technique. From all the dilutions 1 mL was inoculated on to prepared potato dextrose agar plates. Liquid was spread over the surface of the agar plate with a sterile spreader until the liquid is completely absorbed into the medium. Petri dishes were incubated (model INA-300, Gallenkamp, UK) aerobically at 25±1 ºC for 5 days. The colonies were counted using a colony counter in subdued light and the results were expressed as yeast and mould Colony Forming Units (CFU) per 1 gram of the sample as same as APC.

**Determination of *E.coli* Counts (SLS 516-12:2013)**

The MPN Technique was used to determine the level of *E. coli* in dried fish samples. Dried fish homogenate was transferred to Lauryl Sulphate Tryptone Broth (LSTB) tubes and incubated at 37 $^0$C for 48 hours and observed for growth and gas production. Samples from positive LSTB tubes were transferred to EC broth tubes and incubated at 37$^0$C for 24-48 hours, Samples from positive EC broth were inoculated into peptone water tubes at 44+1 $^0$C for 48 hours. Then the indole reagent was added to each tube and examine the red color has appeared to confirm the presence of *E. coli*.

**Determination of presence of *Salmonella* (SLS 516: part 5:2017)**

25 g of sample was homogenized and enriched with 225 mL buffered peptone broth at 37 °C for 24 hours. Selective enrichment of *Salmonella* was carried out. Rappaport vassilidis Soya (RVS) broth and Muller-Kauffman Tetrathionate novobiocin broth (MKTTn). Each of these enriched cultures was streaked in Xylose Lysine Deoxycholate (XLD) Agar and modified Brilliant Green Agar (BGA). Typical *Salmonella* exhibit pink colonies with or without black centers.

**Enumeration of *Staphylococcus aureus* (SLS 516-6-sec,1:2013)**

Using 10 g of sample and 90 mL of MRD initial suspension was prepared. One milliliter of the test sample was transferred in to Baird-Parker agar plates. Inoculum was carefully spread and plates were allowed to dry. Plates were incubated (FTC 90I, VELP Scientifica Refrigerated Incubator, Italy) at 37±1°C for 24±2 h and re-incubated for further 24±2 h. Five typical and atypical colonies were selected and from the surface of each selected colony was removed and transferred to BHI tubes. BHI tubes were incubated at 37±1°C for 24±2 h. 0.3 mL of rabbit plasma was added to 0.1 mL of each culture and incubated at 37±1°C. Clotting of the plasma was examined after 4 – 6 hours and results were expressed accordingly.

**Total Volatile Base- Nitrogen (TVB-N) content**

Initial Total Volatile Base Nitrogen (TVB-N) content of dried fish was determined by official steam distillation method (Analytical Methods Committee, 1979) and continued the analysis until the TVB-N content reach the maximum acceptable level for consumption (40 mg/100 g) and above that level fishery products are considered unfit for the human consumption (Kimura & Kiamukura, 1934). All determinations were done in triplicate and the mean value was reported.

**Physical examination**

Moisture content, water activity and visual observations (discolorations, mould growth) and other physical parameters such as texture and aroma were evaluated according to the Sri Lanka Standard 643:2007 for dried fish. All quantitative determinations were done in triplicates and the mean value was reported.

**Statistical analysis**

Proximate composition analysis and shelf-life analysis were replicated three times (n=3). Results represented are mean values of each determination ± standard deviation (SD). Analysis of variance was performed by one-way ANOVA procedures (SPSS 11.0).

Differences between the mean values of the treatments were determined by the least significant difference (LSD) test and the significance was defined at $p < 0.05$.

