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Immaculate Jeyasanta K
Suganthi Devadason Marine Research Institute, Tuticorin, India.

Sinduja Prakash
Suganthi Devadason Marine Research Institute, Tuticorin, India.

Jamila Patterson
Suganthi Devadason Marine Research Institute, Tuticorin, India.

Correspondence
Immaculate Jeyasanta K
Suganthi Devadason Marine Research Institute, Tuticorin, India.

Wet and dry salting processing of double spotted queen fish *Scomberoides lysan* (Forsskål, 1775)

Immaculate Jeyasanta K, Sinduja Prakash, Jamila Patterson

Abstract
During the present study, processing of wet and dry salting of fresh and delayed double spotted queen fish (*Scomberodes lysan)* was assessed. Freshly and 8 hours delayed processed salted fish *S. lysan* was sensorially acceptable. Fishes wet salted in 25% of brine had highest predicted yield, good quality and the pH and moisture content was acceptable (p<0.05). The Trimethylamine - Nitrogen and Total volatile base -Nitrogen contents increases was highly favored by percentage of salt and delayed salting process (p<0.05). Free Fatty Acid was very high in wet salted fishes with 10% brine (p<0.05) and the peroxide values heavily increased in 12 hours delayed and dry salted fishes than other wet salted fishes (p<0.05). The delayed salted fishes salted with lower concentration of brine had higher thiobarbituric acid content than other wet and dry salted fresh fishes (p>0.05).The total bacterial counts showed an increasing trend upon delayed salting.

Keywords: *Scombroides lysan*, wet and dry salting, Quality changes, Sensory changes

Introduction
Fishery resources are important sources of dietary protein in developing countries especially for the coastal communities. Fish is highly perishable and should be handled with great care to preserve natural attributes and prevent microbial proliferation [1]. Researchers confirmed that fish is a rich source of essential nutrients required to supplement both infant and adult human diets. Fatty fish species such as *Scombroides lysan* is popularly known as double spotted queen fish having high flesh content and good taste and high consumer demand in dried form. Double spotted queen fish is mainly stored in ice after catching and transferred to dry fish processing centers but in some cases due to lack of ice, fish may not be iced during transfer for several hours before salting. Exposure to atmospheric temperature during pre - salting period may accelerate the deterioration process. Fresh fish stored at atmospheric temperature for 12 hours becomes unsuitable for human consumption [2]. Salting and drying of such raw materials does not give good end product. Fish freshness is the most important and fundamental single criteria for judging the quality of fish and fishery products. The loss of freshness and quality depends on many factors including the fish species, handling condition and storage temperature [3].
Salting is one of the techniques for preserving fish and has been practiced for a long period of time; it is an alternative to lowering the water activity of fish flesh. There are two main types of salting methods namely dry salting and wet salting [4]. Quality loss of fish can occur very rapidly after catch [5]. Preservation of fish using salt in combination with drying has been known for thousands of years and it is a simple method that prolongs its shelf life. Considerable quantity of fish is processed into cured products in India [6]. On a global basis, 14 % of the marine landings are processed by curing [7]. In India, utilization of dried fish equal to fresh fish consumption and about 8 million tonnes of the world catch are being used for human consumption in the form of dried, salted, smoked or treated by some combination of these processes [8]. Curing is a simple and cheap method of processing requiring least technical expertise, but it has great significance and relevance in the socio economic system of small scale fisher folk. In India a large quantity of marine landings are being processed in to salted and dried products and it has good internal and export market. During the last few years there has been a decline in the export of Indian cured fishery products due to the poor quality of the dried fish [9] and this caused a considerable loss to the fish curing industry in India.

Salting combination with drying is an important preservation method still being used in several places around the world. In many developing countries salted and dried fish is an important source of low cost dietary protein. In coastal areas most of dried fishes processed from unsold fishes of the day. The main factors affecting the quality of dried salted fish is freshness of fish, salting method, salting period, brine concentration, nature of salt and drying kinetics [10]. Salting and sun drying reduces the water content, which means that many of water soluble vitamins may be lost or lowered, while most of the nutritional value remain the same [11].

In this study the physicochemical changes of fresh and delayed (exposed to atmospheric temperature for 4, 6, 8 and 12 hours) *S. lysan* processed by wet and dry salting were assessed by sensory, microbial and biochemical characters. The appropriate salting method among wet and dry salting was ascertained.

