Chapter 4

FISH SALTING METHODS
4.1. Introduction

Fish is a highly perishable item and it contains various nutrients and minerals. So it is important to preserve the fish without any nutrient loss and spoilage. The lowering of the water content reduces speed of spoilage of fish. So, fish is preserved for a long time at normal conditions without any damage to the product. Also high quality fish nutrient can be supplied (Anon., 1981) to all at low cost if it is preserved properly. Fish salting is a traditional method of preserving fish by simply using common salt followed by drying in sunlight. There is not much expenditure involved in this method and any body can easily study and adopt the same with in minimum period of time.

4.1.2. Methods of salting

Fishes are cleaned with or without head depending upon consumer acceptance. The gut portion is removed and washed to remove blood clots and adhering membrane (Moorjani, 1971). Balachandran & Muraleedharan (1975) suggested that the salting must be done only after cleaning of fish without gills, gut, etc. Dressing and cleaning cause fast salt penetration (Syme, 1966; Valle, 1974; Mendel sohn, 1974; Anon., 1980, FAO., 1975 and Hansan, 1983). Govindan, (1985) reported the process of dressing and cleaning of fish and various methods of salting. Length or thickness of fish pieces has to be reduced so that salt can easily penetrate into the muscle. The suitability of salt depends upon several factors - the chemical composition (Klaveren & Legendre, 1965; Anon., 1982), the microbiological purity (Anon., 1982), and the physical property (Tressler & Lemon, 1951, Anon., 1982). Salt penetration is complicated due to the presence of scale, skin and fat (Doe, 2000).

4.1.3. Dry salting method

Extensive reports are available on different salting Methods (Syme, 1966; Seno, 1974; Gerasimov & Antonova, 1979; Anon., 1982). The survey along the Madras coast showed 1: 4 to 1: 6 salt to fish ratio (Srinivasan & Joseph, 1966, Joseph et al., 1986).
Antony & Govindan (1983) used 1:5 salt to fish for lizard fish. Kalaimani et al., (1988) suggested 25% salt for salting. 1:1 salt to fish for anchovies was suggested for sun drying by Reddy et al. (1991). 1:4 salt to fish was recommended for salting of thread fin bream, Jew fish, shark and mackerel (ISI, 1967a, 1967b, 1969, 1974, Keay, 1986). Thomas & Balachandran (1989) reported that 1:3 to 1:10 salt to fish depending on the size of the fish. Generally it was reported that people of Kerala use 1:4 salt to fish and Tamilnadu people use 1:5 salt to fish and salting time is 12 to 24 hours (Thomas & Balachandran, 1989). Salt contributes flavour at lower concentration and is a bacteriostatic at higher concentration (Daun, 1975). Sikorski et al. (1995) stated that salt penetration during dry salting is critical and fast depending on several factors. He further suggested that the finely grained salt rapidly dissolve in fish muscle fluid causing a too rapid withdrawal of moisture.

4.1.4. Wet salting of fish

5% brine is used for salted anchovies, saturated brine for salted and pressed Decapterus sp., shark and ray (Srinivasan & Joseph, 1966; Prabhu & Kandoran, 1991; Shetty et al., 1991; Sankar & Solanki, 1992 and Gupta & Chakrabarti, 1994). Ragulin (1958) reported that wet salting is more effective than dry salting and salt penetration is fast in wet salting. Anon. (1982) discussed about various wet salting methods. Sikorski et al. (1995) describes the use of saturated brine for fish preservation.

4.1.5. Physico-Chemical properties of salting

Weight loss in ribbon fish during dry salting, yield of mackerel and weight loss in wet and dry salted mackerel and weight loss in Anchovies in the initial 4 and 8 hours were reported by Cutting (1961); Valsan (1976): Seno, (1974) and Ragulin (1958). Salting is reported to change structural and mechanical feature of muscle tissue (Stansby, 1963; Voskresensky, 1965 and Anon., 1982). In fish, rapid loss of weight takes place in the first day and salt content rises to about 18% of wet tissue (FAO., 1957;
Anon., 1965). The uptake of salt by fish depends on different factors namely the fat, thickness, freshness and temperature of fish (Stansby 1963; Anon., 1982). The salt uptake is slower with high fat content and thickness or temperature (Anon., 1982). The freshness of fish has inverse relation to salt uptake while temperature has got a direct relation (Sankar & Solanki, 1992).