## Results

### Determination of optimum percentage salt content of brine

Table 1. The water phase salt values of wet brined fish and dried fish salted fish brine of different strengths

| Fish (n=3) | Salt % in brine | WPS% of wet brined fish | WPS% of dried fish (final product) |
|---|---|---|---|
| Goldstripe sardinella | 6 | 1.12±0.03 | 12.85±0.03 |
| | 7 | 1.42±0.12 | 16.34±0.06 |
| | 8 | 1.59±0.08 | 19.52±0.12 |
| | 10 | 5.27±0.11 | 30.00±0.05 |
| | 12 | 6.68±0.08 | 32.12±0.14 |
| | 15 | 9.07±0.15 | 33.15±0.16 |
| Talang queenfish | 6 | 1.21±0.14 | 11.43±0.11 |
| | 7 | 1.55±0.10 | 14.89±0.12 |
| | 8 | 1.65±0.08 | 17.82±0.05 |
| | 10 | 6.22±0.06 | 25.32±0.11 |
| | 12 | 7.55±0.03 | 30.15±0.04 |
| | 15 | 9.52±0.13 | 31.87±0.08 |

Table 2. Comparison of WPS values of low-salted dried fish and dried fish prepared according to the traditional method

| Treatment | WPS value of wet brined fish (n=3) | WPS value of dried fish (final product) (n=3) |
|---|---|---|
| Low salted Goldstripe sardinella | 5.27±0.11 | 30.00±0.05 |
| Low salted Talang queenfish | 6.22±0.06 | 25.32±0.11 |
| Goldstripe sardinella -Traditional method | 14.32±0.21 | 38.18±0.25 |
| Talang queenfish - Traditional method | 14.85±0.18 | 38.77±0.17 |

**Yield of dried fish**

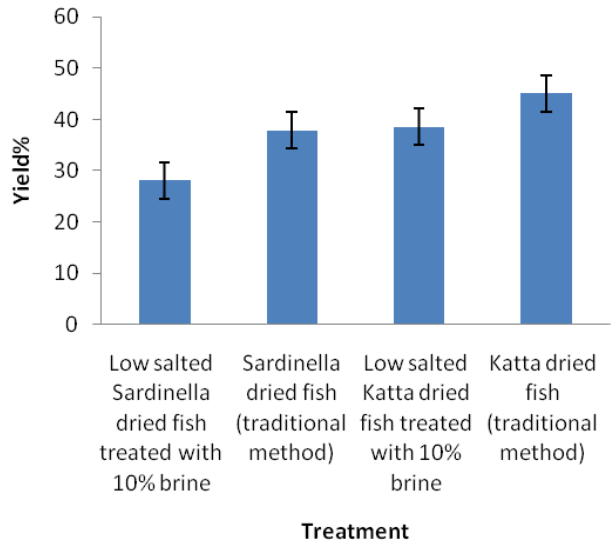


Figure 1. Yield of dried fish as a percentage of initial fish weight

**Sensory evaluation**

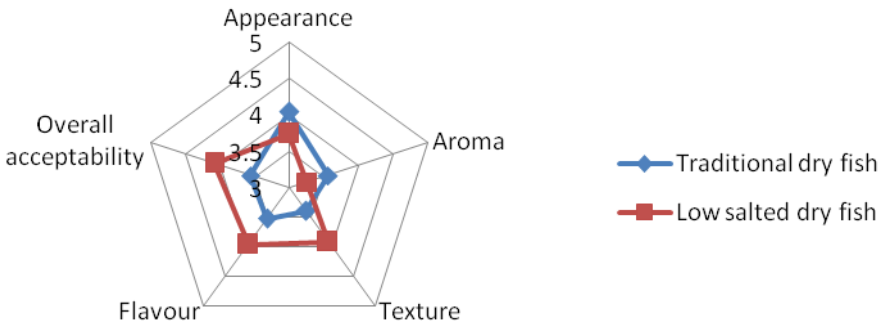


Figure 2. Comparison of sensory properties of Goldstripe sardinella dried fish prepared using low-salted method and traditional method

Flavor and texture of low-salted Goldstripe sardinella dried fish has scored a higher average score than Goldstripe sardinella dried fish prepared using traditional method. Aroma and appearance of low-salted dried fish has scored a less average score compared to dried fish prepared using traditional method. But overall acceptability for low-salted dried fish has scored a higher average score than traditional dried fish.