Materials and methods

Sample preparation and processing

One hundred and fifty fresh *S.lysan* samples with an average length of 23 - 25cm weighing approximately 350g, harvested on August 2011 were procured from Tuticorin fish landing center (13˚ 19' 06" N / 93˚ 04' 24" E) and brought to the laboratory for analysis. The species identification was confirmed using the FAO species identification guide [12]. Fishes were washed in potable water to remove slime, blood and other extraneous matter. To study the effect of preprocessing delay on the quality of the fishes the samples were divided in to five lots each with 30 fishes. One lot was iced immediately in a proportion of 1:1 fish to ice and the rest of the four lots were exposed to atmospheric temperature of 28 to 31 °C for 4, 6, 8 and 12 hours. The effect of salting on the same samples and its quality was assessed.

Salting method

Fishes were gutted by opening the belly and remove the intestine, washed under running water and subjected to wet and dry salting for 48 hours. Salting was done as per the method explained by the Bureau of Indian standard specifications [13]. For wet salting fresh and delayed fishes were immersed in 10, 20, 25, and 33% of brine solution in separate containers. For dry salting, crystal NaCl was spread on the fishes in the ratio of 1:1 (W/W) and kept for 48 hours [14]. After salting the wet salted fishes was towel dried and excess of salt was eliminated in dry salted fishes before analysis. The sensory characters and the microbial and biochemical parameters such as moisture, pH, Salt, Total plate count, Peroxide Value, Thiobarbituric acid, Trimethylamine - Nitrogen and Total Volatile Base Nitrogen were analyzed in triplicates.

Sensory evaluation

For sensory analysis, triplicate samples from all the lots were taken at regular intervals and analysed according to the guidelines presented in (Table.1) [15] by the trained persons. The appearance of skin, colour, clarity and shape of eyes, texture, gill colour and slime appearance were assessed. The samples scoring 3 or above were considered acceptable for human consumption.

For salted fish, the sensory evaluation was determined according to the guidelines and presented in Table 2. The appearance, colour, odour, texture, taste and aroma were checked by the taste panel using the acceptability grade of 1 - 5. Samples scoring 3 or above were considered acceptable for human consumption.

Chemical analysis

Samples drawn and analyzed at different stages of processing were performed in triplicates. Moisture content of fish was determined using the standard AOAC procedure [16] in hot air oven set at 100 ˚C ± 0.5 °C. Salt content of the fish sample was determined titrimetrically using Silver nitrate solution as described by [17] and expressed as percentage of salt. The total volatile base nitrogen (TVB-N) and the trimethylamine nitrogen (TMA-N) contents were determined by the Conway micro diffusion method [18]. pH analysis was done by the method of [19] using HANNA pH213 microprocessor pH meter. Free fatty acids (FFA) of the samples were estimated by the method described by [20] and expressed as percentage of oleic acid on lipid basis. Lipid was extracted by [21] method. Peroxide value expressed as meq of peroxide oxygen / kg fat, was determined according to the method [22]. Thiobarbituric acid (TBA) (mg malondialdehyde/kg fish flesh) was determined according [23].

Microbial analysis

Total Plate count

25 grams of fish samples were taken from each stage of processing and homogenized with 225 ml of sterile physiological saline. Serial dilutions were carried out with the same diluents. The diluted suspensions were spread plated on the plate count agar (Hi media, India) supplemented with 10% NaCl [24].

The plates were incubated for 24 to 48 hours at 37 °C. The number of colonies developed on the plates were counted as total bacterial count and expressed as CFU/g. The isolated bacterial strains were grown in salt concentration of 10, 20, 25 and 33% of brine and dry salt in Plate count agar medium for at least 3 days. Bacteria survived in 10 - 33% NaCl indicating that they could survive both at high and low salt concentration.

Results and discussion

The term quality refer to the sensory characteristics of a product, such as its appearance, flavour, odour and texture but it can also indicate changes in microbial, biochemical and autolytic characteristics. Death initiates a series of deteriorative changes resulting in spoilage [25] and these changes can be accelerated by temperature. Temperature is one of the important factor influencing spoilage, chemical reactions, enzymatic activity and bacterial multiplication [26]. Therefore it has been suggested that no single spoilage or freshness indicator for fish can be used, but rather a combination of selected indicators that represent the different changes occurring during spoilage [27]. In the present study also a combination of sensory assessment, bacterial count and degradation of proteins and nitrogenous compounds indicated by TMA-N and TVB-N, lipid hydrolysis were assessed by FFA, primary and secondary lipid oxidation by PV, TBA and physiological changes such as pH and moisture.