Moisture loss was high during initial period in dry salted shark, but the loss was less during the subsequent salting period (Kandoran et al., 1965; Kandoran et al., 1969; Chakrabarti, 1988; Chellappan, 1989 & 1991; Ramachandran & Solanki 1991). Krishnakumar et al. (1986) reported the lowering of pH in sardine in brine. Lowering of pH in mackerel during salting was observed also by Balachandran & Muraleedharan (1975). The $a_w$ of brine salted fish cake is 0.96 to 0.82 and brine salted anchovies is 0.80 to 0.79 $a_w$ (Chakrabarti et al., 1991 & Reddy et al., 1991). Kandoran et al. (1965) studied TVN loss in dry salted shark. The nitrogenous compound loss during salting in ungutted and gutted mackerel was reported by Mathew & Ragunath (1996) and the decrease of NPN content in wet salting of shark and ray by Sankar & Solanki (1992). Change in SSN in sardine, shark and ray was observed by Krishnakumar et al. (1986) and Sankar & Solanki (1992). The change in urea content in the early period of salting is reported by Kandoran et al. (1965). Decrease in urea in wet salted shark was observed by Ramachandran & Solanki (1991). The formation of FFA in sardine stored in chilled seawater is another change noticed (Krishnakumar et al., 1986 and Shetty et al., 1991). The FFA hydrolysis in heavy salted sample was rapid and is proportional to decrease of phospholipids (Lovern, 1961). The oxidation of FFA to PV in salt solution in presence of dissolved oxygen will take place in brine solution. Krishnakumar et al. (1986) and Sikorski et al. (1995) stated that the salt uptake of fish cause rapid protein denaturation, coagulation and further penetration of salt.
Levendov (1958) and Daun (1975) reported the action of diffusion and osmosis during salting and other characteristics by mass transfer of water and sodium chloride in to fish in brine. The weight of fish increases initially due to up taking of salt and swelling of fish in anchovies. Mrochkov (1958) reported that considerable loss occurs in protein and non-protein nitrogen. Ragulin (1958) reported that there is loss in protein, lipids and minerals during salting and the loss depends on temperature. Zugarramurdi et al. (1993) reported that only certain quantity of salt can be absorbed by fish flesh and at saturation, this quantity is equal to the amount of salt that would dissolve in a quantity of water equal to what the fish might have at the moment of establishing equilibrium.

Fougere (1952) studied moisture loss and salt uptake in fish. Due to the contraction of tissue the electrostatic force of terminal end of the protein molecule determining the structural lattices of proteins results in about 15 to 25% bound water reverted to free state (Voskresensky, 1965). This leads to the shrinkage and structural variations in protein molecules. The salting time and temperature is an important factor for salting fish. It is reported that salting time required is 12 to 24 hours in tropical countries like India (Thomas & Balachandran, 1989). Protein denaturation by using sodium chloride in cod and Baltic herring (Duerr & Dyer, 1952 and Linko & Nikkila, 1961).

4.1.6. Chemical Preservatives

Chemical and natural preservatives are used to increase the storage life. Chemical preservative and salt or salt solution is recommended to increase storage life of the dried or cured fish. These chemicals slow down chemical changes of fish flesh and are anti-oxidants. Valsan (1968) recommended 2% sodium propionate in the wet cured fish and the spoilage can be reduced and shelf life extended up to 9 to 12 months. Joseph et al. (1988b) used 10% brine containing 0.1% citric acid in whole prawns. Gupta & Chakrabarti (1994) and Hiremath et al., (1989) used saturated brine and 0.1%
propionic acid. Prasad et al. (1994) used heat-treated salt to check the growth of red halophiles in salted fish. Anon. (1981) suggested that acetic acid, benzoic acid and propionic acid are cheap and useful as chemical preservative and 1.0% sodium benzoate or benzoic acid dip is useful for dry fish. Potassium benzoate dip is useful against dun and is soluble. Syme (1966) recommended 3% sodium phosphate and 0.25% sodium benzoate. Antony (1990) reported 0.1% calcium propionate dusting on the dried fish before sealing in pouches. Klaveren & Legendre (1965) recommended hypochlorite solution or powdered chloride of lime dip or salt and boric acid dusting or 0.4% sodium acid phosphate and 0.25% sodium benzoate with salt to prevent reddening.