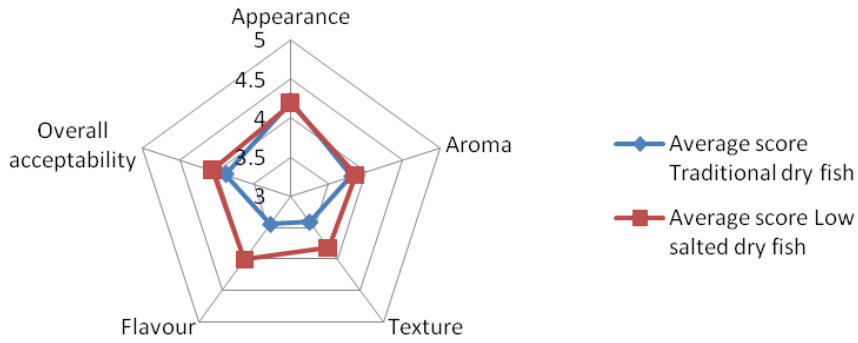


Figure 3. Comparison of sensory properties of dried Talang queenfish prepared using low-salted method and traditional method

Flavour, aroma and texture of low-salted dried Talang queenfish have scored a higher average score than dried Talang queenfish prepared using traditional method. Only the appearance of low-salted dried fish has scored a less average score compared to dried fish prepared using traditional method. But scores for appearance of both low-salted and traditional dried fish are not significantly different ($p>0.5$). overall acceptability for low-salted dried fish has scored a higher average score than traditional dried fish. From the results of sensory evaluation, it has been proved that low-salted dried fish has more preferable sensory attributes than the traditional dried fish.

**Determination of proximate composition**

Table 3. Comparison of proximate composition of dried fish (wet basis)

| Component (%) | Low salted dried fish | | Dried fish (Traditional method) | | Market samples | |
|---|---|---|---|---|---|---|
| | Talang queenfish | Goldstripe sardinella | Talang queenfish | Goldstripe sardinella | Talang queenfish | Goldstripe sardinella |
| Moisture | 26.01±0.12 | 27.32±0.14 | 27.87±0.16 | 27.54±0.18 | 38.39±0.31 | 37.38±0.21 |
| Protein | 56.30±1.57 | 48.27±1.18 | 45.15±2.28 | 37.17±1.34 | 27.87±0.68 | 31.23±0.85 |
| Fat | 2.74±0.14 | 7.30±0.39 | 2.61±0.19 | 7.14±0.62 | 2.75±0.11 | 6.65±0.31 |
| Ash | 12.41±1.63 | 14.54±0.82 | 19.64±0.28 | 15.63 ±0.74 | 19.86±0.32 | 15.75±0.25 |
| Salt | 6.53±0.15 | 8.54±0.54 | 12.73±0.31 | 12.33±0.61 | 14.83±0.35 | 13.32±0.25 |
| Acid insoluble ash by mass, on dry basis max | 1.04±0.86 | 1.15±0.85 | 1.19±0.28 | 1.34±0.32 | 3.21±0.21 | 3.02±0.30 |

**Initial microbiological analysis**

Table 4. Initial microbial counts of dried fish samples

| Treatment | APC CFU/g | Yeast & Mould CFU/g | Coliform MPN/g | *E. coli* MPNg | *Salmonella* /25 g | *S.aureus* CFU/g |
|---|---|---|---|---|---|---|
| Low salted Goldstripe sardinella | $3.82*10^4$ | 38 | 16 | 0.36 | absent | absent |
| Low salted Talang queenfish | $0.98*10^4$ | 29 | 15 | 0.24 | absent | absent |
| Goldstripe sardinella-Traditional method | $4.11*10^4$ | 25 | 21 | 0.36 | absent | absent |
| Talang queenfish - Traditional method | $1.13*10^4$ | 26 | 23 | 0.22 | absent | absent |

In both low-salted and dried fish prepared according to the traditional method, initial microbial counts were complied with the Sri Lanka Standard 643: 2007, specification for dried fish.