Sensory assessment of fresh fish

Sensory assessment of fish is the most convenient and successful method for fish freshness determination [27]. Once fish is caught, it loses its natural resistance to attack by microorganisms and it starts to undergo physical and chemical changes that cause changes in appearance, taste, smell and texture. The changes in sensory properties of *S. lysan* exposed

to 28 to 30 °C for 4, 6, 8 and 12 hours duration and fresh fish changes were noted based on the scores sheets of Table 1 and 2. The average acceptability scores were taken from the mean of 5 sample and the results are shown in Table 3. The *S.lysan* iced immediately after harvest having fresh sea weedy odour, shiny appearance, stiff texture, bright convex eyes and intact belly was considered as excellent and scored 4.95. Changes in sensory scores (except in the gills) for *S.lysan* after 4 hours of delayed fishes had sea weedy odour, slightly flat eyes and intact belly, slight loss in firmness with brown slime with a score of 4.4. A loss in quality was noticed after 6 hours delay with loss of odour, slight soft texture, slightly rancid and pinkish red gills with milky slime had a sensory score of 3.79. *S.lysan* became deteriorated after 8 hours exposure to atmospheric temperature of 28 to 31 °C, with slight putrid odour, loose texture and black discolouration in belly and had a sensory score of 2.84. After 12 hours exposure to atmospheric temperature, fish became totally spoiled with putrid odour and very soft texture, rapid decline and scored value 1. A similar observation was made in Nile perch stored at ambient temperature (20 – 30 °C) spoiled rapidly and was unacceptable for human consumption after 11 hours [28]. Jeyasekaran and Saralya [29] have observed loss of freshness and onset of spoilage in white sardine after 8 hours of exposure to atmospheric temperature. Nile tilapia fish (*Oreochromis niloticus*) was rejected after 11 hours of ambient storage with a development of putrid odour, bitter and itchy flavor [30]. Jamilah and Yusoff [31] have reported the acceptability of big head carp (*Fristichthys nebilis*) after 12 hours of storage at ambient temperature. Acceptable shelf life of common carp (*Cyprinus carpio*) was reported to be 8 hours [32]. In the present study panelist gave excellent scores for fresh fish while 8 and 12 hours delayed iced fishes had a fair and bad sensorial scores.

Table 1: Sensory score sheet for fresh fish

Quality attributes	Sensory scores
Fresh fish Odour, Flavour characteristics of species, Very fresh, firm flesh, shiny skin, Black pupil, bright red gills with little mucus, Clear bright convex eyes, Seaweedy odour, Intact belly, clear translucent slime.	5
Reasonably firm, some loss of resiliency, Slight bleach skin, neutral odour, opaque pupil, red colour gills with some mucus slightly flat eyes, slightly intact, brown slime.	4
Slight off odour/Flavour such as garlic, Bready sour, Fruity, grey pupil, slightly rancid, slight soft texture, discolouration, sunken eyes, pinkish red gills milky slime.	3
Soft texture, faded colour, putrid odour/Flavour such stale cabbage, loose texture, brown colour gills covered with mucus, black discolouration of belly, concave eyes, very soft, Dark brown pupil.	2
Excessively- soft texture, very strong off odour, rancid flavour such as NH_3, putrid, cloudy eyes, blackish brown gills, distinct discolouration, belly burst, cloudy slime, Discoloured pupil.	1

Table2: Sensory score sheet for salted and sun dried fish

Quality Attributes	Sensory scores
Salted and dried fish	
Very firm texture, complete dryness, straw yellow colour, slight dry fish odour, no discolouration, No salt to palate, no detectable rancidity, Excellent flavour, excellent general acceptability.	5
Firm texture, dryness, no discolorations, Slight loss of fishy odour, slight salt, slightly detectable rancidity, good flavour, and good general acceptability.	4
Fairly firm texture, dryness, no discolourations, no-off odour/flavour, and acceptable salt, medium rancid, medium general acceptability.	3
Soft texture, loss of dryness, slight medium flavour, discolouration, slight off odour, slightly too salty highly rancid, slightly undesirable flavour, bad general acceptability.	2
Very soft texture, loss of dryness, yellow or black discolorations, putrid odour, rancid sour, too salty, salt deposit on the surface, Extremely rancid, undesirable flavour, general acceptability was very bad.	1

Table 3: Comparative Sensory acceptability of *S.lysan*

Quality parameters	Fresh fish	Delayed for 4 hours	Delayed for 6 hours	Delayed for 8 hours	Delayed for 12 hours
General appearances	4.98^{b}	4.31^{b}	4.00^{b}	3.33^{c}	1.0^{d}
Texture	5.00^{a}	4.22^{b}	4.00^{b}	3.67^{c}	1.0^{d}
Gill appearances	5.00^{a}	4.33^{b}	3.33^{c}	2.1^{d}	1.0^{d}
Gill odour	5.00^{a}	4.67^{b}	3.67^{c}	2.1^{d}	1.0^{d}
Eye colour	4.95^{b}	4.50^{b}	3.95^{c}	2.84^{d}	1.0^{d}

Physicochemical parameters of wet and dry salted *S. lysan*

The physicochemical parameters such as moisture, pH, and salt, TMA-N, TVB -N, FFA, PV, TBA and TPC were assessed in wet and dry salted fresh as well as delayed (exposed to atmospheric temperature for few hours) fishes of *S. lysan* and variations were observed in the parameters during salting.