A dip of 0.8-mole sodium propionate for 30 sec. or 0.1% sorbic acid with salted fish is more effective. Joseph & Srinivasan (1967) used sodium benzoate and sodium bicarbonate in the ratio of 1:3 in the preparation of dried salted fish. Joseph & Srinivasan (1967) used 25-ppm chlorotetracycline as preservative for dry salted fish. Valsan (1968 & 1985) reported that 3% sodium propionate and salt just before packing is good for better storage. Shewan (1961) reported that fish needs 75% relative humidity for the growth of red halophiles and sorbic acid is the best preservative. Tarr (1961) suggested many preservatives like sodium or potassium nitrites and their salts as chemical preservatives. The nitrates are reduced to nitrites during the storage. He further suggested that formaldehyde, sodium nitrite, penicillic acid, aureomycin (CTC), tetramycin, chloromycin and other strong antibiotics retard bacterial action.

4.1.7. Natural Preservatives

Devadasan et al. (1975) reported on the effect of tartaric acid and garlic as preservative in pickle curing of fish. Balachandran & Muraleedharan (1975) reported colombo curing of mackerel where they used gorukha puli (malabar tamarind) as preservative. The storage of dry cured fish using natural preservative and the anti-
oxidant effect of betel leaf extract was reported by Kalaimani et al. (1984). The action of spices and herbs are greater than the chemical preservatives with cloves, cinnamon and mustard and they exert greater preservative action (Hersom & Hullard, 1981). Cardamom, cumin, coriander, pimento and ginger have little effect and bay leaves; cloves oils are effective against bacteria (Hersom & Hullard, 1981). Rao et al. (1958) used tamarind (Tamarindus indica) as preservative in mackerel.

4.1.8. Drying of fish

There are different Methods used for drying salted fish namely Sun drying or natural drying, Electrical drying and Solar drying. Smoke drying is another method of preserving the fish using the principle of drying technique. (Anon., 1956 & 1982; FAO., 1975; Stansby, 1963; Anon., 1965 and Cutting, 1996). The natural drying of fish is economically viable than using mechanical dryers considering the cost (Zugarramurdi et al., 1993). They also further suggested that good product can be obtained in tropical climates if the products are prepared after considering points namely temperature, humidity of the air and quality of raw material. Sun drying of fish with or with out salting of Bombay duck, silver bellies, anchovies, round sead, ribbon fish and shark had been vividly reported (Srinivasan & Joseph, 1966; Prabhu, 1972; Joseph et al., 1986; Babu et al., 1987 Joseph et al., 1988a; Prabhu & Kandoran, 1991; Garg et al., 1989). Perovic & Samuel (1978) reported that fish is salted and dried all along the Indian coasts from Gujarat to West Bengal. Anon. (1982 & 1994) reported the use of drying on a raised platform with crow-proof and fly-proof environment. The raised plate from besides permitting good air movement prevents contamination of different sorts. Babu et al. (1987) reported on the different surfaces used for purpose of drying.

4.1.9. Time and temperature

Anon (1956) stated that shorter the drying time, the more tender and fibrous was the texture of the products. Gerasimov & Antonova (1979) showed that 30 to 35°C is the
optimum natural temperature and depends on weather condition. Camu et al. (1983) reported that sun drying is good for mackerel at 36 to 49°C. Pillai & Pillai (1989) reported 18 hours sun drying for laminated dry fish. Gopakumar & Devadasan (1983) and Reddy et al. (1991) reported that the fish be dried until a constant weight is obtained. Anon. (1982) suggested some important points to consider while sun drying. The effect of salt during drying was reported by Anon. (1982).

4.1.10. Basic principles of fish drying

Fish drying implies removal of water from fish because water is essential for the activity of all living organisms. The removal of water slows down or stops the growth of microbiological or autolytic activity. The controlled artificial dehydration of fish was carried out regardless of weather conditions (FAO. 1957 & 1975). Several workers have reported the process of drying, flow of water molecule to surface, effect of heat during drying and relative humidity on the fish (Jasson, 1965; Waterman, 1976; Anon., 1982). The physical changes and theoretical application of fish drying was reported by Jason (1965) and Cutting (1996). The relative humidity of air, air velocity, air temperature and surface area of fish are very important factors. The Integrated fisheries project, cochin has a well arranged electrical hot air tunnel drier with a capacity of 1000 kg / 16 hours. The tunnel drier has one upper and another lower chamber. The upper chamber has heating elements and hot air blower. The lower chamber has space to charge the trolley and two exhaust fans to remove highly humidified air and a temperature regulator. The salted fish after washing was arranged on perforated Aluminum trays and kept on the trolley and kept in tunnel. The temperature is regulated between 45 and 50°C. Perovic & Samuel (1978) reported that fish dried in the above method will be better quality than other methods but the unit cost of production will be about 50% higher than sun dried products.
Govindan (1985) described various types of artificial drying methods to dry the materials fast and more efficient, without any contamination by dust, insects, microbes, birds and animals. The different types of drier fabricated include, Cabinet type dryer, Tunnel drier, Multi-deck tunnel drier, Fluidized – bed – drier, Rotary dryer and Solar dryers (Sripathy & Balasaraswathi, 1985; Demir & Evcin, 1993; Anon., 1982 and 1981). Anon. (1987) and Rubbi et al. (1983) reported that solar dryers prevent fish from dust, and protects from birds, animals and dries quickly than sun drying. Anon (1982) reported that the sun light energy is collected and concentrated to produce elevated temperature to increase the rate of drying. Parabolic reflectors and absorption unit are used for sunlight. However, Reddy et al. (1991) and Sripathy & Balasaraswathi (1985) reported that there is no merit in solar drier except in producing dust free product and Anon. (1982) reported that none of the solar driers are used on commercial basis.