**Determination of shelf-life of low-salted dried fish**

**Change in water activity during storage**

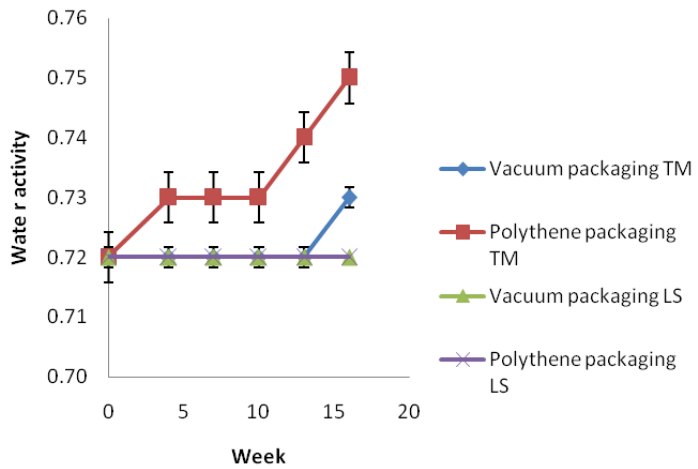


Figure 5. Changes in water activity of dried Talang queenfish during 4 months time under different packaging conditions (TM-traditional method; LS-low slated)

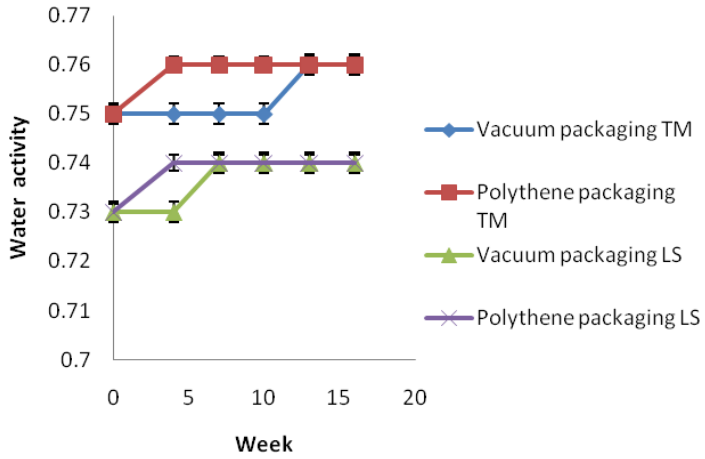


Figure 6. Changes in water activity of Goldstripe sardinella dried fish during 4 months time under different packaging conditions (TM-traditional method; LS-low slated)

**Determination TVB-N**

Table 5. Determination of TVB-N of vacuum-packed dried fish samples during 4 months time

| Month | Talang queenfish fish | | | Goldstripe sardinella fish | | |
|---|---|---|---|---|---|---|
| | Traditional method | Low-salted method | Market sample | Traditional method | Low-salted method | Market sample |
| 0 | 12.51±1.23 | 13.21±1.34 | 38.13±0.52 | 10.12±1.21 | 16.51±0.12 | 41.95±2.92 |
| 1 | 14.12±0.15 | 14.98±1.87 | 39.09±0.34 | 12.34±1.65 | 17.12±0.34 | 43.51±2.21 |
| 2 | 17.32±0.37 | 15.87±2.12 | 42.98±1.65 | 15.87±1.75 | 18.34±1.87 | 45.86±1.65 |
| Month 3 | 20.81±1.07 | 18.86±1.76 | 48.89±1.56 | 16.89±1.95 | 19.46±1.33 | 58.61±2.13 |
| Month 4 | 22.76±1.87 | 23.98±2.01 | 55.81±1.83 | 22.85±1.63 | 30.65±2.14 | 64.87±1.32 |
| Change in TVB-N value during storage | 10.25 | 10.77 | 17.68 | 12.73 | 14.14 | 22.92 |

**Physical examination of dried fish**

Table 6. Physical observations of dried fish (low-salted, traditional and purchased from market) kept open to environment