Moisture

The moisture content of delayed fish wet salted in 10 to 33% brine, did not decrease. This clearly reveals the fact that the moisture content does not substantially decrease with the delay of processing. In the case of fresh fish the moisture content decreased with the increase of the percentage of brine in wet salting (Fig. 1). The moisture content varied in wet salted fishes with higher percentage of brine and it was acceptable in fishes wet salted with 25% brine than the other wet and dry salted fishes ($P < 0.5$). Dry salting produced considerable loss of constituent water due to heavy uptake of salt leads to very tough texture and high salt content retain in the flesh, our result agreed with the result of Sikorski [33]. Salt uptake of fish and water exudation from fish is mutually dependent and in low salt concentration the salt uptake and water release are slow [34]. The moisture loss and salt uptake depends upon the freshness and quality of the fish. Salting of spoiled fishes leads

to lower water loss and lower salt uptake than in fresh fish [35]. In higher concentration of salt the amount of water exudation is more, resulting in very lower moisture content in fish flesh [36].

The moisture content is an exact indicator of the susceptibility of a product to undergo microbial spoilage [37]. It has a potential effect on the chemical reaction rate and microbial growth rate of food product. At low moisture level (<10) enzymatic activity of bacteria and yeast is prevented [38]. Salting or brining of fish is a preservation technique which reduces the moisture content in the fish flesh. Salt penetrates into the fish muscle by dialysis mechanism, and water is diffused out by osmotic pressure [39]. Fresh *S. lysan* had a moisture content of 79.91% and it decrease minimally with delay in processing. In the present study it was observed that 12 hours delayed to processed fish having the moisture content slightly reduced to 77.05% and the texture became loose with water oozing out.

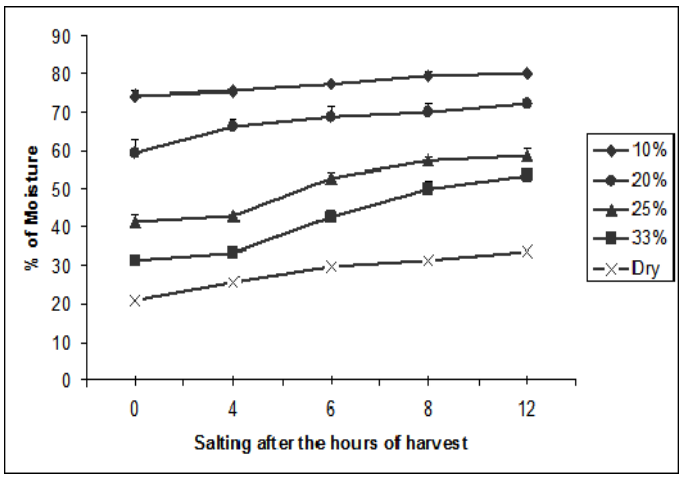

Fig 1: Moisture content of the wet and dry salted *Scomberoides lysan*

pH

pH in fresh fish is almost neutral. The pH 7.35 is the upper limit of acceptable as described by Asian food handling newsletter [40]. The pH of fish has been suggested as a good index of freshness [41]. Variation of pH in wet and dry salted fresh and delayed fishes is represented in Fig. 2. In six hours delayed fishes brined in 10% brine, the pH exceeds the acceptable limit. Further delay too enhances the pH level of the fishes (P <0.05). Fresh fishes wet salted immediately after harvest in 25% of salt, the pH was very low and acceptable than the other wet and dry salted fishes. In the delayed processed fishes, wet salted in 10 % brine, the moisture did not reduce properly and due to the spoilage and the increases of pH in the fish. The post mortem change in the pH of fish muscle has an effect on the physical properties of the muscle texture. pH of the fish meat gives valuable information about the condition of fish [42]. In 12 hours delayed fishes, the pH increased in wet and dry salting but it was found to be lower in 25% brined fishes than other salted fishes even though it exceeds the acceptable limit. During later post mortem changes, pH increases slightly because of the formation of alkaline compounds [43]. During post mortem period, decomposition of nitrogenous compounds leads to increases in pH in the fish flesh. In our result on the basis of sensory evaluation, 12 hours delayed fish is spoiled and unacceptable for human consumption.