4.1.11. Present Methods of transporting

It is an important process to reach the product to the destination in time for better price and sales. The various kinds of transportation methods used are train, truck, cars, etc. by road (Anon., 1982). The salted fishes are usually packed in vallam made by using dried coconut leaves or using dried bamboo sticks. Antony et al. (1988) and Gopakumar (1996) reported that the dried leaves of coconut and palm and jute bags are used for bulk transportation of dried fish (Gopal, 1990; Antony et al., 1988). The cured and dried products thus prepared are not hygienically handled. This allows the entrance of foreign materials and insects. Due to poor handling and packaging the appearance of the fish is not at all good and cause loss (Ward, 1996) to the traders. During rainy season or monsoon season the landing of fresh fish was less and the demand for salted fish was more. This necessitates the need for proper transportation and packaging.
4.1.12.1. **Packaging**

Fishes are bulk packed using palm or coconut dried leaves usually called as 'vallum', contain 15 to 20 kg, easy to handle. It is observed that polythene bags containing 100gm packs sold in city have good acceptance. Kumar (1990) reported the various packing materials like papers and paperboards, cellophane, plastics, vinyl films, metallized plastics, aluminium foils and composite structure etc. But low-density polythene is widely used for packing dried fish due the low cost and transparent quality and better appearance (Antony, 1990). Gopal (2000) suggested LDPE of 100 gauge for dry fish packing.

4.1.12.2. **Purpose of packaging**

The purposes of packing are to contain the product, to protect the product and to help in selling the product (Anon., 1981). Further the psychology of the consumer depends on many factors such as appearance, colour and odour of the products. The fish seller needs to protect the fish from the external environment such as the entrance of external undesirable materials as bacteria, insects, moisture and oxygen. It also protects the products from the attack of mould and pink formation and gives better storage life (FAO, 1957). According to Prabhu & Gopal (1990), Gopakumar (1996) the packaging of dried fish need inertness, leak proofness, impermeability to oxygen, moisture and less transparent. Resistance to mechanical abrasion and puncture is another desired quality.

4.1.13. **Storage temperature**

This is an important factor in dry fish. The dried fishes are usually stored at room temperature 28°C (Antony, 1990). Further the dried fish absorbs moisture from the surrounding atmosphere or it may lose moisture due to dry atmosphere. This is because the moisture content of atmosphere had greater influence on the relative humidity and temperature. FAO. (1957) suggested that the salted dry fish stored at low temperature
would not encourage the growth of red halophiles. FAO. (1991) suggested to keep the fish at the low temperature of 10°C to check the growth of red halophiles. Syme (1966) reported that the dry fish be stored at 41°F (5°C) so that red halophiles do not grow. The maximum growth occurs during the storage at 77°F (25°C). Klaveren & Legendre (1965) suggested that the growth of red halophiles is due to the proteolytic action of the meat at 25°C. Rubbi et al. (1983) reported that the fish stored at +13°C was of superior quality in all cases than the fish stored at room temperature. Camu et al. (1983) suggested that the dried mackerel stored at 18°C is acceptable for 12 weeks. Tressler & Lemon (1951) recommended low temperature for fatty fishes. Sikorski et al. (1995) stated that the salted fish undergoes partial proteolysis due to the activity of muscle proteases in living animal. So to restrict the excessive proteolysis, the dried fish has to be stored at low temperature of +5°C.

4.2. Aim and Objectives

The study is aimed to:

- Develop salting techniques that minimize salt and salting time for economical and cost effective salting.
- To regulate weight changes during salting and yield.
- To improve the quality and shelf life of the salted and dried products by using chemical and natural preservatives.