| Month | Talang queenfish fish | | | Goldstripe sardinella fish | | |
|---|---|---|---|---|---|---|
| | Traditional method | Low-salted method | Market sample | Traditional method | Low-salted method | Market sample |
| 0 | HM- ×<br>LS- ×<br>BB-× | HM- ×<br>LS- ×<br>BB-× | HM- ×<br>LS- ×<br>BB-× | HM- ×<br>LS- ×<br>BB-× | HM- ×<br>LS- ×<br>BB-× | HM- ×<br>LS- ×<br>BB-× |
| 1 | HM- ×<br>LS- ×<br>BB-× | HM- ×<br>LS- ×<br>BB-× | HM- ×<br>LS- ×<br>BB-× | HM- ×<br>LS- ×<br>BB-× | HM- ×<br>LS- ×<br>BB-× | HM- ×<br>LS- ×<br>BB-× |
| 2 | HM- ×<br>LS- ×<br>BB-× | HM- ×<br>LS- ×<br>BB-× | HM- √ (20%)<br>LS- ×<br>BB-× | HM- ×<br>LS- ×<br>BB-× | HM- ×<br>LS- ×<br>BB-× | HM- ×<br>LS- ×<br>BB-√(30%) |
| Month 3 | HM- ×<br>LS- ×<br>BB-× | HM- ×<br>LS- ×<br>BB-× | HM- √ (30%)<br>LS- ×<br>BB-× | HM- ×<br>LS- ×<br>BB-× | HM- ×<br>LS- ×<br>BB-× | HM- ×<br>LS- ×<br>BB-√ (40%) |
| Month 4 | HM- √ (30%)<br>LS- ×<br>BB-× | HM- ×<br>LS- ×<br>BB-× | HM- √ (40%)<br>LS- ×<br>BB-× | HM- ×<br>LS- ×<br>BB-× | HM- ×<br>LS- √ (30%)<br>BB-√ (30%) | HM- ×<br>LS- ×<br>BB-√ (50%) |

HM- Halophilic mould clusters, LS- Liver Stains, BB- Bursting of bellies

## Discussion

Dried fish is normally store under room temperature conditions. Water Phase Salt (WPS) value is directly related to water activity of a food item (Ross and Dalgaard, 2004). In order to store in room temperature and reduced oxygen conditions salted dried fish must have 20% WPS value (Fish and Fisheries Products Hazards and Controls Guidance, 2001). The water phase salt values of wet brined fish and dried fish samples are presented in Table 1. Fish soaked in 10% brine has resulted low-salted dried fish with WPS value higher than 20%. Therefore,10% brine was selected as the brine which provides the required WPS value at least salt concentration. In-order to store in room temperature conditions WPS value should be higher than 20%. Low-salted dried fish has WPS value higher than 20% and dried fish prepared according to traditional method has higher WPS values (Table 1).

Compared to dried fish prepared according to the traditional method has higher yield than low salted dried fish. Low-salted dried Goldstripe sardinella has a yield of 28.08% and dried Goldstripe sardinella prepared using traditional method has a yield of 37.86%. Low-salted dried Talang queenfish has a yield of 38.55% and dried Talang queenfish

prepared using traditional method has a yield of 45.08%. The weight loss in dried Talang queenfish is higher than Goldstripe sardinella fish. In Talang queenfish fish head should be removed and therefore the yield is less compared to Goldstripe sardinella as it is dried as whole fish. When salt content is higher water reabsorption rate is also higher. Therefore, the weight reduction is less in dried fish prepared using traditional method.

Protein % of low-salted dried fish is higher than the dried fish prepared from same fish batch, using the traditional method and some randomly purchased dried fish samples of same species. When salt content increases salt-soluble proteins are leached out and led to reduce the protein content. It has been found that in market samples protein content is very less due to excessive use of salt and during drying process. The recommended maximum acid insoluble ash percentage by mass on dry basis is 1.5% and both low-salted and traditional dried fish prepared for the study were complied with the standard. But dried fish samples purchased from market have shown higher values than the recommended range.

Water is the most abundant and important constituent of food and in terms of food safety. Its presence, quantity and nature determine many chemical and biochemical processes important for the control of product safety and quality. Water activity ($a_w$) is the partial vapor pressure of water in a substance divided by the standard state partial vapor pressure of water. The free or available water in a food supports microbial growth, and participates in and supports chemical and enzymatic reactions and spoilage processes. It is the amount of free water which is called $a_w$ and it is more important for food stability, chemical and microbial, than total water content. The recommended $a_w$ for dried fish is 0.75 or less. There is no difference in $a_w$ of low-salted dried Talang queenfish packed in polythene packaging and vacuum packaging throughout the storage time (4 months) and $a_w$ has remained unchanged. But $a_w$ of dried Talang queenfish prepared using the traditional method and packed in polythene bags has been increased from 0.72 to 0.75 during storage. There is no difference in $a_w$ of low-salted dried Goldstripe sardinella fish packed in polythene packaging and vacuum packaging throughout the storage time (4 months) but $a_w$ of both has increased from 0.01. Water activity of dried Goldstripe sardinella fish prepared using the traditional method and packed in polythene bags has been increased from 0.72 to 0.75 at the end of first month and remained unchanged for the rest of the time. Vacuum packed traditional dried Goldstripe sardinella also reached the same level as polythene packed at the end of storage.