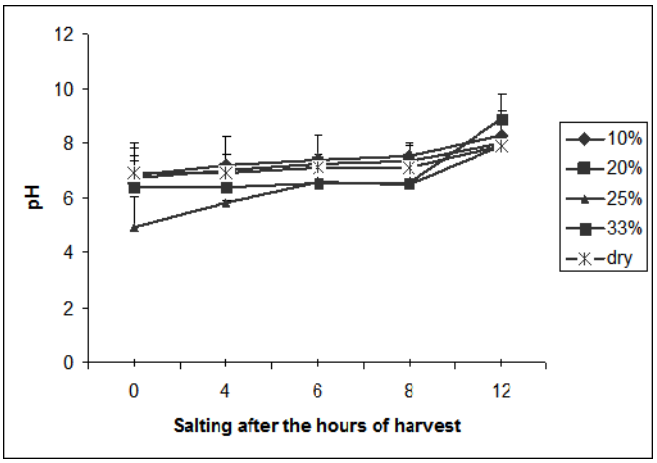

Fig 2: pH of the wet and dry salted *Scomberoides lysan*

Salt content

The percentage of salt among the wet and dry salted fish, the salt content of the fish wet salted in 25% brine were acceptable in all the fresh and delayed salted fishes (Fig. 3). Enhancing the spoilage of fish due to delayed salting decrease the salt uptake in wet and dry salted fishes (P<0.05). The brine concentration showed an important effect on the rate of salt diffusion in to the muscle, leading to quality change during salting [44]. Salt penetrates into *S. lysan* muscle by osmotic pressure. The rate of salt uptake and water release depends on the differences of salt concentration and quality of the fish muscle [45]. The main features of salting are the removal of some of the water from the fish flesh and its partial replacement by salt [46]. During salting salt uptake and water exudation are mutually dependent.

Salting of fresh fish leads to a higher water loss and limited salt uptake. In the fishes exposed to atmospheric temperature for several hours, rapid protein denaturation and coagulation occurs preventing further penetration of salt in to fish muscle and giving rise to a condition known as salt burn [47]. Crean [34] and Zuggaramundi and Lupin [48] reported similar results in different species of fishes.

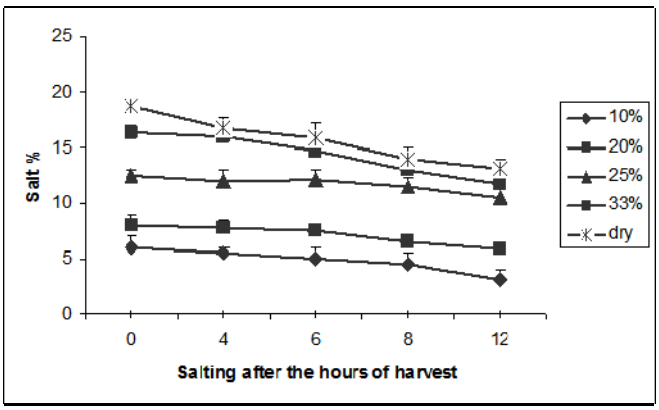

Fig 3: Salt content of the wet and dry salted *Scomberoides lysan*

Trimethylamine nitrogen (TMA-N)

Trimethylamine oxidase produced by spoilage microorganisms reduces trimethylamine oxide in fish flesh to trimethylamine, which is believed to react with fats to produce the typical spoilage [49].

The TMA-N content of fresh *S.lysan* and those delayed for 4, 6, 8 hours were 0.35, 6.7, 8.2, 11.85 mg % and it increased to 21.44 mg % in 12 hours delayed fish (Fig. 4); it is observed

that the increase was above the acceptability limit of 10 -15 mg % [50]. The TMA-N contents increased with the increase of percentage of salt and delayed hours of salting ($p < 0.05$). Fresh fish normally contain between 0.2 and 2.0 mg % TMA-N and development of TMA-N primarily depend on the content of substrates, trimethylamine oxide (TMAO) in fishes [51]. The formation of TMA-N is related to many factors such as difference in species, bacterial growth, processing methods and storage condition [52].

Salting enhanced TMA-N formation by many folds, similar to that observed with TVB-N content and maximum TMA-N was observed in *S. lysan* when delayed for 12 hours. In fishes salted in 10 and 20% of brine, partial dehydration occurred and the TMA-N level was found to be high. TMA-N level also increased gradually with salting but the rate of increase of these values decreased with the increase in salt concentration [53]. But no significant decrease was observed in *S. lysan* treated with saturated salt and dry salt.