4.3. Materials And Methods

4.3.1. Preparation of Sample

Fishes used for the study were mackerel, ribbonfish and shark. Fishes were selected to study the salting and drying behaviour of three widely different groups of fish. Mackerel is a red meat fish with medium fat content, ribbonfish is a white meat fish and shark belongs to elasmobranchs with meat containing high urea. The first two fish belong to teleosts. The fresh iced fish were transported to the
laboratory and cleaned immediately using standard method described below. The fish were washed to remove any foreign materials and measured for total length. They were weighed before and after cleaning to find the yield. The fishes were then cleaned without any gills, gut, and blood clotting and intestinal membrane. They were washed to remove blood and separated into eight lots - among them four lots used for dry salting and other four lots used for wet salting. Salting proceeded as follows. Salting of different sets was carried out for different durations (days).

4.3.2. Dry salting method

The first four lots of fish as mentioned above were salted with refined salt (Ramachandran et al., 1990) as the bacterial load is less in the ratio of 1: 4 salt to fish and chemical preservative, calcium propionate was mixed at different level of 0, 1%, 2% and 3% (four lots) to the salt initially as fishes to be stored at semi-dried condition. Separate 10 samples were prepared in each lot to find weight loss of the fish at different hours during salting and sun drying. The salted samples were dipped in water to remove excess salt. Samples were also removed at every four hours and dipped in water for one to two minutes to remove the excess salt to study biochemical changes of fish up to 48 hours. The flow sheet for dry salted fish is in Table 4.1.

4.3.3. Wet salting method

The next four lots of fish were dipped in saturated brine solution 1: 2 ratio of fish and brine solution (w/v). The natural preservative, the filtered tamarind juice (T.Indicus) of the strength of 0, 5%, 10% and 15% (four lots) were added (w/v). This solution was changed after 8 hours and fresh solution of the same strength was added to maintain the strength of the solution. Further samples were separated as above and to fulfill the above purpose. Swaminathan (1993) reported the chemical constituents of T.Indicus. The flow sheet for wet salted fish is in Table 4.2.
4.3.4. Washing and drying of fish

The salted fish as above, after 48 hours were washed for 1 to 2 minutes to remove the excess salt and dried for eight hours. The samples were weighed to find the weight loss and separated after four hours at noon and after eight hours at evening during drying to study the weight loss and biochemical changes such as moisture and salt. The temperature and relative humidity were measured. After drying, the best lot of each type of fish was selected for storage studies.

4.3.5. Storage

The best dry or wet salted lots from the four lots were selected and divided further into four lots for storage study. The 1st lot was stored without packing in room condition. The 2nd lot was packed and sealed in polyethane bags and stored at room condition and temperature and relative humidity were noted for one month at morning, noon and evening. The 3rd and 4th lots were packed sealed in polyethane bags and stored in a refrigerator at +13°C and cold store at −20°C respectively to study the organoleptic and chemical changes during the storage periods using the standard methods. The 1st and 2nd lot's samples were removed at 10, 20 and 30 days interval and 3rd and 4th lot's samples were removed at 1, 2, 3 and 4 months interval. (Table 4.3)

4.4. Statistical analysis of results

The experimental data were subjected to statistical analysis using the two factor ANOVA as Fisher & Yates (1963) and Snedecor & Cochren (1980), the mathematical model used for the purpose was

\[ X_{ij} = \mu + \alpha_i + \beta_j + \epsilon_{ij} \]

The ANOVA results prepared are given on anova tables. Where ever the treatment effect were found to be significant, least significant difference (LSD) were calculated using the formula

\[ \text{LSD} = \left( \frac{2r V_e}{t_a \text{(error d.f.)}} \right) \]
The results of the analysis of the data are given at the end of each chapter.

4.4. Results

4.4.1. Processing yield of fresh fish

Average yield of mackerel after cleaning and evisceration was 83.74% with a range of 80.54 to 86.06% and ribbon fish showed 76.47% with a range of 70.52 to 87.01% and shark showed 63.57% yield with a range of 50.01 to 67.30%.