The acceptable 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 & Kiamukura, 1934). Randomly purchased market samples have shown higher TVB-N values compared to low-salted and traditional dried fish prepared for the study. In dried Talang queenfish, prepared according to new low-salted method and traditional method

TVB-N contents were not significantly different ($p<0.5$) during storage time. But in dried Goldstripe sardinella fish TVB-N levels have shown a significant difference ($p>0.5$) in low-salted and traditional method during the storage time of four months.

TVB-N measurement indicates the extent of the breakdown of protein due to bacterial and enzymatic action leading to production of amines. 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 the spoilage. In small fish processing microbial invasions are higher due to visceral matter and gills than the large fish. When dip in saturated salt solution microbial activities are inhibited and therefore the formation of TVB-N gets suppressed. In- low-salted dried fish processing sudden inactivation of microorganisms does not happen as the strength of brine is low. But when properly dried ($a_w \leq 0.75$) microbial activities will be suppressed. Therefore, when processing low-salted dried fish, maintenance of hygienic conditions and initial quality of fish are crucial than the processing of dried fish according to the traditional method.

Figure 7. Solar dehydrator used to dry low-salted fish

Using a solar dehydrator low-salted dried fish production can be done under hygienic conditions. As the fish are not exposed to the outer environment when kept inside the drying chamber of solar dryer pest attacks and contaminations are limited.

According to the Sri Lanka standard for dried fish (SLS 643:2007) to be considered as defective 30% or more of the fish in the sample unit should be affected by any of the halophilic mold clusters, Liver stains (yellow or yellowish orange discolorations caused by the presence of liver) or severe burning due to overheating during drying.

In this study for each treatment and for each packaging physical examination were done for 10 pieces of dried fish. According to the Table 6, in dried Talang queenfish samples purchased from market halophilic mould growth has been started in the second month of storage (2 out of 10 (20%) of dried Talang queenfish pieces were found with mouldy patches). In dried Goldstripe sardinella fish purchased from market belly bursting had been started at the second month. 30% of Goldstripe sardinella fish were found with burst

bellies. At the end of four months time low-salted dried Goldstripe sardinella fish were found with 30% of liver stains and 30% of burst bellies. But in low-salted Talang queenfish no defect had been found at the end of four months time. In vacuum packed dried fish samples, no any defect had been found in any sample. In polythene packaging only 20% of low-salted Goldstripe sardinella dried fish were found with belly bursting. Low-salted Talang queenfish packed in polythene bags had not shown any defect during four months of storage.

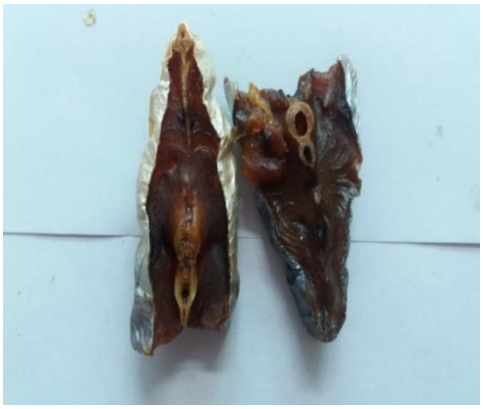

Figure 8. Physical appearance of low-salted dried Talang queenfish and dried Goldstripe sardinella at the end of four months of storage.