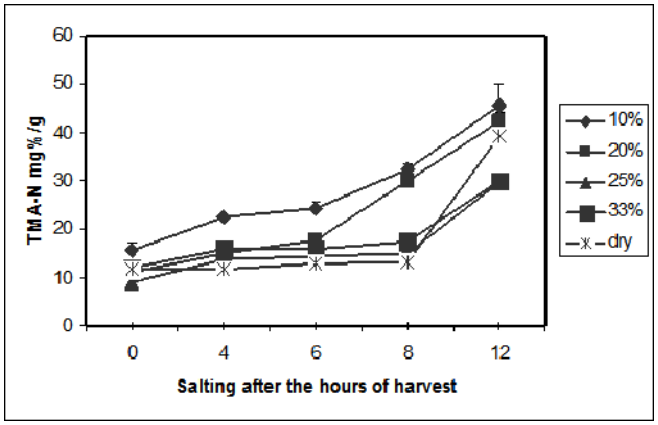

Fig 4: TMA-N content of the wet and dry salted *Scomberoides lysan*

Total Volatile Base Nitrogen (TVB-N)

TVB-N is produced from degradation of protein and non protein nitrogenous compounds mainly as a result of microbial activity. It is a product of bacterial spoilage and their contents are often used as an index to assess storing quality and the shelf life of seafood [33]. TVB-N formed due to the liberation of ammonia through deamination of adenosine monophosphate (AMP) by autolytic enzymes. Level of total volatile nitrogen in fish is commonly used as a spoilage indicator [54]. TVB-N measurement indicates the extent of the breakdown of protein due to bacterial and enzymatic action leading to amine production causing low nutritional value of the product.

Fresh and 4, 6, 8 and 12 hours of delayed *S.lysan* wet and dry salted with different percentage of brine. In dry salted fishes the TVB-N content increased with the delay of salting the fishes (Fig. 5). From the result, it is understood that the formation of volatile base nitrogenous compounds is highly favored by delayed salting process and it had brought about manifold increase in TVB-N contents. The highest content of TVB-N was recorded in 12 hours delayed wet and dry salted *S.lysan* samples ($p < 0.05$) compared to other treatments and the differences is due to partial dehydration of dried samples [55]. TVB-N values increased gradually with delay in salting period but the rate of increase of these values decreased with the increase in salt concentration. Only slight variations of TVB-N values were observed in samples brined with 25, 33% of brine and dry salted. Similar results were observed by Jeyashakila *et al* [56] and Nooralabettu [53].

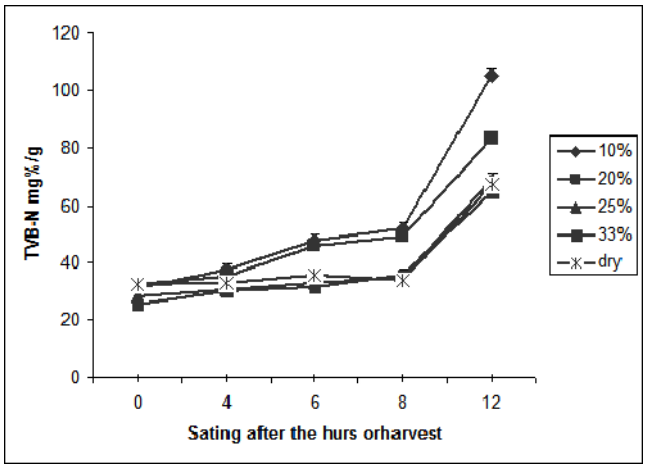

Fig. 5: TVB-N content of the wet and dry salted *Scomberoides lysan*

Free Fatty Acid (FFA)

Lipid hydrolysis is more rapid at high ambient temperature than during storage in ice. High level of free fatty acid is an indication of microbial spoilage activity. Most fat acidity begins to be noticeable to the palate when the free fatty acid value of oleic acid is about 0.5 - 1.5% in the fish lipid, but the acceptable limit of FFA was 2 - 5% [57]. In dead fish, lipases from internal organs might be released into muscle, where lipids are localized. In delayed fishes there is an increase in the release of lipases in to the muscle. During preparation such as eviscerating, filleting and washing, some enzymes might be discarded but some are still associated with muscle. When the fish was subjected to salt the remained enzyme was reactivated and hence lipid hydrolysis took place and resulted in the formation of free fatty acids [58]. Accumulation of FFA has detrimental effect on ATPase activity, protein solubility relative viscosity. This results in texture deterioration due to the interaction with proteins and also with lipid oxidation [59].

The variation in FFA in wet and dry salted *S.lysan* is graphically represented in (Fig. 6). The percentage of FFA in wet salted fresh *S.lysan* at 10% brine was 2.2 / g fat and it reduced with the increase of brine concentration for wet salting but with the delayed fishes, FFA was very high in wet salted fish with 10% brine ($p < 0.05$) and it was not reduced with increasing the brine concentration. Fresh fish has low FFA and it increases in delayed fishes due to the factors of high temperature and autolytic bacteria and these factors catalyses lipolytic activity and release FFA from glycerides and phospholipids. Ozogul *et al* [60] have reported that there is an interrelationship between FFA release and loss of freshness.