4.4.2. Weight loss during salting and drying

4.4.2.1. Dry and wet salted Mackerel

Weight losses in four dry salted lots at the initial stage (at four hours) were high at 11.76%, 14.24%, 10.96% and 8.18% respectively. Maximum weight loss was noted in the first eight hours of salting. After that period only slight weight loss was observed up to 48 hours. The weight loss at 48 hours was 16.18, 20.83, 15.61 and 12.84% respectively in these four lots (Figure 4.1). ANOVA results show that there is significant difference between lots (p < 0.001). Lot one is significantly different from lot 2, 3 and 4 and lot two is significantly different from lot 1, 3 and 4. Also lot 3 and 4 are significantly different from others. The average weight change of fish showed significant difference between hours in all occasion depending on the control and preservative (Table 1). Initial weight losses in four lots of wet salted mackerel were 6.79%, 6.69%, 5.54% and 5.80% at four hours. Weight loss increases a little at eight hours. The weight loss decreases subsequently at 24 hours. The weight loss at 48th hours was 3.53%, 11.04%, 8.65% and 14.51% in four lots respectively. Wet salting showed very little weight changes (Figure – 4.1). The ANOVA results show that each lot is significantly different (p < 0.001) the difference is not so pronounced as in dry salted fish. There is significant difference in weight loss between hours (p < 0.001) (Table 2).

During drying of dry salted lot, the morning temperature and relative humidity were 33.2°C and 54% respectively. At four hours they were 36.1°C and 45.1% and at
eight hours 33.3°C and 63% respectively. The weight losses after one day drying of four lots were 3.99, 3.97, 4.30 and 3.42% respectively. The yields of the four lots are 80.50, 76.04, 78.74 and 79.40% (Table 4.4). 3rd lot was selected for storage studies on the basis of Organoleptic and physical observations. The ANOVA result shows that there is significance in rate of drying between 4 lots as lot 1 & 2, 2 & 3 and 3 & 4 and no significant difference between columns (p < 0.001) (Table 3).

During drying of wet salted lots, temperature and relative humidity in morning were 32.7°C and 57%. At four hours they were 36.2°C and 51% and at eight hours they were 32.4°C and 65%. The weight losses in four lots were 17.58, 16.01, 14.02 and 14.88% respectively. Yield of samples were 80.16, 75.25, 77.85 and 73.09% respectively (Table - 4.4). The 2nd lot was selected for storage studies. The ANOVA result shows that there is significance in drying between lots 1 & 2, 2 & 3 and 3 & 4 and also in columns (p < 0.001) (Table 4).

**4.4.2.2. Dry and wet salted ribbonfish**

The four dry salted lots had the weight loss of 9.48%, 11.36%, 13.29% and 12.76% at four hours. At eight hours only little change was noticed. At 48 hours the weight loss in four lots were 13.5, 16.56, 16.28 and 21.07% respectively (Figure 4.2). The ANOVA results show that the 1st and 2nd lot had no significance. Significant values are observed in case of lots 2, 3 and 4. The weight loss between the hours is much significant at initial time between the lots and is less as the salting time advances (Table 5). In all the four wet salted lots weight decrease were found to be 11.29%, 10.14%, 10.80 and 12.01% respectively at four hours and no much weight loss was occurred there after. The weight loss at 48 hours is 12.54, 14.37, 16.07 and 13.58% respectively (Figure 4.2). ANOVA showed highly significant difference (p< 0.001) between lots 1 and 2 and are less significant between 2 and 3 and more significant between 3 and 4 lots.
The loss during salting also show significant difference between the hours in lot 1 and 2 and is less significant between 2 and 3 and 4 (Table 6).

During drying of dry salted lots, the morning temperature and relative humidity were 32.50°C and 64%, at four hours they were 36.4°C and 49% and at 8 hours, 33.0°C and 57% respectively. The weight losses at evening were 27.19%, 30.46%, 31.54% and 22.97% respectively in the four lots. The yields of fish were 64.83%, 59.42%, 58.80% and 58.38% respectively (Table 4.4). The lot two was selected for storage studies. Drying result shows significant difference ($p < 0.001$) between lots 1 and 2, 2 and 3 and 4 but no significance in lot 2 and 3 and in column (Table 7). During drying, of wet salted lots, the temperature and relative humidity at morning were 32.6°C and 60.0%, at four hours they were 36.6°C and 51 and at 8 hours, 34.2°C and 65. The weight loss on the day was 18.06, 22.31, 25.72 and 27.09% respectively (Table - 4.4). The yield of fish was 72.1, 67.32, 63.43 and 61.98% respectively. The lot 3 was selected for storage studies. The rows are much significant between lots 1 and 2, 2 and 3 and 3 and 4 and little significant in column (Table 8).