## Conclusion

This study reveals that using brine of 10% salt strength and soaking for 30 minutes, WPS value of dried fish can be brought to value of more than 20% which is safe to store at room temperature. The protein content of low-salted dried fish is comparatively higher than the dried fish prepared using the traditional method. With the time increment of water activity is lesser in low-salted dried fish than traditional dried fish. To avoid spoilage due to microbial activities it is recommended to dry low-salted dried fish inside a solar dryer under hygienic conditions. Low-salted dried fish which are polythene packed and kept under environmental conditions can be stored for more than three months maintaining the safe to consume status. To prolong the shelf life, it is recommended to vacuum pack the low-salted dried fish. Low-salted method is much more suitable for large fishes cut in to slices than for small fishes.

## Reference

Analytical Methods Committee. (1979). Recommended General Methods for the Examination of Fish and Fish Products.*Analyst*,**1238**.

Association of Official Analytical Chemists (AOAC). (1995). Official Methods of Analysis of the Association of Official Analytical Chemistry (16 ed.). Washington, USA: AOAC International.

Association of Official Analytical Chemists (AOAC). (2000). AOAC official method salt (Chlorine as Sodium Chloride) in sea food volumetric method. Association of Official Analytical Chemists. Washington, USA: AOAC International.

Association of Official Analytical Chemists (AOAC). (2005). Official Methods of Analysis of the Association of Official Analytical Chemistry (16 ed.). Washington, USA: AOAC International.

Balachandran, K. (2001). Post-Harvest Technology of Fish and Fish Products (Vol. 1). Daya Publishing House: Delhi.

BAM. (2007). In: Bacteriological Analytical Manual (Dec 2007 ed., p. 5). FDA.

Bibbins-Domingo, K., Chertow, G., Coxson, P., Moran, A., Lightwood, J., Pletcher, M., & Goldman, L. (2010). Projected effect of dietary salt reductions on future cardiovascular disease. New England Journal of Medicine, **362 (7):** pp 590-599.

Fish and Fisheries Products Hazards and Controls Guidance (2001). Food and Drug Administration. pp. 45318-45319

Khan, M. and Khan, Y. (2001). Insect infestation and preventive measures in dry fish storage of Chittagong, Bangladesh. *International Journal of Biological Sciences,* **1:** pp. 963-965.

Kimura, K. and Kiamukura, S. (1934). Detection of the onset of decomposition of fish meat as shown by the content of Ammonia. Pacific Science Congress, **5.**

Kimura, K. and Kiamukura, S. (1934). Detection of the onset of decomposition of fish meat as shown by the content of Ammonia. Proceedings of Pacific Science Congress, **5:** pp. 3709.

Ministry of Fisheries and Aquatic Resources Development (2015). Performance Report., Colombo, Sri Lanka.

Rao, S., Valsan, A., Kandoran, M., and Nair, M. (1962). Storage behaviour of salted and dried fish in relation to humidity conditions. *Indian Journal of Fish,* **9 (1):** pp. 156-161.

Ravichandran, S., Joseph, F., Kanagalakshmi, R., and Ramya, M. (2012). Variation in nutritive composition of two commercially important marine fin fishes. *British Journal of Biomedical Science,* **8:** pp. 43-51.

Ross, T. and Dalgaard, P. (2004). Modelling Microbial Responses in Foods. Boca Raton, CRC Press, USA.

Sanjeev, S. and Surendran, G. (1996). Fate of enterotoxigenic Staphylococci in fish subjected to curing. *Fishery Technology,* **33:** pp. 66-68.

Sri Lanka Standards. (1991b). Microbiological Test Methods, Part 2: Enumeration of yeasts and moulds, SLS 516: Part 2: 1991, Sri Lanka standards Institution, Colombo, Sri Lanka.

Sri Lanka Standards. (2007). Specification for dried fish, SLS 643:2007, Sri Lanka Standards Institution, Colombo, Sri Lanka.

Sri Lanka Standards Institution (SLS). (2013). Methods of test for Microbiology of food and animal feeding stuffs. Sri Lanka Standards Institution, Colombo.

Turan, H., Sonmez, G., Celik, M., Yalcin, M. and Kaya, Y. (2007). Effects of different salting process on the storage quality of mediterranean mussel (Mytilus galloprovincialis L. 1819. *Journal of Muscle Foods,* **18:** pp. 380-390.