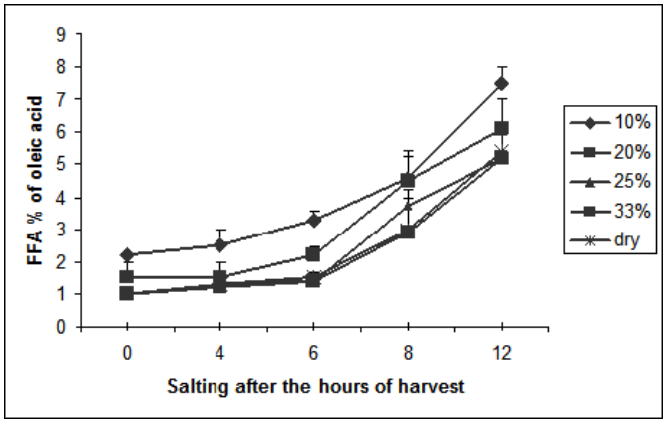

Fig. 6: FFA content of the wet and dry salted *Scomberoides lysan*

Peroxide value (PV)

The Peroxide value (PV) is used to measure the primary lipid oxidation especially hydro peroxides. These are mainly due to chemical changes in muscle tissue as a result of a wide range of factors particularly the nature of lipid, the process involving oxidation of unsaturated fatty acids or triglycerides in fish [61]. Factors that may influence lipid oxidation are microbial spoilage, biochemical substances and environmental conditions [62]. In this study fresh fish had a PV value of 2.09 meq / kg of fat and it increased with delay of hours and after 12 hours of delay it increased to 14.36 meq/kg of fat but the value is within the acceptable limit of 10 - 20 meq / kg of fat [63]. In fish wet salted in 10 to 33% of brine after 0, 4, 6, 8 and 12 hours of harvest, the PV value increased with the delaying hours of salting (Fig. 7). The PV value heavily increased (80.21 meq/kg) in 12 hours delayed dry salted fishes than other wet salted fishes ($p < 0.05$). Variation of PV observed in between salting may be due to start the secondary oxidation reactions of the carbonyl compounds and volatilization [64]. In the present study, peroxide value increased with the increase of salt concentration because PV showed an inverse relationship with salt concentration [65]. Increase in the concentration of salt favors the formation of peroxides, which in turn inversely correlates with the quality preference [53]. Rhee and Ziprin [66] have demonstrated that addition of salt to be pro-oxidative to promote lipid oxidation. Dry salted fishes produced higher PV throughout the salting period compared to wet salted fishes. This was probably due to restrictions of oxygen access by immersion retarding the rancidity reaction [39]. The highly unsaturated lipid in fat rich fish is easily susceptible to oxidation that results in a rancid smell and taste as well as alteration in texture, colour and nutritive value [47]. Our results showed primary lipid oxidation limited up to 8 hours delayed fish with wet salted in 25% brine. Similar lipid oxidation trend was observed by [67] in dried grouper. Atayeter and Euroskum [65] have found similar results in European squid.

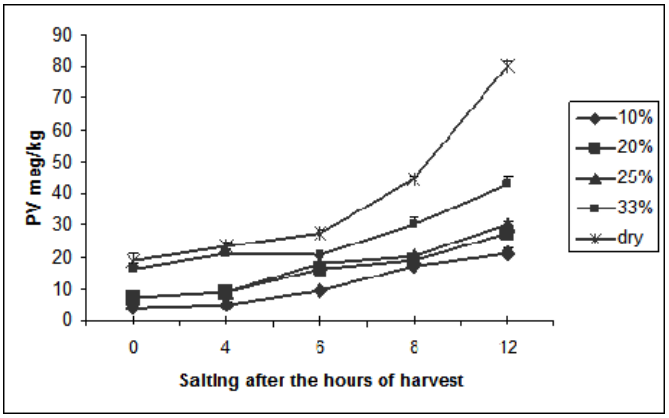

Fig. 7: Peroxide value (PV) of the wet and dry salted *Scomberoides lysan*

Thiobarbituric acid (TBA)