### 4.4.2.3. Dry and wet salted Shark

Weight loss of four dry salted lots were 12.45, 11.54, 10.58 and 10.73% in four hours of salting than fresh fish and 2.50, 2.78, 2.80 and 1.37% at eight hours of salting than four hours and the weight loss was little there after. At 48 hours the weight loss was 17.11, 16.29, 17.50 and 17.48% respectively (Figure 4.3). The ANOVA results showed significant different ($p < 0.001$) between the lots 1 and 2, 2 and 3 and 3 and 4 but less as salting time advances. As salting time increased, the weight loss is highly significant between lots 1 and 2 and is less between lot 2 and 3 and 3 and 4 (Table 9). The weight loss of 4 wet salted lots were very less in the 1st and 3rd lots as 0.81%, 2.3%, 1.14% and 5.67% at four hours than fresh fish and at eight hours they were 2.87%, 2.01%, 4.23% and 1.77% respectively due the moisture loss. At 48 hours the weight loss was 3.03%,
6.23%, 11.79% and 13.67% respectively (Figure - 4.3). There is significant difference (p < 0.001) between lot 1 and 2, 2 and 3 and 3 and 4. As the salting time increases, there is significant difference in weight loss between 1 and 2, but the significance is less in 2 and 3 and 3 and 4 (Table 10).

The four dry salted lots were dried at 34.0°C and 45% relative humidity in the morning, 37.2°C and 34.5% relative humidity at four hours and 34.8°C and 52% relative humidity at eight hours of drying. The weight losses of the lots at evening were 22.03, 16.40, 11.70 and 18.27% respectively. The yields of the four lots were 63.02, 69.28, 74.92 and 69.63% respectively. The lot three was selected for storage studies. The weight losses in four dry salted samples were significant (p < 0.001) lot 1 and 2, 2 and 3 and 3 and 4 are significant in column (Table 4.4). The four wet salted lots were dried at 30.3°C and 55 relative humidity in the morning, 34.1°C and 45 relative humidity four hours and 32.2°C and 53 relative humidity eight hours. The lots had weight loss of 12.37, 12.97, 15.54 and 18.16% respectively in one day. The yields of the lots were 86.02, 81.31, 75.29 and 71.33% respectively (Table - 4.4). The 2nd lot was selected for storage studies. The weight loss is significant in lots 1 and 2, 2 and 3 and 3 and 4 and is more significance in column (Table 12).

4.5. Discussion

The results showed that dry salted lots loss maximum weight with in the first four hours and the weight loss occurs after four to eight hours were very limited. The range of loss depends on the concentration of preservative also. The yield of mackerel was high in 1st and 4th samples than in 2nd and 3rd samples. The results of wet salted mackerel shows that the weight loss is less than dry salted mackerel in the initial four and eight hours as reported by Ragulin (1958) in anchovies and agrees the finding. But weight loss increased a little after addition of freshly prepared solution to equalize the osmotic pressure. The weight loss was high in 2nd and 4th lots than 1st and 3rd lots. The weight
loss during drying showed that weight loss was high in wet salted lot than dry salted lots. This may be due to the high moisture content in wet salted mackerel and evaporated during drying. The rate of yield shows that there is not much difference in both cases. The result agrees with the weight loss of brined anchovies reported by Prabhu & Kandoran (1991) and is depended on moisture content. The yield of mackerel agrees with result reported by Valsan (1976) on mackerel. There was much difference in yield in dry and wet salted mackerel in lot 4 only.

The results showed on weight loss of ribbon fish during dry salting was very high at initial period of salting as noted by Cutting (1961) and agrees with the result. Weight loss was little during later hours. The weight loss in 1st and 4th lots was high than other two and yield was high in lot one. The results of the wet salted ribbonfish showed that the weight loss was as noted in wet salted mackerel. The yield was high in wet salted ribbonfish than dry salted ribbonfish. But the 4th lot of both dry and wet salted ribbonfish have almost same yield.

The dry and wet salted shark lots, during salting showed same results as above. The weight loss, during salting was high in dry salted shark. Weight loss was maximum up to 24 hours and was marginal from 24 to 48 hours. There was not much difference in weight loss of dry and wet salted lots during drying and weight loss was high in wet salted lots. The results showed that there was much difference in yield in dry and wet salted shark. There was more difference in dry salted shark lot three than others. The yield in wet salted lots showed that it was in decreasing order from 1st to 4th lots. This may be due to the fact that wet salted fish do not extrude much moisture during salting as dry salted ones.
Figure - 4.1 Average weight loss in mackerel in different conc. of preservatives
Figure 4.2 Average weight loss in ribbonfish in different conc. of preservatives.
Figure - 4.3. Average weight loss in shark in different conc. of preservatives
Table – 4.1
FLOW SHEET FOR DRY SALTED FISH

Landing

Transport

Raw material washing

Sorting

Cleaning

Washing

Size cutting & scoring

Salting

(1:4 salt and fish) + adding preservative with through mixing (Wt.basis).