TBA is widely used as an indicator for the assessment of degree of secondary lipid oxidation. Even though hydro peroxidases are odorless and flavorless compounds and not related directly to the actual sensorially objectionable rancification and discolouration, the final dried products might later lead to objectionable secondary reactions [68]. *S.lysan* lipids are highly susceptible to oxidation because they contain 50 - 60% of polyunsaturated fatty acids including 15 -18 % eicosapentaoic acids (EPA) and 35 - 38% docosahexaenoic acid (DHA). The oxidative breakdown of lipids is also evidenced by the incidence of high TBA values in the respective samples. Generally the increase in TBA indicated the formation of secondary oxidation products such as aldehydes and other volatile compounds [69] responsible for rancid flavour and off odors as well as colour and texture deterioration. The oxidative breakdown of lipids is also evidenced by the incidence of high TBA values in the respective samples. In our present study fresh *S. lysan* having the initial value of TBARS was 0.234 mg MDA/kg of flesh, suggesting that in fresh fish secondary lipid oxidation did not occur during post mortem handling. To some extent, slight increase in TBA number was observed during delayed time in all the samples to reach 6.070 mg MDA /kg in flesh. TBA value for *S.lysan* samples delayed for 4, 6, 8 and 12 hours were higher than the immediately iced samples (Fig. 8). Among the wet and dry salted fresh *S.lysan,* higher TBA was observed in wet salted fishes at 10%. The delayed salted fishes had higher TBA content was observed both in wet and dry salted fishes ($p > 0.05$). The lower salt concentration promotes lipid autooxidation [70]. The increase in TBA value during processing may be attributed to the partial dehydration of fish and to the increase of oxidation of unsaturated fatty acids as a result of drying in sunlight. Occurrence of bad taste and aroma are due to the oxidation of lipids including unsaturated lipid and PUFA and defined as rancidity. TBA values of less than 3 mg malanaldehyde/kg of sample are considered to indicate good quality fishery products [71]. Antonios *et al* [72] suggested the brine salting treatment had a significantly lower level of lipid oxidation which may be attributed to treatment of the fish by soaking in dilute mixture of NaCl before drying. The TBA values were within acceptable level up to 8 hours of delayed fishes.

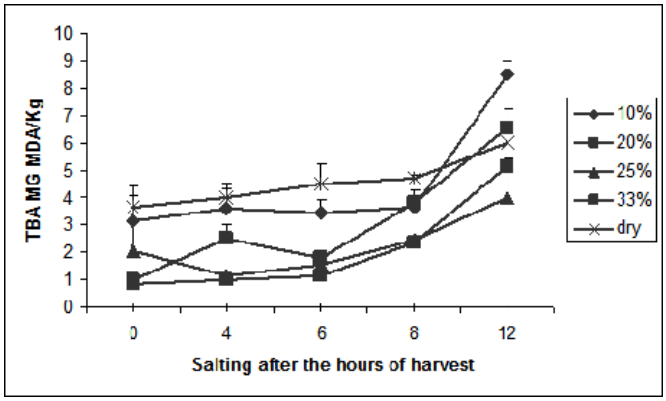

Fig. 8: Thiobarbituric acid (TBA) value of the wet and dry salted *Scomberoides lysan*

Total Plate Count (TPC)

The total bacterial load of fresh *S.lysan* was 4.5×10^5 CFU/g, which remained the same (10^5) in *S.lysan* delayed salting up to 6 hours. The total bacterial load of 10^4 - 10^5 CFU/g in fresh fish was recorded by [73] & [56]. The counts increased consecutively after 8 and 12 hours delay and reached 5.1×10^6 CFU/g and 2.2×10^9 CFU/g respectively. Ababouch *et al* [74] have found that TPC in sardines held at ambient temperature increased upon storage and reached a maximum of 10^8 CFU/g after 24 hours. The total bacterial counts showed an increasing trend upon salting.

In the present study the bacterial count varied widely in the raw material delayed for 4 to 12 hours, but differences were

observed during salting. This is in accordance with previous studies [75]. Due to the bacterial load in fresh and delayed fishes, it was prevalent in salt cured fresh and delayed fish too. Sensory panelist's detected musty odour in 12 hours delayed fishes. Spoilage bacteria causing a musty off-odour being sensory detectable at approximately 10^6 - 10^7 CFU/g of fish [76]. High salt concentration impedes the growth of spoilage microorganism. Only halophilic microorganism can grow in high salt concentration [77].

Conclusion

The physicochemical changes of *S. lysan* muscle during salting depended on the delayed salting and salting method. The dry salted fish had very tough texture and salt was deposited on the surface. Fish wet salted in 25% of brine were of better quality than dry salted. The concentration of salt, pH, TVB-N, TMA-N, were higher in salted fishes but due to oxidation and hydrolysis of lipid, FFA, PV and TBA were lower and it was within the acceptable limit in fresh fish and within 8 hours of delayed fishes. Immediate icing before curing is a recommended necessary for a best final product.

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