Control 1:4 + 1% Ca. 1:4 + 2% Ca. 1:4 + 3% Ca.

(1:4 salt & fish) Propionate Propionate Propionate

(Lot – 1.) (Lot – 2) (Lot – 3) (Lot – 4)
Samples collected at every 4 hrs. dipped in water for 1 min.

(To remove excess salt)

Draining (5 min.) ----------- (to remove excess adhering water)

Spreading over perforated Aluminium trays.

Keeping on cemented plate form

Drying (9 am to 5 pm.).

Organoleptic and sensory observations

Selection of the best

Packing in polyethane bags

Sealing

Storage
Table - 4.2
FLOW SHEET FOR WET SALTED FISH

Landing

Transport

Raw material washing

Sorting

Cleaning

Washing

Size cutting & scoring

Salting

(1: 2 of fish and saturated brine solution, SBS)

Control. SBS 1: 2 + 5% SBS 1: 2 + 10% SBS 1: 2 + 15%

SBS 1: 2 ratio Tamarind Tamarind Tamarind

(Lot - 1) (Lot - 2) (Lot - 3) (Lot - 4)
Addition of same conc. Solutions in the respective lots after 8 hrs

Sample collection at every 4 hrs intervals and dipped in water for 1 min

Draining for 5 min.

Spreading on Aluminium trays

Keeping on cement plate form

Drying (9. am to 5. pm)

Organoleptic and sensory observation

Selection of the good

Packing

Storing
Table – 4.3

FLOW SHEET FOR STORAGE OF DRY AND WET SALTED FISH

(The bio-chemical and organoleptic value assessed during the period)

<table>
<thead>
<tr>
<th>Open air store (Without packing)</th>
<th>Open air store (Packed)</th>
<th>Refrigerator (Packed)</th>
<th>Cold storage (Packed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lot – 1</td>
<td>Lot – 2</td>
<td>Lot – 3</td>
<td>Lot – 4</td>
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<tr>
<td>10 days</td>
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<td>one month</td>
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<tr>
<td>20 days</td>
<td>20 days</td>
<td>2 months</td>
<td>2 months</td>
</tr>
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<td>30 days</td>
<td>30 days</td>
<td>3 months</td>
<td>3 months</td>
</tr>
<tr>
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<td></td>
<td>4 months</td>
<td>4 months</td>
</tr>
<tr>
<td></td>
<td>0 Hours drying</td>
<td>After 4 hrs drying</td>
<td>After 8 hrs drying</td>
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<td>-------</td>
<td>----------------</td>
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<td>Lot 4</td>
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<td>Lot 3</td>
<td>52.8</td>
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<td>Lot 3</td>
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<td>Lot 4</td>
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<td>51.5</td>
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<td>Wet salted shark</td>
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<tr>
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<td>Lot 4</td>
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Table 1 Results of two-way ANOVA on average weight loss of D.S. mackerel

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<th>MS</th>
<th>F</th>
<th>P-value</th>
<th>F crit</th>
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Table 2 Results of two-way ANOVA on average weight loss of D.S mackerel on drying.

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Table 3 Results of two-way ANOVA on average weight loss of W.S mackerel

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</table>

Table 4 Results of two-way ANOVA on average weight loss of W.S mackerel on drying.

<table>
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<th>P-value</th>
<th>F crit</th>
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<td>0.154583</td>
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</table>
Table 5 Results of two-way ANOVA on average weight loss of D.S. ribbonfish

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Table 6 Results of two-way ANOVA on average weight loss of D.S. ribbonfish on drying.

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<th>P-value</th>
<th>F crit</th>
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</table>

Table 7 Results of two-way ANOVA on average weight loss of W.S. ribbonfish

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Table 8 Results of two-way ANOVA on average weight loss of W.S. ribbonfish on drying.

<table>
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Table 9 Results of two-way ANOVA on average weight loss of D.S.shark

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Table 10 Results of two-way ANOVA on average weight loss of D.S shark on drying.

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Table 11 Results of two-way ANOVA on average weight loss of W.S.shark

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Table 12 Results of two-way ANOVA on average weight loss of W.S shark on drying.

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